KS 9

OFFICE OF INTERNATIONAL AGRICULTURAL PROGRAMS
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SELECTED PROCEEDINGS
OF KANSAS STATE UNIVERSITY'S
1984 FARMING SYSTEMS RESEARCH SYMPOSIUM

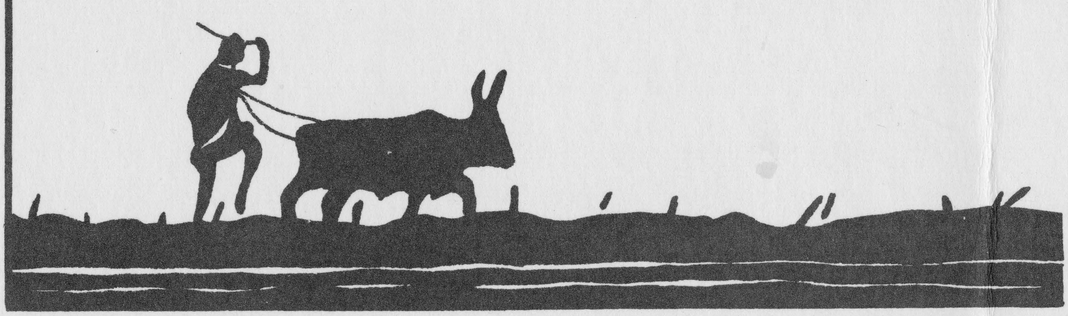
FARMING SYSTEMS RESEARCH & EXTENSION:
IMPLEMENTATION AND MONITORING

Edited by
Cornelia Butler Flora & Martha Tomecek

Paper No. 9 February, 1986

FARMING SYSTEMS RESEARCH

PAPER SERIES



Resources on developing countries

KANSAS STATE UNIVERSITY.
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FARMING SYSTEMS RESEARCH PAPER SERIES

Kansas State University's Farming Systems Research (FSR) Paper Series is supported by the U.S. Agency for International Development Title XII Strengthening Grant. The goal of the Strengthening Grant is to increase the University's ability to implement Title XII agricultural and nutritional development assistance programs in less-developed countries. This series is maintained by the FSR Program Associates -- a multidisciplinary team of professors who are aiming their activities at applied research on farming from a systems perspective.

The purpose of the FSR Paper Series is to seminate information on FSR. Publication categories include updated bibliographies from KSU's FSR data base; proceedings from KSU's annual Farming Systems Symposium; selected papers presented in KSU's FSR Seminar Series; selected papers prepared by KSU's Programs Associates.

Copies of these papers may be obtained from the Distribution Center, Umberger Hall, Kansas State University, Manhattan, Kansas 66506. There will be a charge for selected papers and multiple copies to help defray cost of printing.

Vernon C. Larson
Director

FARMING SYTEMS RESEARCH AND EXTENSION:
IMPLEMENTATION AND MONITORING

OCTOBER 7 - 10, 1984

FARMING SYSTEMS RESEARCH SYMPOSIUM

sponsored by the
Title XII Strengthening Grant

by the

Office of
International Agricultural Programs
Kansas State University
Manhattan, Kansas 66506

Symposium Planning Committee:

Cornelia Butler Flora, Chair
William J. Jorns, Co-Chair

Wayne Geyer
Carole Harbers
Vernon Larson
Wayne Rohrer
Meredith Smith
L. V. Withee

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8:00-12:00 pm	-	Registration: 2nd Floor Concourse

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9:15- 9:45	-	"The Missouri Balanced Farming Experience as FSR/E" Albert Hagan, Agricultural Economics, University of Missouri
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R. Jaubert, Farming Systems Program, ICARDA, Syria

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Michael Yates & Juan Carlos Martinez, CIMMYT

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Gregory Sullivan, Auburn University

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Dick Tinsley & Maya ter Kuile, Egypt Water Use & Management Program, Colorado State University

3 - "Farming Systems Approach to Animal Husbandry Problems in Botswana"
Berl A. Koch, Agricultural Technology Improvement Project, Botswana

5 - "Row Vs. Broadcast Cropping System in Botswana"
Robert J. Bevins & Melvin Blase, Agricultural Economics, University of Missouri & Nyangayezi Macala, Botswana Ministry of Agriculture

7 - "A Microcomputer Spreadsheet Farm System Model as an Analytical Framework for On-Farm Experimentation & Linkage between Research & Extension"
Robert D. Hart, Winrock International

9 - "The Socio-Economic Dimensions of Farm Level Trials & Demonstrations"
Barry Michie, Kansas State University

11 - "The Sorjan Cropping System as a Method of Growing a Dryland and Wetland Crop Simultaneously"
Howard Hagerman, Lyman Briggs School, Michigan State University

13 - "On-Farm Trials in Farming Systems Research"
Jan L. Flora, Kansas State University

15 - "Economic Analysis within the Farming Systems Research & Technology Development Methodology: An Empirical Application in Central America"
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John L Wake, University of Florida

19 - "Designing a FSR/E Project in Rwanda"
K. B. Paul, Lincoln University & Don Voth, University of Arkansas

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23 - "Inclusion of Food Consumption Concerns in Farming Systems Projects"
Timothy Frankenberger, University of Kentucky

25 - "Organization of the Sondeo Report"
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27 - "Technology Transfer in a Farming Systems Setting in Ghana"
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3:30- 5:00 pm - POSTER SESSION II: K & S Ballrooms

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Christopher R. Smith, Chemonics International, Washington, D.C.

4 - "The Farmer Involvement Program: A Multi-Disciplinary Approach to the Teaching of Agriculture at the Rural Development Institute, Bong County, Liberia"
David C. Meyers, Rural Development Institute, Cuttington University College, Liberia

6 - "Farm Size Questions in the Small Farm Economy of Korea"
Robert M. Finley, University of Missouri

8 - "Profitability and Appropriateness of Improved Sorghum Product Technology Disseminated from a Research Station in Northern Nigeria"
Samm Bbuyemsoke, Ahmadu Bello University, Nigeria

10 - "Group Extension Methods in Lesotho"
Darlene Townsend, Washington State University

12 - "Stratification and Differentiation within Small Holder Strata: A North Carolina Case Study"
Michael D. Schulman, North Carolina State University

14 - "Defining Agricultural Recommendation Domains in South-Central Niger"
Scott M. Swinton, Purdue University & Ly Samba, Instuit National de Recherches Agronomique du Niger

16 - "Agricultural Research and Development: Viable Objectives for Small Holder Programs"
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Angela Neilan, John Caldwell, Mary Rojas & Miew Leng Mark-Teo, Virginia Polytechnic Institute & State University

22 - "Incorporating Socioeconomic Environmental Variables in FSR/E"
James A. Chapman, Chemonics International, Washington, D.C.

24 - "Farming Systems Project Implementation, Start-up and Replanning: Experience from the Eastern Caribbean & Sudan"
J. B. Henson, J. Noel & M. Ingle, Washington State University

26 - "Generation of Technology Appropriate for the Small Farmer: The Honduran Case"
A. Silva, Secretaria de Recursos Naturales, Honduras

28 - "The Role of the Information Professional in FSR/E"
Jim Bemis, (N)PUT International, Inc.

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Randy Barker, Cornell University
Responses: Bob Hart, Winrock International/CARDI
Charles Francis, Rodale Press

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Presiding: Merle L. Esmay, Michigan State University

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Zakaria El Haddad & Mr. Sahrigi, Egypt

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A. F. Lima, CPATSA, Petrolina, Brazil

9:20-10:00 - "The Role of Physical Technology in the FSR/E Program of CARDI in the Caribbean"
Laxman Singh, CARDI

10:00-10:30 am - Break: 2nd Floor Concourse

10:30-12:00 pm - CONCURRENT SESSIONS: ON-FARM TRIALS - Little Theatre
EXTENSION - Big Eight Room
MONITORING - Room 212

ON-FARM TRIALS: Little Theatre
Presiding: L. H. Harbers, Kansas State University

10:30-10:50 - "Simulating the Technology Adoption Process: A Case of Groundnut Farmers in Northern Nigeria"
K. Agori-Iwe, Institute for Agricultural Research, Ahmadu Bello University, Nigeria

10:50-11:00 - Discussion

11:00-11:20 - "An On-Farm Research Strategy for Improving Small Ruminant Production in Humid West Africa"
A. Atta-Krah, International Livestock Center for Africa, Nigeria

11:20-11:30 - Discussion

11:30-11:50 - "A Case Study on Evaluating New Technology in Farmers' Fields with Emphasis on Plant Drills for Wheat in Charbiya Governorate, Egypt"
Robert Deuson, Purdue University

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EXTENSION: Big Eight Room
Presiding: Bob Johnson, Kansas State University

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Federico Poey, AGRIDEC, Florida

10:50-11:00 - Discussion

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Thomas F. Trail, Washington State University

11:20-11:30 - Discussion

11:30-11:50 - "FSR/E: Shifting the Intersection of Research and Extension"
Sam H. Johnson & John B. Claar, University of Illinois

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MONITORING: Room 212
Presiding: Wayne Geyer, Kansas State University

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Della McMillan, University of Florida

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11:00-11:20 - "Comparing the Results of an Informal Survey with Those of a Formal Survey: A Case Study of Farming Systems Research/Extension (FSR/E) in Middle Kirinyaga, Kenya"
Steve Franzel, Development Alternatives, Inc., Washington, D.C.

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M. Diomande, OFRIC, Ivory Coast

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12:00- 1:30 pm - Lunch: Main Ballroom
Presiding: Jim Jorns, Kansas State University
Address: "Cacqueza and Puebla - The Institutionalization Process"
Kenneth Swanberg, Bureau of Science & Technology, USAID/Washington

1:30- 3:00 pm - CONCURRENT SESSIONS: INSTITUTIONALIZATION - Little Theatre
ON-FARM TRIALS - Big Eight Room
EXTENSION - Room 212

INSTITUTIONALIZATION: Little Theatre
Presiding: Janet Benson, Kansas State University

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A. Doyle Baker & J.A. Hobbs, Agricultural Technology Improvement Project, Botswana

1:50- 2:00 - Discussion

2:00- 2:20 - "Institutionalizing Farming Systems Reserch: The Case of Farming Systems Research in Nigeria"
George Abalu, Institute for Agricultural Research, Nigeria

2:20- 2:30 - Discussion

2:30- 2:50 - "Technological Innovations and Impact of Cropping Systems Research in Different Sites in Indonesia"
Soetjipto Partohardjono, Central Research Institute for Food Crops, Indonesia

2:50- 3:00 - Discussion

ON-FARM TRIALS: Big Eight Room
Presiding: Jan Flora, Kansas State University

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Mazo Price & V. Balasubramanian, World Bank FSR Project, Rwanda

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Dianne Rocheleau, International Council for Research in Agroforestry, Kenya

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2:00- 2:20	-	"A Comparative Analysis of Two Representations: Farm Systems in Burkina Fasso" Mike Roth, Purdue University
2:20- 2:30	-	Discussion
2:30- 2:50	-	"Constraints & Opportunities to Extension Training in Swaziland" Glen W. Easter, Cropping Systems & Research, Malkerns Research Station, Swaziland
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3:30- 4:00 pm	-	WRAP-UP SESSION: Little Theatre Presiding: John Wheat, Kansas State University Jerry McIntosh, IRRI, Philippines Peter Hildebrand, University of Florida Ray Morton, AID/ARD

INTRODUCTION

Cornelia Butler Flora & Martha Tomecek

This is the first year we have submitted the papers presented at the symposium to peer review. It has proved a time consuming, but rewarding task. We undertook this innovation in order to improve the quality of the proceedings and to provide recognition for the quality of work done by FSR/E practitioners around the world, in that FSR/E studies do require rigor and systematic method, but do not fall into the criteria established by disciplinary journals.

We would particularily like to thank the reviewers for their excellent comments and critiques. Their ability to offer systematic comments attests to the growing body of knowledge and accepted practice in FSR/E.

REVIEWERS

Ponniah Anandajayasekeram
CIMMYT-East Africa

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Robert Waugh
Independent Consultant, Farming
Systems Support Project (FSSP)

Donald Winkeleman
CIMMYT

Laureston V. Withee
Kansas State University

Hubert Zandstra
International Development
Research Centre (IDRC)

DOMESTIC FSR/E EXPERIENCE

John S. Caldwell, Mary H. Rojas and Angela M. Neilan

Harold J. McArthur, Jr.

THE DIFFICULTIES IN SUPERIMPOSING A FARMING SYSTEMS RESEARCH AND EXTENSION PROJECT ON THE EXISTING COOPERATIVE EXTENSION STRUCTURE IN SOUTHWEST VIRGINIA

John S. Caldwell, Mary H. Rojas, Angela M. Neilan

INTRODUCTION: TWO ISSUES IN FSR/E

Farming Systems Research and Extension (FSR/E) is an approach to development for "small" (limited resource) farms that is receiving increasing attention now in domestic as well as international contexts. This paper addresses two key issues of FSR/E: the inclusion of the household in FSR/E, and the institutionalization of FSR/E within the United States land grant-Cooperative Extension system.

As a conceptual framework for organizing research and extension, FSR/E is more encompassing than traditional agricultural research. Traditional agricultural research has been termed "reductionist": it studies only a limited number of factors (typically, crop biophysical variables that can be measured quantitatively, such as plant response to fertilizers or pesticides) while holding other variables constant under controlled conditions. The assumption is that improvements in individual components of the total farming system are additive and collectively result in improvement of the whole system (Dillon, 1976).

In contrast, FSR/E is based on the premise that interactions among components in the natural and human environments of the farming system have a significant effect on whether or not changes in individual system components result in improvement in the system as a whole (Gilbert et al., 1980). For this reason, as a conceptual framework, FSR/E does not limit its scope of concern to the biophysical environment that is the traditional domain of agricultural research and extension, but rather explicitly recognizes the key role of the household. The conceptual models of two major pioneers in FSR/E both show the household as one of the three major subsystems of the farming system, together with crop and animal subsystems (McDowell and Hildebrand, 1980; Zandstra, 1980). Moreover, a recent text which has synthesized a unified FSR/E methodology from various similar methodologies that have been tested in different countries has termed the household "the integrating unit" for the other two subsystems, crop and animal (Shaner et al., 1982).

However, as a working methodology, FSR/E has tended to focus almost exclusively on agricultural productivity. The primary objective of FSR/E has been defined in terms of improving the linkage between traditional, reductionist agricultural research on the one hand, and agricultural extension on the other hand (McDermott, 1982). FSR/E is thus evolving as a mechanism for improving agricultural technology generation for more limited resource farms. The working methodology retains the whole farm viewpoint by using farm surveys in an initial diagnostic phase in order to design agricultural production trials to be conducted on farms rather than solely on an experiment station (Gilbert et al., 1980). In addition, the response of households to agricultural technology innovation, their "acceptability index" in the research area, is studied as a key variable (Shaner et al., 1982).

FSR/E methodology as described above, therefore, recognizes non-agricultural priorities of the household only implicitly, insofar as they result in a low degree of acceptance of agricultural technology innovation. Non-agricultural family priorities and the impact of agricultural technology change on family well-being defined more broadly than economic benefit have not been the main concern to date of FSR/E as a working methodology (Hildebrand, 1982; Whelan, 1983; Behnke and Kerven, 1983).

The approach of the Southwest Virginia Farming Systems Research and Extension project was explicitly based on the original premise of the FSR/E conceptual framework that the household is a key element of the system. The project recognized that too often the farm household has been undervalued in rural development theory as an integral part of the production of the total farm. Too often the role of the household is seen by researchers, teachers, and Extension as primarily a consumption unit, separate from farm production.

FSR/E has developed outside the United States, frequently through internationally-funded, applied research-oriented projects. Greater emphasis has been placed on the diagnostic and on-farm research stages of the FSR/E process. Also, research institutions and personnel have tended to be more involved in FSR/E projects than Extension institutions and personnel.

In the United States, however, the Cooperative Extension system has a long history of working with farm families. Its organizational structure reaches far into rural communities nationwide. Through special programs for limited resource farms and families, it has also developed techniques with some similarities to the FSR/E process. If FSR/E is to be applicable in the United States, it must, therefore, be made compatible with the existing Cooperative Extension system.

At the same time, the process of seeking to institutionalize FSR/E within the Cooperative Extension system in the United States can help FSR/E practitioners from the United States better appreciate the difficulties that counterparts in developing countries have in institutionalizing FSR/E within their own national research and extension organizations.

Therefore, the Southwest Virginia FSR/E project was conceived and implemented from the beginning as a project within the existing Cooperative Extension system, in order to provide a case study of how best FSR/E with a household focus might be institutionalized within that system.

DIAGNOSTIC STAGE: MATERIALS AND METHODS

The Southwest Virginia Farming Systems Research and Extension (FSR/E) project was funded from October 1981 to April 1984 by the United

States Department of Agriculture Office of International Cooperation and Development (USDA/OICD). Project objectives related to the two issues presented above: to examine the relationships of family systems to farming systems, and to apply FSR/E methodology within the land grant university - Cooperative Extension Service system. Virginia Polytechnic Institute and State University (Virginia Tech), the 1862 land grant institution of Virginia, was the lead institution.

Southwest Virginia was selected as the target area because of the predominance of limited resource farms in that area. Within the target area, three counties were selected in consultation with Extension personnel as the research area because of their small farm para-professional agricultural program (Rich, 1982). These para-professionals are frequently called small farm technicians. Over half (56%) of the 4,276 farms in the research area has harvested cropland areas of less than four ha (10 ac) (U. S. Department of Commerce Bureau of Census, 1981). This places them within the range of cropland available to many farms in less highly populated parts of the developing world.

The project used a modified form of the 4-stage FSR/E methodology (Norman, 1983). Diagnosis began in 1982, with an FSR/E multidisciplinary team consisting of faculty, students and Extension personnel in horticulture, home economics, nutrition, sociology and anthropology. This team conducted three activities in the diagnostic phase. First, there were reconnaissance interviews (sondeos) with 47 limited resource farm households. Each sondeo paired one university team member and one Extension technician. The purposes of the sondeo were to enable team members to gain experience in working in a multi-disciplinary team, to characterize the predominant farming systems in the area, to gather information on the major goals, problems, and constraints of limited resource farm families, and to evaluate the Extension para-professional technician program in the area as a model for working with the whole farm family (Shaner et al., 1982; Caldwell et al., 1984a, 1984b; Rojas et al., 1984).

The next step of the diagnostic stage was to quantify some of the interactions depicted in a qualitative model of the predominant farming systems of the area (Hart, 1983). Figure 1 is a generalized model showing the components of several different major farming systems in the area. Tobacco was common to all major systems (43 of the 47 sondeo farms), but it was increasingly being complemented by commercial fruits and vegetables (21 farms) as tobacco allocations decreased and the political future of tobacco appeared more uncertain. Marketing of alternative crops, especially pepper, was thus a major concern expressed by farm family members during the sondeos. Prices of beef cattle had also been poor. Thus, on farms with beef cattle (28 sample farms), financial difficulties and reluctance to borrow were major constraints. Women played a predominant role in record keeping and farm household budgeting, and in providing household income through off-farm employment (32 sample farms had off-farm employment). Only on dairy farms (12 sample farms) did financial difficulties appear to be less critical.

The above qualitative model thus served as a guide both for future quantitative diagnosis and for design of alternative solutions to problems identified by the initial diagnosis. Two types of follow-up case studies were initiated to quantify key interactions. The first quantitative diagnostic activity was a time budget record keeping by a sub-sample of limited resource farm households. The time budget record keeping by 10 of the original 47 families interviewed covered the period May through September, 1982. All members of the household over 10 years old were included. The purposes of the activity were to learn more about the allocation of family member time among competing farm, on-farm non-agricultural production activities, and off-farm employment; the contributions of women to farm production; and the extent of intra-familial and family-community interaction (Caldwell et al., 1983).

The other quantitative diagnostic activity was food consumption record-keeping. The same sub-sample of the 10 farm households that recorded their time allocation also recorded their food consumption. The purpose of this activity was to investigate possible relationships between nutritional status, predominant farm enterprises, and the status of the farm family unit (presence or absence of off-farm employment of the woman, and nuclear versus female-headed family type) (Hertzler, 1983).

Based on problems identified in the diagnostic phase and the project's focus on the total household, the FSR/E team recommended two interventions, a farming systems intervention and an institutional intervention (Caldwell et al., 1984b). In other words, design and testing involved both institutional and farming changes. The farming systems intervention was based on the recognition of a need for a re-evaluation of the marketing situation for vegetables, to determine if there were marketing alternatives which had not yet been explored (Caldwell, 1982). The farming systems intervention accordingly involved the introduction of broccoli as a new alternative crop with a favorable market window in Virginia (Runyan and Coale, 1983). It is high in nutrients and as indicated by the food consumption study, it is most likely to be deficient in the diets of women with off-farm employment, and compatible with tobacco labor use. Details of the problems investigated through on-farm broccoli trials are presented elsewhere (Caldwell et al., 1984a, 1984b). The remainder of this paper will focus on observations on the structural and procedural difficulties in integrating the institutional intervention into the Cooperative Extension Service, and on institutional issues that emerged in the process of using FSR/E within the Cooperative Extension Service to design and test the farming systems intervention. Although these are observations of a single case study, they are useful as guidelines and warnings for academicians, Extension personnel, and FSR/E practitioners as to the potential advantages and pitfalls of the collaboration of FSR/E teams and an established Extension service.

DESIGN AND TESTING OF THE INSTITUTIONAL INTERVENTION: THE "AGRI-HOME ECONOMICS" TECHNICIAN TEAM

The institutional intervention was based on the FSR/E team's recommendations that priority be given to strengthening the implementation of the original technican model in record keeping and farm management, and addressing the nutriutional needs of limited resource farm families identified by the food consumption survey. Since the majority of farms had supplemental off-farm income, household member time frequently had to be allocated among on-farm, off-farm, and household activities. For this reason, the FSR/E project team recommended greater coordination between the agricultural technician program and home economics programs (Caldwell, 1982).

As the diagnostic phase progressed, however, the FSR/E multidisciplinary team became particularly aware of the strong dichotomy between the home economics unit and the agriculture unit in Extension. It also became apparent that the clientele served by these two units was for the most part divided by gender. Agriculture served men and home economics served women, although this division in the roles within the limited resource farms surveyed was not always clearly apparent. On the contrary, it was found that both men and women did a wide variety of tasks both on-farm and off (Rojas, 1983).

Therefore, the institutional intervention that the FSR/E team recommended was to hire a home management technician to work as a team with the two agricultural technicians already working for Extension with limited resource farms. This team of three technicians was to address the needs of the total farm family. For example, the three technicians were not only to take soil samples and grow broccoli, but were also to advise on broccoli preservation and preparation. It was to be an "agri-home economics" team.

As a counterpart to this integrated approach, the FSR/E team took seriously Glenn Johnson's call at the Kansas State Farming Systems Symposium in 1981 to integrate women into all phases of farming systems (Johnson, 1982). Rural women around the world have been called invisible laborers (Gross, 1982). Several reasons have been cited for this invisibility. First, are stereotypes which view women as economically inactive. "Essentially, in this view, women don't 'work'; or if they do, they shouldn't" (Tinker, 1979). For example, a 1977 draft of an AID agricultural policy paper suggested that one measure of development could be a reduction of the number of women working in the fields (Tinker, 1979). Terminology such as "productive" to describe women's market value and "non-productive" for use-value work also has perpetuated the myth of women's economic inactivity (Zeidenstein, 1979). Similarly, in rural extension, the farm household, the traditional domain of the woman, has been seen as the "consumption" unit; the farm firm as the "production" unit.

Not only do stereotypes shroud the labor of rural women, but national statistics also contribute to their invisibility. The statistics reflect only the activities of the modern cash economy. For example, data in Africa have shown that only 5% of women work, whereas in reality 60-80% of the subsistence agricultural labor is done by women. This is uncounted work, as it falls outside the modern sector (Tinker, 1979). According to the United States census, only 5% of farmers are women. The census allows for only one individual to be named primary farm operator. Generally the man of the farm is named (Kalbacher, 1981). Nevertheless, in a national survey by the USDA of women on farms, 55% of the women answered affirmatively the question "Do you consider yourself one of the primary operators" (Jones and Rosenfeld, 1981 [emphasis supplied]).

The invisibility of rural women is so complete that often researchers, policy makers, and practitioners must be convinced of their productive worth. As Sondra Zeidenstein (1979) notes,

> It is astonishing that the fact of women's participation in agriculture--one of the most obvious phenomena of rural life--has to be proved in almost every country and then the nature of this participation analyzed and its value measured.

In order to better address needs arising from the actual work of the limited resource farm families, and thereby to assure rural women visibility, in the Southwest Virginia FSR/E project, the technician team sought to provide women with agricultural as well as home economics skills. Therefore, the multidisciplinary FSR/E team at the University worked with both the agriculture and home economics Extension agents and the newly formed agri-home economics technician team.

The structural difficulties in superimposing such an approach on the existing Cooperative Extension structure became readily apparent. There are three major components to the Cooperative Extension structure in Virginia: the land grant universities,[1] the field Extension Units, and the clientele. This structure is further divided by subject matter into agriculture, home economics, community resource development, and 4-H. In this project only agriculture and home economics were involved (Figure 2). Therefore, in the agricultural sector, the University provides research to and by specialists, who transmit the research to the Extension agents and the agricultural technicians in the field. The Extension agricultural personnel serve their clientele, the local farms, and, specifically, in the case of the agricultural technicians, limited resource farms. In turn, farmers provide feedback to both Extension and the University. Both the clientele and personnel of agricultural Extension in Southwest Virginia are primarily male. The home economics structure is similar to that of agriculture but with the difference that its personnel and clientele are primarily women. The existing structure, therefore, provides women predominately with home economics skills which focus on consumption (A Force for Families, 1984). The home economics stream also is primarily directed to townspeople. Communication between the agriculture and home economics Extension agents appeared to be weak.

Given this existing structure, we superimposed a modification that attempted to extend FSR/E methodology to the Extension unit in the field (Figure 3). The two major conflicts between FSR/E methodology and the structure of Extension were the team approach demanded by FSR/E to which

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[1]In Virginia there are two land grant universities, the historically black 1890 school, Virginia State University, and the historically white 1862 school, Virginia Tech. Although the two universities are now collaborating closely in a new domestic FSR/E project, the project here described was conducted by Virginia Tech.

Extension is unaccustomed and the differences in the project cycles of FSR/E and Extension.

The project was based on the assumption that agriculture and home economics units within Extension worked closely together. This was the basic premise of the "agri-home economics" team. However, many incidents proved this assumption faulty.

First, at the Extension field level, in the County Unit, the home management technician of the "agri-home economics" team was supervised by the Unit home economics extension agent. The agent had expectations as to the new technician's job content based on her on-going programs which emphasized consumption issues with middle class women. However, the new technician was expected by the FSR/E project team to work with the agriculture technicians housed under the Unit agriculture Extension agent with limited resource farm families. In the end, the FSR/E project team concluded that if a similar "agri-home economics" team were established in a different Extension Unit, the whole team should be under one chain of command, from either the agriculture or home economics agent, depending on the local situation.

Another difficulty with the team approach was that some Extension personnel questioned the value of combining agriculture and home economics skills in one position. They saw FSR/E as a return back from the specialization approach of recent years to an earlier, more generalist approach of the Farm and Home Development (F&HD) Program of the 1950's. Their perceptions thus corresponded with Johnson (1982), who saw F&HD as having important parallels with FSR/E.

Gender related role expectations in the local culture also limited the flow of agri-home economics information. While it was acceptable for the female home management technician to provide agricultural information to both men and women, the male agricultural technicians had little interest in providing home economics information to either men or women (Figure 4).

The merging of the agricultural production focus of traditional FSR/E with the special focus of this project on the household and the farm woman was also sometimes confusing to Extension field staff. Agricultural Extension staff are strongly production and income generation oriented, while home economics Extension staff are family and consumption oriented. The focus on the woman, the traditional clientele of home economics, as an agricultural producer cut across both traditional domains in a new way.

INSTITUTIONAL ISSUES IN THE DESIGN AND TESTING OF THE FARMING SYSTEMS INTERVENTION: FSR/E AND THE EXTENSION PROGRAM CYCLE

Not only, however, was the team approach at odds with the structure of Extension at the Unit level, but also the interaction of the University and Extension personnel within the project cycle of FSR/E differed from the interaction of University and Extension personnel in the cycle of the development of a new Extension program.

Figure 5 shows the relationship of the development of the farming systems intervention to the program cycle of Extension. The sequence of stages in the development of a new Extension educational program are shown in the inner ring, and the stages of diagnosis, design, testing, and extension of the farming systems intervention are shown in the outer ring.

In most Extension educational programs (the inner ring), program development begins at the local level, and campus-based specialists are brought in as resource persons at the request of the Unit to assist in designing implementation of programs for problems identified by Extension field staff. Specialists are usually not involved in problem identification for program development, and their involvement in field implementation is decreasing.

In contrast, in this FSR/E project, campus based specialists were involved in program development from the beginning, including the sondeo, follow up studies, and initial goal setting discussions in the diagnostic stage (outer ring). FSR/E involvement of specialists in the diagnostic stage contrasts with the lesser role of specialists in the program development stage of the Extension cycle. This was sometimes seen as an unexpected intrusion by the specialists into the traditional domain of locally-based Extension.

In addition, as educators, specialists are being encouraged to train Extension field staff in area wide meetings, and minimize one-on-one contact with farm family clientele in implementation, in order to reduce costs in an era of tight budgets. The FSR/E specialist team took the position, however, that carefully targeted one-on-one contact in design and testing is essential, not so much for the specialist as a direct educator of farm families, but more critically for the specialists as learners.

In this FSR/E project, the farming systems intervention involved adapting existing tobacco transplanting technology and equipment to high density broccoli production and using old milk coolers for removal of field heat of broccoli for market sale, combines with freezing and meal preparation of broccoli not marketed. Specialists, the agri-home economics technician team, and participating family members all worked together.

This carefully targeted one-on-one learning by the specialists was necessary for the specialists to adapt production and cooling principles to local equipment and practices. This made the specialists better educators because they were able to present principles in a follow up area wide meeting that extended the results of the farming systems testing in a way that built better on local circumstances. Extension field staff questioned, however, whether adequate funds were available to make this approach sustainable. In other words, specialists' involvement in the FSR/E project was both longer in duration, beginning from program development, and greater in intensity, including direct one-on-one contact in design and testing, than specialist involvement in many Extension programs.

One result of this in terms of the structure presented in Figure 3 was that strong ties developed between the specialists on the one hand, and the farm family members and the technicians on the other hand. This was a positive development, serving to increase specialists' understanding of local conditions, while at the same time making farm family members and technicians feel that specialists were more assessible and their skills more relevant. However, a negative result was a feeling of being threatened on the part of the Unit agents. The FSR/E project empowered the technicians and gave greater recognition to their role. One of the agents in the Unit asked if FSR/E implied fewer agents and more technicians.

Targeted one-on-one contact by specialists with farm family members can also help specialists provide field based Extension staff with more relevant on-farm trial design and analysis skills. To design and analyze on-farm trials in large enough numbers to apply the environmental index (Hildebrand, 1983a) or analysis of variance across farms (Hammerton and Lauckner, 1984) requires different skills than those used in designing and conducting simple, single location demonstrations. Initially, the design of on-farm trials may be dependent on campus based specialists' skills. Execution, however, cannot depend on campus based specialists. Campus based specialists have other instructional and administrative responsibilities which may preclude their travel at key times in experiments, and declining travel budgets limit their mobility also. As Lightfoot (1984) pointed out in his paper at the 1983 Farming Systems symposium, however, execution of trials based on specialists' schedules defeats the very objectives of placing the trials on farm. Close interaction of farm family members, campus based specialists, and field based Extension personnel in implementation, therefore, again has the objective that specialists first become learners. As campus based specialists learn how field based Extension staff work with farm family members in executing trials, the specialists can become better trainers of Extension field staff in on-farm trial design and analysis skills.

CONCLUSIONS

FSR/E, through the sondeo and the on-farm trial, has sought to reduce time needed for the generation and acceptance of new technology. In FSR/E, a distinction has been made between project and program modes (Shaner et al., 1982; S. Poats, remarks made at The Gambia/West Africa Farming Systems workshop, March, 1984). The objective of reduced time is appropriate in the project mode, but in the program mode, to institutionalize the FSR/E approach may require increased time. One conclusion of this FSR/E project was that more time needs to be built in up front for team building between Extension agents and FSR/E project specialists, by involving Extension agents in design and execution of the on-farm trials.

Another conclusion of this FSR/E project is that it introduced too many institutional changes at once. Not only did the project introduce changes in specialist involvement in the program cycle of Extension associated with the farming systems intervention, but it also introduced structural changes at the Unit level associated with the institutional intervention.

In retrospect, although we would judge that the structural changes were justified by the multiplicity of family member roles revealed in the diagnostic stage, from the standpoint of institutional change, they perhaps should have been introduced after one or two years of first introducing the changes in the program cycle due to the sondeo and on-farm trials.

The institutional changes associated with on-farm trials are changes that focus on agricultural production. Those institutional changes, therefore, would have been easier for agricultural Extension field staff to accept initially. Then, through their involvement with the FSR/E specialist team in the diagnostic and on-farm trial work, the agricultural Extension field staff might have gradually come to recognize on their own accord the need for greater integration of the family perspective in their programs for limited resource farms. At that point, the impetus for structural change in the interaction of agricultural and home economics Extension field staff might come more from within, and be viewed institutionally less as an "intervention" from "outside."

The FSR/E literature indicates that, in working with farmers, it is necessary to introduce change incrementally, moving step by step up the learning curve presented at the 1982 Symposium (Hildebrand, 1982, 1983b). In the program mode, the major objectives are not only generation of agricultural technology to meet currently identified problems, but also a more fundamental strengthening of the capability of research and extension institutions to identify and address future problems. To achieve the latter objective, in introducing institutional change, FSR/E practitioners may need to think of an institutional learning curve, that FSR/E projects move up in a similar step by step, incremental process.

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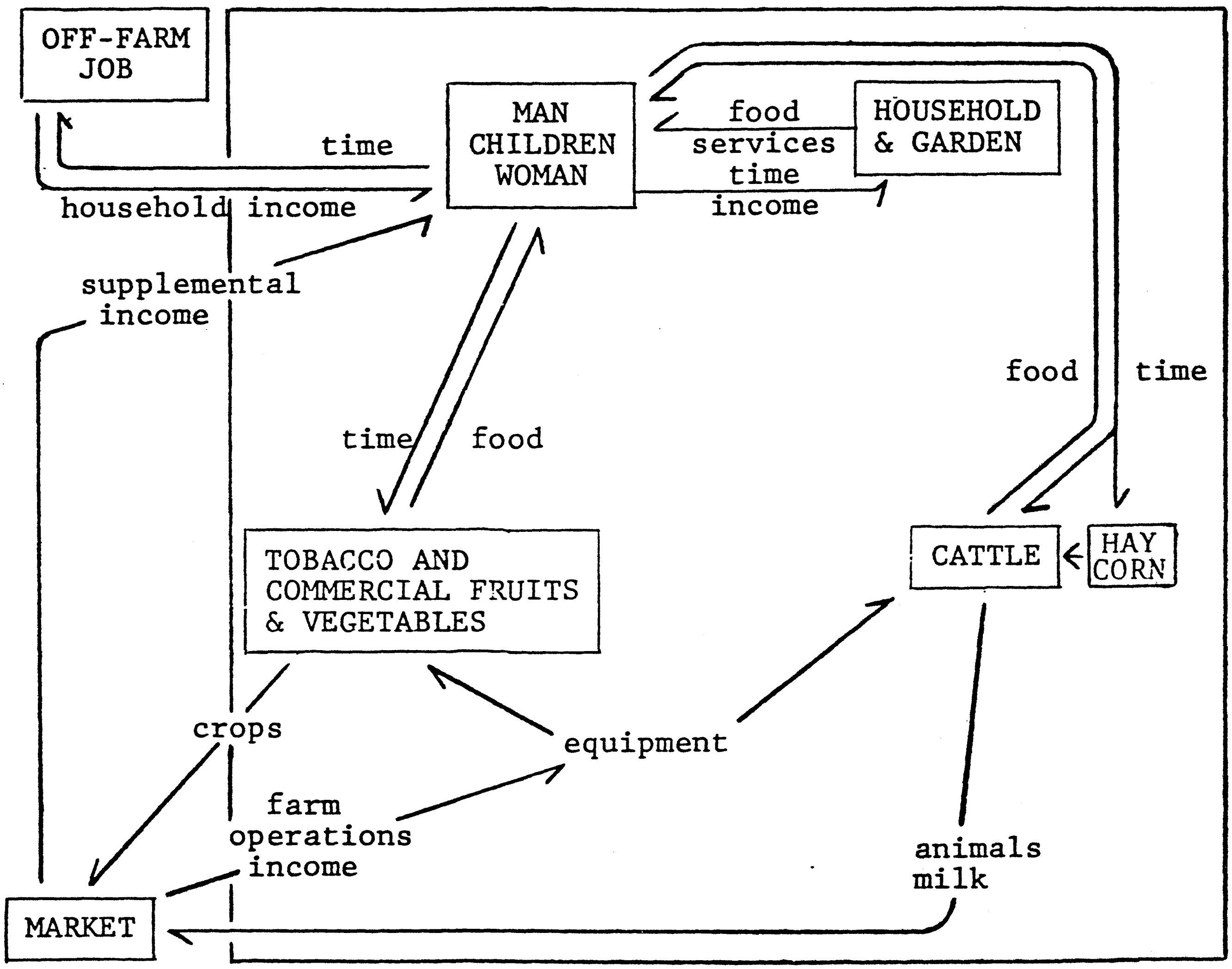


Figure 1. Model of a mixed crop-livestock farming system in Southwest Virginia [after Caldwell et al. (1983) and Teo (1982)].

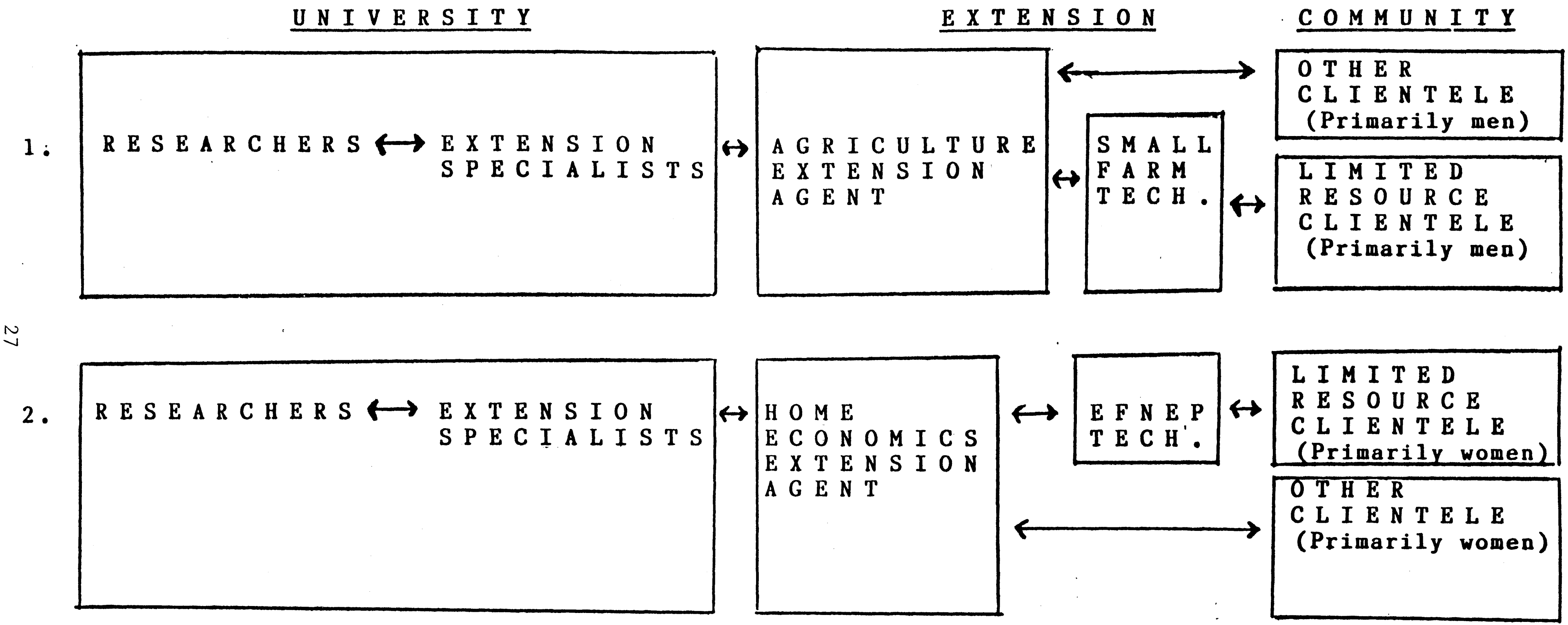


Figure 2: The Institutional Structure of the Extension Service in Virginia

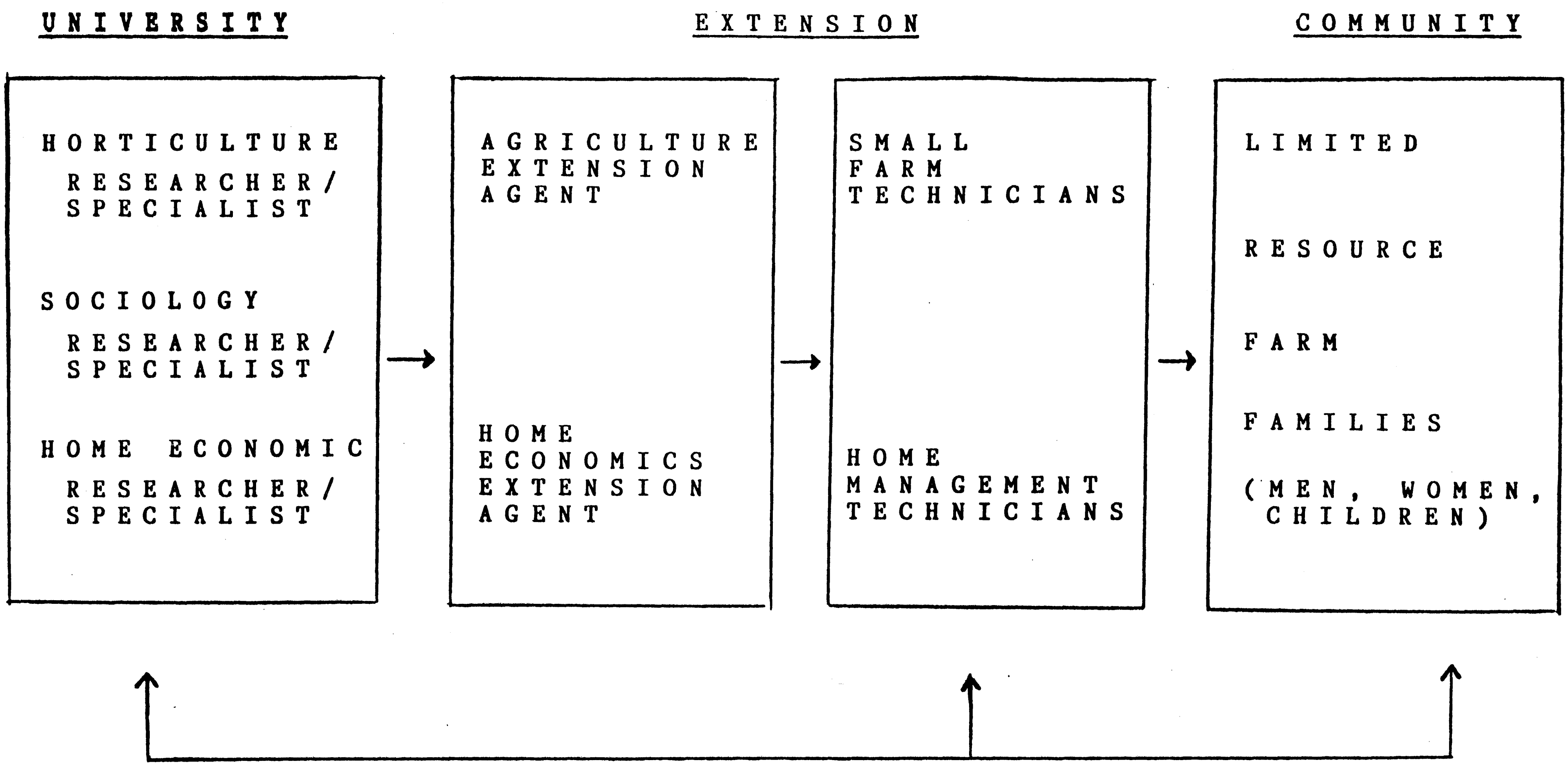
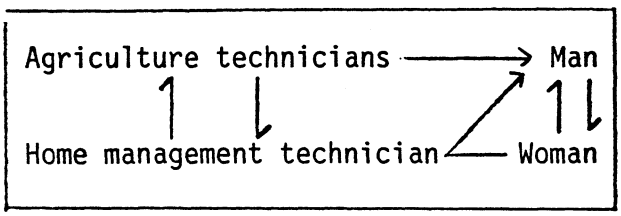
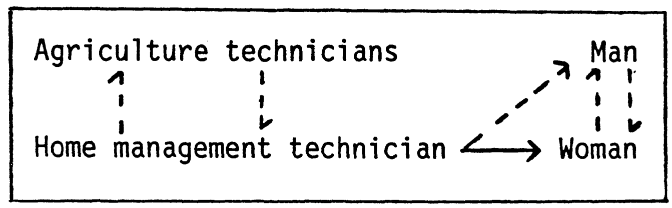


Figure 3: The Structure of the Southwest Virginia Farming Systems Project.



(4a)



(4b)

Figure 4: Agricultural (4a) and home economics (4b) information flow among technician team and farm family members.[z]

[z] Strong flow in solid lines.
Weak flows in broken lines.

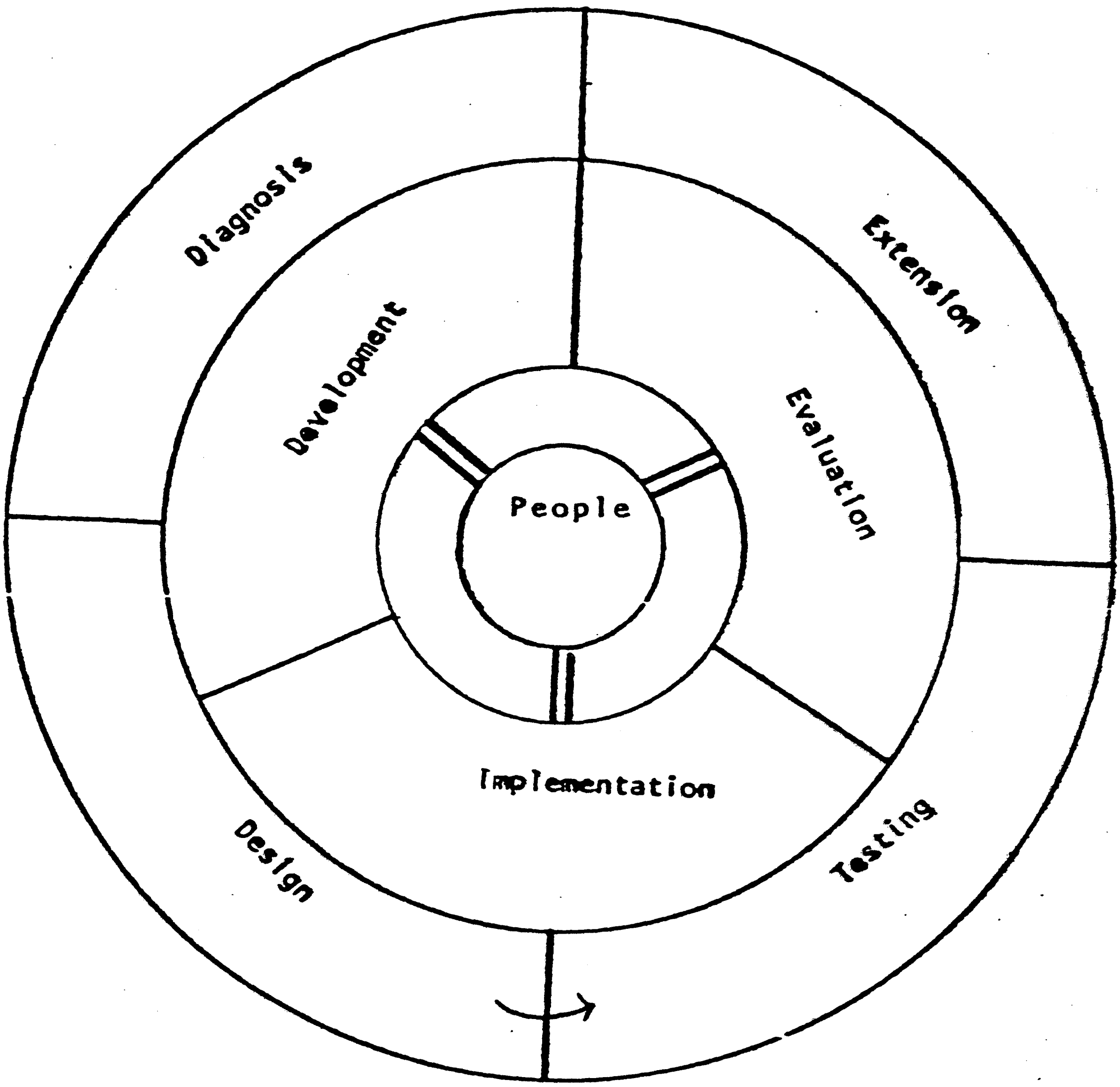


Figure 5: The program cycle of FSR/E (outer ring) superimposed on the program cycle of Extension (inner ring).

APPLICATION OF THE FSR&D APPROACH TO DOMESTIC AGRICULTURE: SOME LESSONS AND QUESTIONS FROM HAWAII

By

Harold J. McArthur, Jr.

The College of Tropical Agriculture and Human Resources has been involved in farming systems research for over six years. Our interest in the domestic application of the FSR&D approach to agricultural development emerged from a growing awareness of numerous similarities between the basic operating conditions and constraints of small farmers in Hawaii and those in many parts of rural Asia.

Historically, Hawaii's economy was based on the production of two export crops--sugar and pineapple, a situation similar to that found in many developing nations. The majority of Hawaii's small farmers, like those in many parts of the tropics, farm marginal lands not suitable for plantation use. Many of them rent the land they cultivate. They are dependent on costly imported equipment and agricultural inputs. Most have little control over market conditions and find themselves in competition with foreign and Mainland producers.

As part of our plan to assess the applicability of FSR&D in Hawaii, a group of 20 faculty from 11 disciplines and extension were trained in the basic principles and methods of farming systems. As part of the year-long training program (conducted in Fall, 1981 and Spring and Summer, 1982) this group was divided into teams that conducted a sondeo or rapid reconnaisance survey in two farming communities in Hawaii, one on the Waianae Coast of the Island of Oahu, and the other along the Hilo Coast of the Island of Hawaii.

What is important for the purposes of this discussion is not the specific data that was generated in each of these studies but the process and the aspects of the FSR&D approach that were applied. I will summarize the process by briefly addressing each of five key issues: Farmer participation, Recommendation domains, Research constraints, Interdisciplinary coordination and Institutionalization.

Farmer Participation

A representative farmer from each community met with the teams during a two-day retreat before they went into the field. In both cases initial assumptions and strategies were changed based on information provided by the farmer consultants. All members of the team participated in four days of intensive farmer interviews following a modified sondeo approach.[1]

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[1]Team members interviewed farmers in groups of two. The paring was changed twice daily so that each member worked with every person on the team.

This exercise generated a rich body of farmer-based knowledge that demonstrated the inapplicability of many of the recommendations that the agricultural researchers expected to make. For example, it was assumed that the key constraint of the independent sugar growers on the Hilo coast was a cost of production that was higher than the current world market price for sugar. The logical solution, if production costs could not be reduced, would be to switch to an alternative crop. Considerable thought was given by the researchers to the kinds of crops that would be agronomically suitable, economically feasible and socially acceptable to the local farmers as a replacement for sugar. It was not until the sondeo interviews were conducted that the team learned that the majority of the independent sugar farmers were operating on lands leased from the plantation under agreements that required them to grow only sugarcane. Even those who owned or had access to fee simple land were often constrained from immediately converting to another crop. Such factors as the assigned harvest schedule, State agricultural loans and location of fields often prevented farmers from doing something else. A person who had just planted and was assigned a 36-month growing period by the co-op would have to wait 3 years before any changes could be made. If the farmer carried a high debt load in low-interest State agricultural loans, he might be forced to stay in agriculture, rather than get out. And finally, a person might be prevented from growing an alternative crop, such as ginger, if his or her land was adjacent to an active cane field. When cane is sprayed and particularly, when it is burned prior to harvest, there is often damage to adjacent crops. These examples are illustrative of a list of factors that tended to negate most of the ideas that the faculty had hoped to generate into research projects.

Recommendation Domains

Perhaps the most important finding from the perspective of farming systems methodology was the lack of truly homogeneous farming communities in Hawaii. The FSR approach assumes the existence of a recommendation domain that consists of a number of population centers or groups of farmers occupying the same agro-climatic zone and sharing similar cropping patterns and factors of production. If this holds, then the recommendations that are developed from work in one community or district should be readily transferable to all other communities within the same or similar domains.

In Hawaii there are few farming communities such as may be found on the mainland, where the majority of individuals are engaged in similar agricultural production under similar physical, economic, and social conditions. Rather, we have a number of rural residential centers that become the focus of a wide range of activities -- backyard gardening, recreational pursuits, commercial farming, and small business operation. Even in the agricultural sector, the range of systems found in a given area can be quite broad. No two communities are the same in terms of their population structure or agricultural base. Certain areas are known for the production of particular crops such as vegetables, onions, and flowers in the Kula area of Maui. Similar vegetable farms, however, are also found in the Waimanalo and Waianae areas of Oahu where environmental conditions and marketing constraints are quite different.

It is possible to divide each of these rural residential units into subareas that are relatively homogeneous and can be referred to as Target Areas (Shanner, Philipp & Schmehl, 1981) or Recommendation Domains (Byerlee, Collinson, et al., 1980). Such groupings of farmers would be generally similar in terms of their farming practices and the various natural (rainfall, soil, temperature) and socio-economic (farm size, availability of resources and labor, etc.) conditions that influence their operations.

In Hawaii, the problem becomes one of scale and transferability. The independent sugarcane growers on the Hilo coast of the island of Hawaii, for example, constitute a rather homogeneous group in terms of the above criteria. However, they constitute a population of less than 100. It would be possible to focus research upon this group but the recommendations from such an effort would not be transferable to a larger recommendation domain defined by similar characteristics.

The question is one of size. What is the minimum critical number of potential clients to justify an intensive micro-level farming systems research effort? The answer to this question will vary, of course, from place to place. In Hawaii, the lack of sizeable populations of farmers producing the same crops under similar physical, environmental and socio-economic conditions make it difficult to justify the use of the farming systems approach as it is commonly employed in many developing countries.

It may be that for Hawaii and other areas characterized by many micro-sized research areas that a focus on common problems rather than area attributes may be more useful as a means to define recommendation domains. The basic research would be done on the general problem with the full recognition that the specific recommendations would have to be adapted to meet the varying environmental and socio-economic conditions of the different subareas. One of the key criteria for selection of the problem areas for research attention would be the size of the population that would ultimately benefit from the research. In a developing country where subsistance level farmers who are operating under similar sets of constraints number in the thousands this is not a problem. In areas characterized by small and extremely diverse agricultural populations the issue is extremely important.

Research Constraints

One of the key discoveries from the community-based surveys was that most of the problems farmers identified were not agricultural in nature. The issues that concerned them most dealt with such factors such as cost of land, lease conditions, marketing constraints, cost of inputs and labor. The real need is for work in the area of farming systems infrastructure and policy or FSIP, rather than on improving local farm systems. I wonder to what degree FSR&D projects in other states and countries have found similar situations. There is no question that such needs are real. The problem is that such concerns are not regularly dealt with in colleges of agriculture, except perhaps to a limited degree by agricultural economists. How does one maintain the farmer-based aspect of FSR when dealing with these kinds of issues. Does work on water use regulations, zoning, and agricultural policy planning qualify as farming systems when it involves primarily urban and regional planners, economists and possibly political scientists?

Although increasing mention is now being given to FSIP and the role of extension in FSR, there seems to be a tendency for most farming systems research programs to be dominantly agronomic in orientation. The assumption is that there are improvements that can be made in the indigeneous systems and that through an integrated research effort technologies can be developed that can be accepted and sustained by farmers.

In the case of Hawaii, the findings of both sondeos indicated that much of the need was more for information than new technology. This becomes an issue of extension and information dissemination rather than research.

Interdisciplinary Coordination

We encountered considerable difficulty in sustaining the necessary interdisciplanary interaction over a long period of time when faculty are constantly drawn and pulled from different directions by their university teaching and research assignments.

The final phase of the orientation consisted of a two-day retreat away from campus for the teams to make plans for the sondeo. At one point during this planning session all the particpants were asked to write down on a piece of paper what they perceived their contribution would be to the team objectives. They were then asked to do the same thing for each other person on their team. These impressions were then shared with the group to see how close the participants were in their perceptions of each other's contribution. Perhaps most significant was the distance between how researchers perceived the input of the extension personnel and their own contributions in their particular area of specialization -- cattle management, vegetable production, etc. The researchers, on the other hand, tended to see extension agents in a more facilitative role. These were the people who would help the team interact with the farmers. This exercise proved to be a useful technique in our efforts to facilitate interdisciplinary communication.

During the sondeo exercise, however, we experienced the true benefits of interdisciplinary communication. The team objective was to learn as much as possible about the needs and constraints in the community during the four day period. It mattered not that one was an agronomist, or a home economist, the goal was to learn about the clients we wished to serve.

During the sondeo the team members met at lunch and again at dinner to disucss the days' interviews and the kinds of topics and issues they needed to pursue in their discussions with farmers and community representatives. One indicator of the degree of interdisciplinary communication that occurred was the fact that if one had tape recorded the various interviews, it would have been impossible for an uninformed listener to determine the disciplinary backgrounds of many of the interviewers by hearing the tapes. Agronomists were asking questions about off-farm labor and cost of inputs and home economists were gathering data on use of fertilizer and pesticides. Weekly meetings back on campus, however, were not sufficient to sustain the same level of interdisciplinary synergy.

By its very structure of separate disciplinary departments, each serving multiple objectives and client groups, the American university is not set up to effectively manage and sustain a farming systems effort. Even if it were possible to designate faculty as full-time members of an FSR team for a designated period of time, I wonder if a problem would not still exist in matching the project objectives with the research interests and professional aspirations of the individual team members. I am becoming more and more convinced that we have reached a point in the development and implementation of FSR&D where dealing with human motivations and weaknesses is of equal, if not more, importance than the creation of a common research framework.

Institutionalization

We encountered this issue early on in the process of testing our assumptions about the local applicability of the FSR approach. The basic dilemma was that senior decision makers wanted to see demonstrated results that could be measured in terms of increased production and income generation, before committing themselves to major policy and organizational changes necessary for the institutionalization of FSR&D within the land-grant and state agricultural research and delivery system.

The faculty who were invited to participate in the farming systems forum and sondeo exercise freely gave of their time and effort out of a genuine interest in the idea of systems-focused research or just plain curiosity. For the most part, these people felt the program was beneficial and that the FSR&D approach might have promise if it could be applied to the problems of a specific community or district. These same people, however, were consistent in their feeling that without tacit approval and support in terms of time allocations and research funds, it would be extremely difficult to sustain staff interest and commitment.

The administration, recognizes these concerns, but is also faced with having to justify its research and extension programs in terms of a state agricultural plan and the college's mandate to promote and serve diversified commercial agriculture.

Although this discussion has focused on constraints, I do not wish to leave the impression that Hawaii has abandoned the farming systems approach. FSR&D has received its greatest acceptance at UH in the areas of instruction and international agricultural development. We have conducted several programs and now have a regular course in FSR&D concepts and methodology. This approach has also become a major focus of one of our overseas development projects. With respect to the domestic application of the approach we are in the process of assessing how some of the problems we identified can be overcome. Even though we are not able to initially develop the kind of farming systems research program we anticipated, the effort was by no means a failure. We learned a lot from the sondeo exercise about our small farm communities and now have a better understanding of the kinds of problems that can and cannot be addressed by FSR&D and what it really takes in terms of support, coordination and personal motivation to mount and sustain a truly interdisciplinary research effort.

Although my comments have focused on domestic application of farming systems, increasing evidence suggests that projects in developing countries are encountering similar constraints. Several farming systems and related research projects in Asia are having to deal with a high level of inter-domain variability. Data from our farming systems-focused soils management project in Indonesia suggest that farm-level variability may be one of the main reasons that farmers are still adopting only components or pieces of technological packages. We are hoping to learn from the international experience some new approaches to defining functional domains in areas of high variability. We would be most anxious to learn of any experiences you or your colleagues may have had in this and other aspects of FSR implementation.

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EXTENSION & FSR

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DEVELOPMENT OF EXTENSION PROGRAMS WITHIN THE CONTEXT OF FSR&E- THE CONSERVATION CROPPING CASE IN QUEENSLAND, AUSTRALIA

S. Chamala and K. J. Keith

INTRODUCTION

Current literature on FSR&E has emphasized the research process. Extension is implied or assumed to be comparatively easy once the relevant technology is developed. This assumption is contradicted by several studies on the adoption and diffusion process which suggest that extension of technology is not simple when a complex set of inter-related innovations are involved. Adoption studies on packages of improved practices show that they are never accepted as a total package. High selectivity of individual practices and adaptation of these recommendations occurs. To plan an effective extension program it is necessary to understand both the complexities of existing farming systems and the constraints and potentials of the extension network.

The adoption of conservation cropping in Queensland is an example of a complex farming systems change, in which an FSR&E data collection approach was used primarily to identify extension target groups and strategies. It became evident that research priorities could and should also be a product of this approach. The experience with conservation cropping in Queensland has also shown there is a significant development process intermediate between research and extension to try things out and get them working within the complex system.

It is proposed that the extension component needs to figure prominently as a primary objective along with the research and development programs at the information collection stage of FSR&E.

In this paper, a process used to identify socioeconomic factors and cropping practices to assist in extension planning is described. The uses of the process in identifying and overcoming constraints and in improving the cohesiveness of extension and research efforts are discussed. From this a revised model of the FSR&E process is developed which gives appropriate recognition to extension aspects of the process.

Although the importance of this process for extension has been highlighted through experiences in a developed country, it is considered that the process is needed wherever complex changes or a number of changes are involved. Conversely, although the need to use FSR&E to identify research goals first became evident in developing countries, successfully directed research requires it whenever complex system changes are involved.

ADOPTION OF CONSERVATION CROPPING IN QUEENSLAND

a) Research, Extension and Farmer Action before 1980:

Conservation cropping, often called conservation tillage, refers to a way of farming which emphasises long term productivity from the land resource, while recognizing the need for profitability in the short term. Conservation cropping involves the use of practices such as stubble mulching which retain soil cover and store moisture, reduced or zero tillage which minimizes disturbance and exposure of soil, the selection of suitable crops and crop rotations, and suitable use of fertilizers, pesticides and soil moisture in crop management.

Ninety percent of the 2.8m ha of cropping land in Queensland suffers from water erosion (sheet, rill, gully). Most of this land is used for dryland production of wheat and sorghum in areas where average rainfall is only moderate (500-800mm) but mostly comes in storms of variable frequency and high intensity. Intensive cropping of legumes, vegetables, fruit, and sugarcane takes place in generally higher rainfall areas (800-1500m), often on fairly steep slopes.

Because of the variable and often harsh climate farmers have tended to make the most of every opportunity to recoup earlier losses or to minimize future hardship. This has led to continued use of cropping systems which leave an exposed and pulverized soil open to heavy summer rainfall. Although this seriously endangers long term crop production, the introduction of a system which requires not only complex but often unclear changes in practices is not easy. While a few enthusiastic farmers and soil conservationists generated some awareness and evaluated machinery suitable for stubble mulching practices in the 1970's, progress was slow. However, in 1977, the Queensland Department of Primary Industries commenced "upstream" surface management research to provide some answers on the effectiveness of new cropping practices in reducing erosion and to look into potential problems.

Unlike the land grant college system, teaching, research, and extension are not in one organization. State departments conduct applied research and extension. Universities mainly provide teaching, training, and some research and the Commonwealth Scientific and Industrial Research Organization (CSIRO) is mainly involved in research. Cooperation and coordination between these institutions is based on individual initiatives. The joint socioeconomic research project described in this paper is an example of such collaboration between the state department and university.

The activities of the Queensland Department of Primary Industries are organized along disciplinary specialist lines, with fairly independent divisional organization, often containing separate research and extension branches. Hence, agronomic research and extension occur within the Division of Plant Industry, while soil conservation research and extension are separate branch functions within the Division of Land Utilization. Funds and programs tend to be administered separately unless definite steps are taken to ensure coordination.

The "surface management research" program was one such case. Research being undertaken includes: assessment of erosion and crop yields under different fallow management practices; determination of the effects of surface condition on infiltration; measurement of sediment concentrations under different field conditions; measurement of effect of the cover on evaporation and soil moisture, and development of a model integrating aspects of crop production, soil water and soil erosion in grainlands.

Although considerable general awareness had been generated through the media, little planned extension had been undertaken by 1980.

Some constraints to successful planned extension were:

- lack of clearly definable systems. Only in one agro-ecological area there was a neat package to promote. Elsewhere extension officers had little more than the principles that stubble gives soil cover, and that soil moisture improvements might be achievable with stubble.

- lack of knowledge by departmental officers on practical problems with the new approaches.

- a high workload of requests for advice on conventional systems of contour bank and waterway surveys (for soil conservationists) and crop husbandry advice (for extension agronomists).

- insufficient teamwork and concurrence on goals between extension staff from different specialist areas.

b) <u>Socioeconomic research to stimulate action in the Darling Downs Region</u>:

To find the answer to some of the problems facing extension officers and to understand why farmers are more responsive to commercial innovations (such as improved cultivars, machinery, fertilizers, pest, and disease control) and not so responsive to soil conservation methods (contour banks, waterways, stubble mulching, minimum or zero tillage, grass strips, and contour cultivation), a joint research project between the University of Queensland and Queensland Department of Primary Industries was initiated in 1980. The study also examined the farmers' exposure to various kinds of innovations and their attitude to adoption of various practices. (Chamala et al. 1982.)

This was followed in 1982 by a closer examination of one homogeneous area - the Eastern Uplands of the Darling Downs where the erosion problem was more severe and adoption of agronomic soil conservation methods was slow. The joint project's objectives were formulated by the research team and senior administrators but the regional and district field officers specified the focus on farmers' cultivation practices and patterns of fallowing croplands. The aim was to have a more successful planned extension program and this involved intervention into staff and organizational matters as well as farmers' practices, attitudes, and knowledge.

A brief description of the study area will provide the situational context to appreciate the study.

The Darling Downs region as a whole covers some 700,000 ha with about 7500 farms on fertile, but erodible black self mulching clays. A large low sloping alluvial plain area experiences erosive flooding, while severe soil erosion occurs on the cropped uplands areas. The project under discussion concentrated on the eastern uplands area where cropped land has slopes generally ranging from 2-12% and both deep and shallow soils. Severe summer storms occur inflicting serious damage on areas of bare soil. The area sustains a wide range of summer and winter crops and also supports dairy and beef enterprises.

The joint project process involved: (a) meetings at field and head office to clarify goals; (b) preparation and carrying out of a farmer survey using a team approach; (c) a survey of extension staff; (d) a workshop to consider information collected and look at targets and strategies; and (e) a meeting of regional project leaders with their head office supervisors to discuss priorities and resources. The full process is illustrated in Figure 1.

The problem identification phase from goal clarification, through the preparation, conduct and analysis of surveys, to resources negotiation took just over three months, culminating in the June 1982 workshop.

Soon after the workshop and management meetings, district teams of extension agronomists and soil conservationists planned initial extension approaches. Pilot trials were set up and information collection continued. Team members participated in 'hands-on' training workshops to improve skills in handling new farm equipment.

Follow-up meetings with head office management helped to generate organizational support for inter-branch coordination and necessary funds for training activities for field officers. Management also provided funds for developing and testing a Conservation Cropping Information Package. Here again, the research team which developed the package included field extension personnel as well as the original coordinators of the joint project, departmental and university personnel. The information package consisted of two video programs, one pamphlet, and an extension officers' guide. The guide provided a conceptual framework of conservation cropping practices, extension principles, and practical strategies in targeting the audience and using the videos in group situations. This package was pretested using market research methodology in which field extension workers, farmers, and high school students were involved in its evaluation. (The entire package was modified, including re-editing of the videos, incorporating major suggestions of all these respondents. (Chamala et al. 1984, a, b & c.) This was followed by training workshops to familiarize field staff with the package for inclusion in their extension planning and implementation.

c) <u>Development and Extension in Other Parts of Queensland</u>

Conservation cropping programs developed in two other agricultural areas; viz. South Burnett region and Central Highlands in Queensland used some FSR&E processes in a less deliberate manner. They suggest that tne FSR&E process is appropriate for intensive and mixed farming situations but less relevant for broadacre restricted enterprise situations. One case is worth mentioning here.

<u>South Burnett region</u>:

The South Burnett area of about 1300 farms contains about 150,000 ha of red friable soils used mainly for peanuts and other summer crops. About 100,000 ha has been protected by contour banks but additional conservation measures are needed. A suitable cropping system has been developed and extension is taking place through demonstration farms. The development involved a great deal of farmer cooperation with most of the development taking place on two pilot farms on a subcommercial then commercial scale after preliminary trials on an experiment station.

Many features of the FSR&E system presented by Norman (1982) can be seen in the following framework (Figure 2) drawn up following the South Burnett experience to illustrate the very significant "development" component (as distinct from pure research or extension) in getting a new cropping system on the ground.

Apart from its heavy detailing of the development component, the process illustrates that useful extension can usually take place even before the system is fully developed. The Burnett case was fortunate in that, because of the homogeneity of the area and limited cropping options, a neat system could be tested. The greater range of enterprises and diverse cropping choices on the Darling Downs produced a very complex situation making it difficult to draw up and test straight forward systems.

d) <u>Linkage with FSR&E</u>:

To what extent does the process described mesh with Farming Systems Research and Extension?

In Shaner et al. (1982), F.S.R. & E. is summarized as being "farmer based, problem solving, comprehensive, interdisciplinary, complementary, iterative, dynamic, and responsible to society".

These qualities are found in Queensland's conservation cropping program in the following ways:

- <u>farmer based</u> in that (a) innovative farmers were influential in acquiring suitable stubble handling machinery for evaluation in the early 1970's; (b) most development work has taken place on farms rather than research stations, with the interested cooperation of innovative farmers; (c) farmer- based information has been sought throughout the extension planning process described earlier.

- <u>problem solving</u> in that (a) it was focussed on farmers' tillage practices during different fallows and its relationship to soil erosion problems; (b) it examined the constraints of extension personnel in embarking on planned extension activities on conservation cropping; (c) the approach used in development trials has been to make a start in cooperation with farmers and handle problems as they arise rather than waiting for a complete package to be developed.

- <u>interdisciplinary</u> in that technical research and development involves agronomists, soil physicists, soil conservationists, biologists, agricultural engineers, and economists; while teamwork between extension agronomists, soil conservationists, machinery advisers, and economists, together with rural sociologists and extension educationists, was essential in preparing extension programs. Agronomists and sales representatives from chemical companies, and engineers from local machinery firms also have significant roles in the development and promotion of practices and equipment in Queensland.

- <u>complementary</u> in that a tertiary institution and government agency acted jointly in contributing skills from various disciplines. The collaboration between teaching or training institutions and the government agriculture department will make training more practical and inject fresh thinking into field extension and research work.

- <u>iterative</u> in that extension officers recognize the need to enable farmers to move a step at a time towards adequate conservation cropping practices in accord with resources available to them and the extent to which technology is known.

- <u>dynamic</u> in that the development of technology and the relative operating costs of chemicals and fuel are very mobile, with a potential to alter in ways that could make large changes acceptable of new practices.

- <u>responsible to society</u> in that a basic premise of the conservation cropping program is that land should be protected for future productive use.

There are some ways in which the conservation cropping program to date falls short of the FSR&E model. Although livestock enterprises have been encountered in the study, the emphasis has been on the cropping component because it is the area where the erosion problem is most significant. In areas almost entirely devoted to cropping, the approach could be considered comprehensive. In other districts, where livestock enterprises are significant, a broader conservation farming perspective needs to be taken to enable the comprehensive view of the whole farm as required by Norman (1982).

The 'Eastern Downs' case we have described has used many elements of the FSR&E approach. Some differences between this case and most applications of FSR&E are:

- Although usually family based, Queensland's agriculture involves high capital inputs and mechanization compared with developing countries where it has usually been applied. Queensland farmers also probably have more opportunity to voice their needs through formal and informal systems than farmers in many countries. Grower associations such as the Queensland Graingrowers Association, the Queensland Dairymen's Organization, the Fruit and Vegetable Growers Association and the Cattlemen's Union act as a voice for farmers who are interested in being heard. Advisory committees on soil conservation, and on agricultural research also exist. Landowners also have reasonably direct access to politicians in the case of any strong complaint.

- Changes in the interests of long term productivity are being attempted, as distinct from the priority in many programs for changes in farming systems which increase short term productivity.

- The process was primarily introduced to give direction to the extension program, whereas other programs have concentrated on its benefits to directing research. This obverse view highlights its value for both research and the extension which is conducted in parallel with ongoing research.

IMPLICATIONS FOR THE PLACE OF EXTENSION IN THE FSR&E FRAMEWORK

Some implications which can be drawn from the Queensland conservation cropping studies to show how the extension and development components can be better represented in the FSR&E framework are that:

- Detailed farming practices information for the whole farming system (including social aspects of the farm family) is useful in delineating target groups (based on their resources, knowledge gaps, and attitudes) for extension of improved systems as well as for designing them.

- Extension goes on in parallel with research. It does not wait until researchers and developers have tried and proved a neat package for each domain.

- Difficiencies in organizational cooperation and the motivation and competence of extension agency staff are very real factors in the implementation of farming systems changes.

- The diverse nature of rural industry means that innovative developments and extension "research" (socioeconomic studies) may need to be conducted by extension workers who are cut off from proximity to researchers in experiment stations. This calls for a high level of practical and scientific skills.

Figure 3 is an amended version of the Shaner et al. (1982) FSR&E model.

The major addition to Shaner's model is in expanding the extension collaboration which was nominally shown in the original model.

The following points may be worth noting:

1. In the first phase, extension activities, like research, should start in defining the target areas through situation analysis of farming systems and communities. Hence, defining extension targets should be an integral part of the first activity shown in Shaner's model. In the figure 3, 'Target Area Identification' (Stage 1) is shown as a common stage for both extension and research cycle and in practice this should be one joint or integrated activity directed at both programs.

   The number of research stations involved in on-farm research in a region is understandably limited, whereas extension planning and implementation occurs in every part of the country. Therefore, extension situational analysis results could be combined and fed back to research stations.

2. Similarly, in the second phase, problem identification needs to focus on both research and extension aspects. It requires a multidisciplinary team which should include both research and extension expertise.

   Extension and management also need a systematic investigation involving the social sciences (rural sociologists, management specialists, extension educationalists).

   Organizational limitations such as staff training needs, information support to field extension staff, potentials for inter-branch coordination, staff motivation, and supervision needs to be identified.

3. In the third phase of activities, just as planning on-farm research calls for elaborate organization of data, inputs, locations, and personnel, so planning extension strategies also relies on knowing:

   (i) Farm-based problems which can be resolved by extension of current knowledge;
   (ii) Farm-based problems which can only be rectified by extension after some research;
   (iii) Some organizational constraints which cannot be removed and some approaches will not be feasible;
   (iv) Some organizational limitations which can be rectified and must be attended to before the extension strategy is implemented.

4. In the fourth phase is administration of extension for effective delivery of inputs and information. This may call for coordination with commercial agencies, extension services, farmers organizations, and other groups.

   New or improved methods or packages are developed as the body of knowledge improves due to on-farm and off-farm research. Any new extension strategies or information packages need to be pretested using social science methods.

5. The final implementation of extension strategies draws information and knowledge from all three processes the extension and management process, the on-farm research process, and the research station results.

Issues for Discussion:

1. Should extension personnel be actively involved in technical and socioeconomic research?

2. Can the needs of extension and research programs be served by the same problem identification process?

3. How should demonstrations be linked to on-farm research trials?

4. What are the appropriate training facilities required to upgrade extension to take on new roles?

5. To what extent should extension personnel be recognized and rewarded in implementing these new roles?

6. Should universities and agricultural training institutes be involved in research into the transfer of technology phase?

7. Who should monitor the performance of research and extension?

8. How can inter-departmental or branch linkages and inter-institutional linkages be resolved to achieve a better standard of life for farmers?

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THE EASTERN UPLANDS SCENE : 1981

LAND
Continuing erosion under traditional methods but capable of diverse crops and enterprises

ECONOMICS
Cost-price squeeze hits small-scale farmer

FARMERS
Unresponsive to change without quick profit

RESEARCH & DEVELOPERS
Some progress with :
. macro parameters
. machinery develop't
. cropping technique

EXTENSION WORKERS
Needing :
. conviction
. competence
. time
. teamwork

Inter-institutional/interdisciplinary project to :

A. Clarify the problem: i.e. how to :
. define targets & strategies for extension
. define research and resources needed
. find a way round organizational/institutional constraints.

B. Decide on Social Research Methods and Initiate

STAFF SURVEY (April 1982)

Objectives Clarify views on :
. why farmers are not adopting
. problems preventing team extension
. their own goals and abilities.

Method
. Extension training specialist administers questionnaire
. Data from 29 agriculture and soil conservation officers analysed

FARMER SURVEY (Mar - May 1982)

Objectives Information on farms and farmers':
. cropping practices and rationale
. perceptions (attitudes to erosion)
. personal characteristics
. resources & sources of information

Method - Research team, with field staff :
. clarifies objectives
. prepares questionnaire
. interviews 106 farmers
. analyses and collates results

I N P U T

I N P U T

W O R K S H O P (JUNE 1982) (Diagnosis & Planning) involving
. research team
. other affected regional field co-workers
.field officers involved in surveys
. R & D representatives

O U T C O M E S

Open concern at lack of skills

Hands-on machinery training 1982/83

Request for firmer H.O. support and resources

(June 1982) Meeting with H.O. on priorities & resources

Endorsement of funds promised

Better Understanding of farm situations

Better team work

Willingness to work in district teams on targets.

Request for information support.

PROJECT TEAM TO DEVELOP PACKAGE

Market Research field staff & farmer involvement in package preparation testing (1983)

EXTENSION PACKAGE
Videos, pamphlets, Extension guide.

Specific Extension Planning

. Pilot trials set up. (Farm-level development) & demonstration
. Continuation of information seeking at local level

W O R K S H O P (April 1984) involving :
. District and regional field staff
. H.O. presentatives
. Project team (Research & Information package development)
. Research and Development representatives (Departmental and commercial

Discussion on Extension methods

Review of extension progress

Update on research and development

Feedback on further training needs

Familiarization with information package

FIGURE 1 Flow diagram of socio-economic Research & Extension Process Eastern Darling Downs.

A FRAMEWORK TO FACILITATE THE ADOPTION OF
CHANGE TO FARMING SYSTEMS

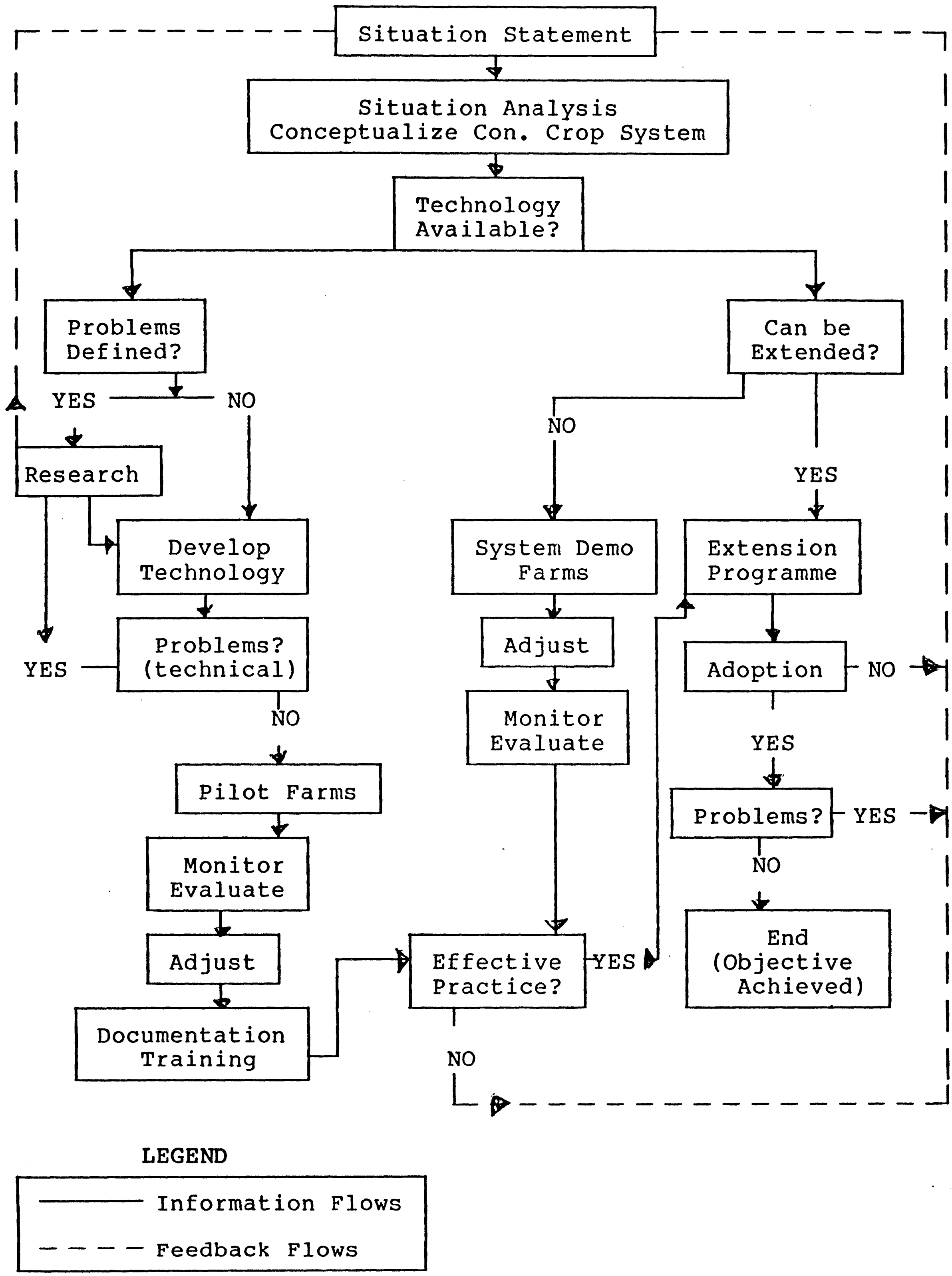

FIG. 2 From Bateman, R.J., (1984)
<u>The Development Process - a Framework to Bring About Change in Farming Systems</u>

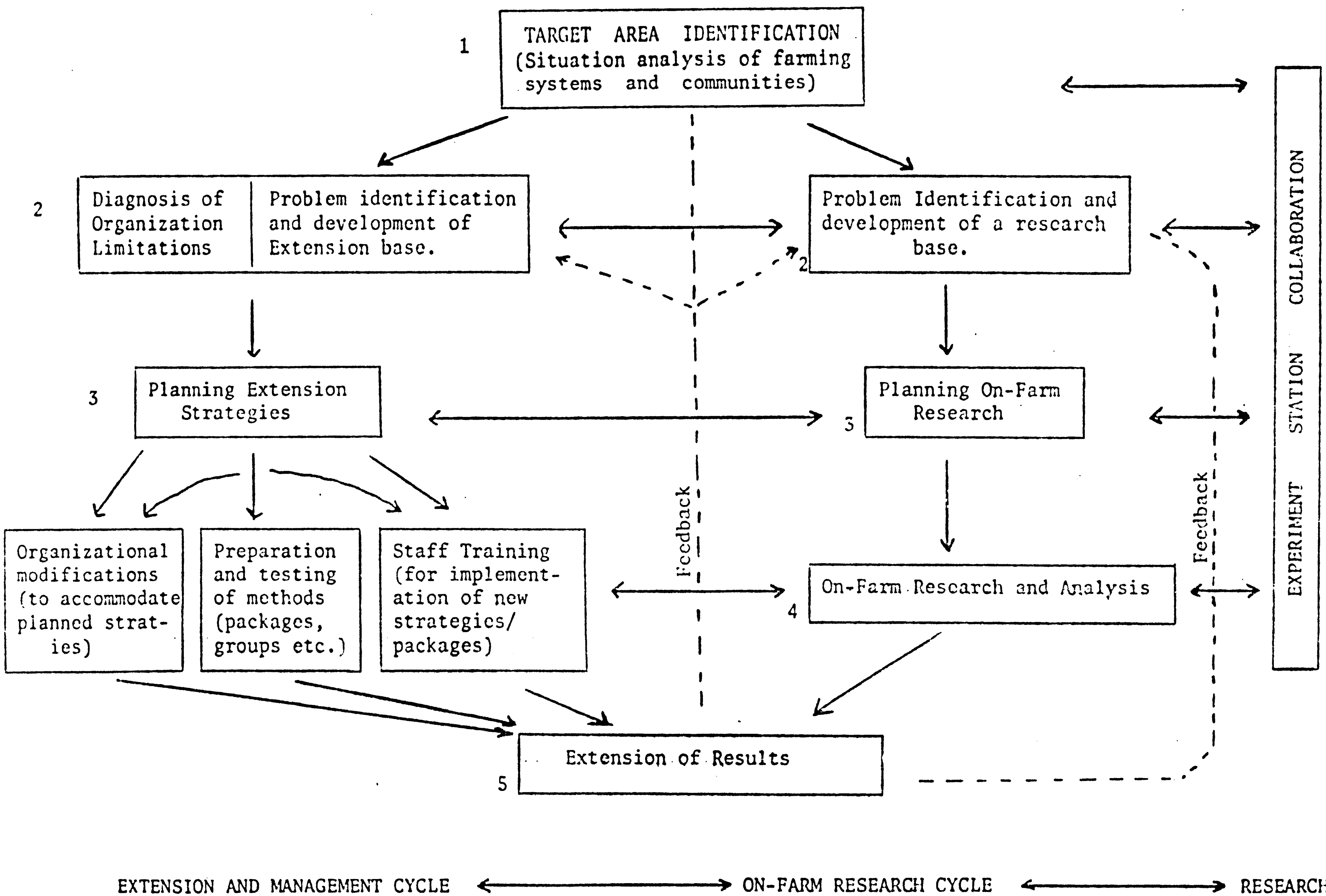

Fig. 3 Modified Model of FSR & D incorporating Extension and Monitoring Feedback.

SUBREGIONAL ISSUES IN THE IMPLEMENTATION OF FARMING SYSTEMS RESEARCH AND EXTENSION METHODOLOGY - A CASE STUDY IN ZAMBIA[1]

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INTRODUCTION

Considerable attention has been given to the institutionalization of Farming Systems Research and Extension in Latin America (Arauz and Martinez, 1983; Brown, 1981) and Africa (Collinson, 1982; Kean, 1982), and a glance at the program for this symposium shows that reports are coming in from more and more countries every year. With FSR/E practitioners taking to the field in record numbers armed with FSR/E academic theory and renewed optimism in agricultural development, much can be learned by sharing experiences. The purpose of this paper is therefore to highlight several practical issues that have arisen in FSR/E implementation in the Central Province of Zambia, and to discuss the response of the multidisciplinary team to these problems.

BACKGROUND AND INSTITUTIONAL FRAMEWORK OF FSR/E IN ZAMBIA

In 1978, the government of Zambia, aware of a lack of relevance in research to the problems of the small farmers in the traditional agricultural sector, invited the CIMMYT Eastern African Economics Program to demonstrate procedures leading to an interdisciplinary approach to agricultural research. This demonstration of formal survey techniques involved economists from the University of Zambia and biological scientists from the Central Research Station, Mount Makulu and used the Serenje District in the Central Province for a pilot study. A demonstration of zoning techniques for the entire Central Province followed this exercise in 1979, and in 1980, Zambia formally adopted a two level hierarchy for agricultural research consisting at present of six Provincial Adaptive Research Planning Teams (ARPT) and sixteen Commodity and Specialist Research Teams (CSRT). In Zambia, FSR/E is now institutionalized in the form of provincial Adaptive Research Planning Teams. While FSR/E is under the direction of the host government, each provincial ARPT receives financial and technical assistance from a different foreign donor, and efforts are underway to expand the ARPT program into the remaining three provinces as additional foreign donor support is obtained.

The multidisciplinary USAID FSR/E team in the Central Province is composed of an Agronomist, Agricultural Economist, Research Extension Liaison Officer, and Zambian counterparts. While agronomic and economic

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disciplines form the core of each provincial ARPT, these are supported by a Rural Sociologist and a Nutritionist who function on a national level. The national FSR/E effort is coordinated by an ARPT Team Leader in Lusaka, who also maintains formal linkages with the Extension Branch and Planning Divisions within the Ministry of Agriculture and Water Development (MAWD). CIMMYT has influenced the form and Structure of FSR/E in Zambia from conception through regional implementation, and continues to provide training assistance such as the five-session training program for all ARPT staff in Zambia in 1983/84. Field exercises in conducting informal and formal surveys and in designing and interpreting on-farm experiments were completed in the Central Province as part of the CIMMYT Training Program.

FSR/E IN THE CENTRAL PROVINCE

The location of the Central Province in relation to the urban markets in Lusaka and the Copperbelt (Figure 1) have given it a comparative advantage for commercial agricultural production and in the last decade, commercialization in the small farm sector has accelerated. As a result, the Central Province ranks among the most agriculturally productive regions of the country in terms of the total volume of maize produced and marketed.[2] Although maize is the dominant starch staple and cash crop in Zambia, the Central Province also has the largest acreage of sunflower, groundnuts, sorghum, and millets. The province has a low rural population density of about 3 person/km^2, plateau characteristics with a consistent altitude of 1,000 m above sea level and a rainfall period from November to April, which has a long term average from 800 to 1,000 mm. Most of the area under cultivation has a uniform topography with sandy (Sandveldt) soils. The exceptions are two small pockets of heavier textured soils and low lying drainage areas (Dambos). Dambo areas are generally not cultivated because of their high water table, but are used for dry season grazing. The Central Province is traversed by a railway and highway system leading from Lusaka to the Copperbelt and Tanzania. The input supply and crop marketing infrastructure has undergone a transition since 1981 from the parastatal National Agricultural Marketing Board (NAMBOARD) to the Central Province Cooperative Marketing Union (CPCMU), which is currently responsible for the distribution and sale of inputs and the purchase of agricultural produce at government controlled prices.

MAWD distinguishes three farmer categories in Zambia based on the degree of agricultural commercialization. Approximately 39% of the farms in the Central Province fall into the "traditional" category, which implies a minimal involvement in the market economy either for selling produce or purchasing inputs. "Traditional" farms use very little hired labor and consequently have a small acreage under cultivation. On the other polar extreme of this hierarchical grouping are the capital

[2]Central Statistics Office. 1981. National Commission for Development Planning: Economic Report. MAWD. Zambia.

intensive (highly mechanized) "large scale commercial" farmers. Between these extremes is a third group consisting of "emergent farmers", who cultivate 10-40 ha, rely on ox power supplemented by tractor hire, and use hired labor and purchased inputs. Although zoning activities have been based on this MAWD classification, ARPT has been given a mandate to work with both "traditional" and "emergent" farmers under the new banner of "small scale commercial farmers".

The 1979 zoning activities in the Central Province identified six Recommendation Domains for traditional farmers and one each for emergent and large scale commercial farmers. ARPT on-farm experiments were initiated during the 1981-82 cropping season in the domain with the largest concentration of traditional farmers. With the financial and technical backstopping of USAID, diagnostic studies and on-farm experiments expanded to include a second domain in 1982/83 and a third domain in 1983/84. These three domains contain 70% of the traditional farmers and a large percentage of the emergent farmers in the province. The on-farm experimentation grew from 2 experiments on 16 farms in 1981/82 to 12 experiments on 59 farms in 1983-84. Informal (exploratory) and formal (verification) surveys have been completed in all three domains, and an intensive labor use study is now in its second year in one domain. In-Service Extension Training activities, which include a monthly newsletter, field days, demonstrations, and short courses, encompass the entire province.

ISSUES ENCOUNTERED IN FSR/E IMPLEMENTATION

Aside from the "teething" problems involved in setting up a functional FSR/E administration on a regional level (i.e. bookkeeping, inventories, communication, transport, etc.), operational difficulties were encountered within each disciplinary component of the FSR/E team. While most of these procedural issues have been successfully resolved within the context of FSR/E in the Central Province, documenting them in this paper may be of benefit to those involved in turning FSR/E theory into practice elsewhere. For the purposes of this presentation, twelve procedural issues will be discussed under three general topics: Zoning and Stratification, Technology Development and Testing, and Communication and People Management.

A. Zoning and Stratification

1. Zoning in relation to the organization of the extension service

The demarcation of subregions is not unique to FSR/E, and the output of such an exercise is directly related to objectives and academic perspective of those involved. For example, Zambia has been divided into agroecological zones (Figure 2) by meterologists on the basis of length of the growing season, dry periods of 10 days with less than 30 mm rainfall within the growing period, water holding capacity of the soil, amount of radiation in the rainy season, and temperature regimes. The Maize Research Team subdivides the country into four major regions (Figure 3) on the basis of maize genetic potential. These zones are drawn from knowledge of crop performance in relation to rainfall, soil, and other climatic (e.g. evapotranspiration) factors. Plant breeding activities focus on developing maize varieties for each of these zones. Although agronomic research places importance on agroecological factors, the administrative infrastructure for the extension service is not organized accordingly. This situation leads to operational difficulties for FSR/E on two levels.

With the administrative organization of the extension service in mind, FSR/E was institutionalized in Zambia on a national level according to the existing regional political structure. Whereas having an ARPT in each province guarantees that the FSR/E effort is decentralized and distributed evenly throughout the country, when six autonomous provincial units are superimposed over the broad agroecological zones, the danger of ARPTSs duplicating agronomic research becomes evident. Not only is a duplication of effort possible, but technical recommendations emanating from one ARPT may be applicable over a much larger area beyond the political confines of a province. FSR/E success under such circumstances requires a strong national coordination and viable communication links between provincial teams.

On a regional level the issue of zoning has different implications. For example, in spite of the fact that the Central Province contains only one major soil type and generally falls within one of the Maize Research Team's genetic regions, the CIMMYT-coordinated zoning activity identified six separate recommendation domains for traditional farmers (Figure 4) and a separate domain for emergent farmers (Figure 5) according to socioeconomic characteristics of the farming systems (Collinson, 1979). At the same time, the extension service in the province is organized and funded according to the four main administrative units (districts) shown in Figure 6. The complication arises from the fact that each district, in which ARPT is working, has parts of three recommendation domains for traditional farmers. While this problem is not insurmountable, it does present problems in the transfer of technology.

Since extension training programs must be organized within the communication structure of the Extension Branch of MAWD, which moves through national, provincial, district, block, and camp levels, ARPT recommendation domains have not provided a logical framework on which to base the initial activities of the ARPT Research Extension Liaison Officer (RELO). In order to sensitize extension workers to a farming systems perspective that would allow them to distinguish between different farming practices and tailor technical recommendations according to the resource base and risk aversion levels of particular strata of the ARPT target group, extension training must start at the top of the extension organization and move down to the lowest echelon extension worker in the field. Not only does this approach have a multiplier effect, it also assures institutional support when training programs reach the field level. Consequently, ARPT training programs, newsletter distribution, and annual field days have been organized at first on a provincial and district basis. It has taken two years to work down to the camp level in the Central Province. Training programs are now being planned for camp staff to help them differentiate farmer groups and stress the need to understand the circumstances of each individual farm unit before giving advice. In this way the camp level extension staff will be in a better position to handle flexible technical recommendations on crop husbandry practices for each ARPT recommendation domain.

2. The Dynamic Nature of Farming Systems

A comparison of the zoning criteria for three recommendation domains in the Central Province with findings from subsequent ARPT surveys is presented in Table 1. Many of the characteristics of the three farming systems were confirmed in latter studies, which reinforces the value of cost effective Rapid Rural Appraisal techniques (Chambers, 1980) that have been formalized into the fabric of FSR/E methodology (Tripp, 1982; Collinson, 1979). Of the differences that are apparent in this comparison, the most notable reflect the rapid commercialization of agriculture in the farming systems. The heavy demand for maize in urban areas in conjunction with the availability of hybrid seed, fertilizer, and credit at the local level have provided the catalyst for a shift from traditional starch staple crops to commercial maize. Without a land constraint, due to the low population density, the commercialization of agriculture was primarily limited by labor constraints. Since maize has lower labor demands for weeding and harvesting than finger millet and sorghum, and since it is compatible with local taste preferences when made into staple starch food (Nshima), in the last five years maize has begun to replace traditional starch crops of lower labor productivity. At the same time, labor constraints have caused an increase in labor hiring and in the use of animal and tractor power for preparing seedbeds. Commercialization has led to an expansion of acreage for other cash crops such as cotton and sunflower.

While it is not surprising to find that farming systems in the Central Province are not static, the speed with which they are changing presents a special challenge to FSR/E. Annual informal surveys with extension field staff and farmers in each domain have been necessary to keep abreast of changes in the farming systems. Research strategies must now have the foresight to be aimed at trends rather than simply developing rigid characterizations of a system based on an outdated survey.

The growing commercialization of the ARPT target group has been dealt severe blows recently by a series of abnormally dry years and rapid economic changes. Although the ratio of fertilizer price to maize market price (Table 2) has remained relatively stable since ARPT began operations in the Central Province, the price of fertilizer has increased 132%. This price increase places added pressure on the limited capital resources of small scale commercial farmers. Recent surveys have shown reduced rates of fertilizer application, a shift away from formula fertilizers toward fertilizers of higher nitrogen content, an increased tendency to use hybrid maize seed obtained from previous crops, and an emphasis on cash crops that require fewer purchased inputs (e.g. sunflowers). With continuing devaluation of the local currency, abnormal rainfall, and government policy changes, current management levels are likely to evolve further in spite of government price subsidies. FSR/E requires mechanisms for monitoring these changes and transmitting flexible technical recommendations that allow freedom for management decisions based on variations in climate, prices, and resource base. The crucial step is the training of extension workers to monitor changes in farming practices and to deliver relevant messages.

3. Stratification of the Target Group Within Recommendation Domains

It is obvious that the ARPT target group of small scale commercial farmers represents a spectrum of producers with different resources and different capacities to take risks. It is therefore necessary to further stratify the target group within the boundaries of previously zoned farming systems in order to more appropriately tailor extension messages (Shaner, 1983). Given the fact that hand hoe cultivators exist alongside farmers with access to draft power within each farming system, power source was one of the first parameters used in stratifying farmer types in the Central Province. Table 3 gives an example of the characteristics of substrata in one recommendation domain using this parameter. Separate technical recommendations can then be developed for each type of farmer within the confines of the more general characteristics of the farming system (i.e. cropping pattern, labor use calendar, etc.). For example, in the case of hand hoe cultivators, efforts are underway to improve the LIMA recommendations, which were an earlier attempt of the MAWD Research Branch to scale existing crop recommendations down to unit areas of land consistent with hand hoe cultivation. Whereas LIMA recommendations concentrate on assuring uniform plant population densities and rates of fertilizer application, ARPT seeks to expand the concept to include incorporating lime into a crop rotation, which involves maize and groundnuts or soybean, in such a way as to sustain the agricultural productivity of a given field over time. Other agronomic research strategies include labor-saving technologies (e.g. 0-tillage, herbicides, etc.), improving the returns to cash and labor during the peak labor period, and moving labor demand out of the critical November-January period (e.g. winter plowing, late season cash crops, etc.). Up-coming studies of female and male headed houses, according to the criteria used in management decisions, resource base, and sources of technical information, will determine the need for additional stratification by gender.

B. Technology Development and Testing

1. Research Strategies for Short-term and Long-term Outputs

The ultimate success of ARPT in the Central Province will depend to a large extent on the establishment of strong research-extension and ARPT-CRST linkages during the first years of project implementation. Moreover, the FSR/E effort must develop credibility with both farmers and extension personnel from the beginning. Therefore, a research strategy has been developed to capitalize on the "spin off" information, which is generated in the course of annual on-farm research, geared to improving crop husbandry practices. Focusing on a refinement of current farmer practices, in the short run, assures close interaction with the respective CSRTs, while generating information to improve the effectiveness of extension recommendations. Although this short-term strategy is unlikely to result in large yield increases, it has stimulated farmer and extension interest in ARPT on-farm research, because useful information is visible each year. During the 1983/84 cropping cycle, 66% of ARPT on-farm experiments in the Central Province were devoted to this short-term strategy. The remainder of the research trials were directed toward long-term ("pipeline") interventions, which have a greater potential for improving productivity, but which require more thorough investigation to assure their feasibility. These technical alternatives must be "introduced" into the farming systems, involve more radical changes in farmer practices, and require changes in the institutional infrastructure for input delivery and credit. Examples of 1983/84 experiments pertaining to this long-term strategy include 0-tillage for maize, early maturing maize varieties for late planting, the introduction of commercial grain sorghum as a late season cash crop, and the use of lime in crop rotations to sustain production levels.

2. Extension Involvement at the Testing Stage

After three years of on-farm research in the Central Province, it is felt that ARPT has outgrown the initial CIMMYT methodological structure of exploratory, levels, and verification stages and is entering a pioneering phase of extension managed and farmer managed testing. Recognizing a void in the methodological sequence (Figure 7), from research managed/research implemented (RM/FI), ARPT initiated 36 extension demonstrations in 1983/84 under the category of research managed/extension implemented (RM/EI), which is an expansion of the Testing Stage of FSR/E (Norman, 1983). Last season's demonstrations compared yields from small plots planted with F_1 (fresh) and hybrid maize seed and F_2 (older generation) hybrid seed retained from previous harvests. This was in response to survey findings showing that a large percentage of small scale commercial farmers in the Central Province were not using F_1 seed. ARPT provided the seed, fertilizers, and planting instructions during an extension training workshop designed to teach extension workers how to effectively utilize demonstration plots. Extension workers selected farmers, supervised planting, conducted local field days, recorded yields at harvest, and sent the information back to ARPT at the end of the season. More of these demonstrations will be conducted next season in different areas, and new demonstrations will be undertaken to compare soybeans grown with and without lime to demonstrate the current credit package for soybeans which requires lime. The use of RM/EI demonstrations increases the active involvement of extension workers in FSR/E and guarantees that extension ideas are incorporated into FSR/E testing and evaluation. However, it is important that RM/EI testing be visible to farmers in the same areas where RM/RI trials have been conducted so farmers can appreciate the methodological stages of technology generation. It is also preferable that the RM/EI testing be derived from on-farm trials so there is some assurance of what outcome to expect.

C. Communication and People Management

1. Agronomists in FSR/E

Zambia is unique among most Third World countries in that the population density is very low and land is not a limiting production factor in the small scale commercial farming systems. Nevertheless, the research methods inherited from on-station experimentation place emphasis on treatment comparisons on the basis of "yields per unit land area". While recognizing that yields expressed in this fashion can be easily converted into productivity per unit scarce resource (labor or capital) by economists on FSR/E teams, this inflexibility on the part of agronomists makes it difficult to instill a farming systems perspective into national counterparts, who consistently discover non-significant statistical differences between treatments using the tools of their trade only to be shown by economists that there were in fact tremendous treatment differences. The issue is using the right yard stick to measure the differences.

A good example of this occurred in the 0-tillage experiment last season. The statistical analysis confirmed that there were no significant differences in the yields of herbicide treated plots and those prepared with conventional tillage methods. However, the economic analysis showed that the variable costs of the herbicide treatments were less than those of land preparation with oxen due to a saving of labor for weeding and the elimination of the need to hire oxen. Therefore, the net benefits were significantly higher for the herbicide treatments and the marginal rate of return on capital invested was 14 times greater than the cost of the capital. Additional benefits were accrued when this information was extrapolated onto older, weedier fields, where an even greater labor saving can be anticipated.

At risk is the feeling among national agronomists that they are locked into an infexible discipline (i.e. that only economists are in a position to interpret farming systems implications) and the danger that they would subconsciously stress on-farm work with high yielding varieties and fertilizers (land saving technology) in the face of a need for labor saving technology (e.g. herbicides). Vain attempts by ARPT in the Central Province were made to conduct an analysis of variance for different experiments using yield per unit labor invested (Hudgens, 1984). Unfortunately, the small plots used in the RM/RI trials were inadequate for generating labor information for treatment application, and the available benchmark labor use data from other studies did not consider labor for filling backpack sprayers, mixing chemicals, and applying herbicides. The exercise became one of speculation similar to "pre-screening technology" and again we were back in the discipline of economics.

2. Linkage with Commodity Research Teams

Adaptive Research Planning Teams should, as the name implies, "adapt" existing technologies to technical problems identified in specific farming systems. However, in many cases the technologies are not appropriate for ARPT target group farmers (e.g. ripping hardpans that develop in Sandveldt soils using tractor power), varietal development has not progressed to the point of going into on-farm tests (e.g. bean varieties), or the CSRT's recognize a problem area, but are powerless to address it because of limitations in manpower and funding. Whereas ARPT has influenced the nature of CSRT work such as in screening maize and sunflower varieties with and without fertilizer in CSRT national variety trials, ARPT is on its own in other areas where there is no CSRT backstopping (e.g. ox drawn tillage implements).

In light of the absence of technologies to "adapt", ARPT in the Central Province was faced with three options: a) generate our own technical solutions in farmers' fields, which is far from an ideal research environment from the standpoint of controlling non-experimental variables; b) skip the problem for the moment and wait for CSRTs to generate the necessary technologies; c) import technologies from other countries. Although CIMMYT has provided some useful regional networking in relation to international conferences, it is difficult and politically insensitive to circumvent the system and import ox plows directly from Botswana, ox planters from India, rippers from Zimbabwe, or varieties directly from CIAT or ICRISAT through personal contacts. Consequently, ARPT has been forced to generate some of its own information and skip priority problems for which there is no appropriate solution at the moment. This has led to fertilizer response curve studies for late planting, the screening of local sorghum, bean, and finger millet varieties, and trials to work out basic interactions between new maize varieties and fertilizer levels.

3. Policy Decisions

In the institutionalization of FSR/E in Zambia (Kean and Chibasa, 1982), the research-extension linkage centered on the creation of a position for a Research Extension Liaison Officer (RELO) on each provincial ARPT and the establishment of Provincial ARPT Steering Committee, composed of provincial and district extension officers, ARPT members, and the Officer-in-Charge of the regional research station. The main function of the committee was to select ARPT work areas (recommendation domains), approve annual research programs, and decide the appropriate time for releasing recommendations. In the Central Province the steering committee has been very successful in providing Extension Branch input into ARPT decision-making, but it has not ventured outside the MAWD to influence policy-making in marketing, input, and credit institutions. When this was raised at the last committee meeting, it was decided that group dynamics would prevent an expansion of the committee membership to include representatives of other agencies, but that they could be invited for special meetings to present research evidence arguing in favor of a policy change. Thus, the Provincial ARPT Steering Committee would remain the vehicle for influencing policy makers at the regional level and would assure that research reports (policy papers) were processed through the appropriate channels at the national level.

4. Supervision of On-Farm Trials

Overseeing widely distributed on-farm trials in the Central Province requires a great investment of manpower, time, transport, and expensive fuel. A solution was found in utilizing local extension workers on a full-time basis as ARPT Trials Assistants. One such extension worker, supplied with an ARPT motorbike, is now living and working in each recommendation domain. After some basic instruction, Trials Assistants, under the supervision of ARPT agronomists, are responsible for selecting sites for on-farm experiments, timely planting and input application, and collecting and recording data. However, they are training extension workers without previous research experience, and as such they seldom understand or appreciate the need for replication, border areas, precision in measurements, and farmer involvement in the trials. Illness (e.g. malaria), motorbike accidents, voter registration, or deaths in the family can lead to long periods in which the ARPT traials are unattended.

ARPT Trial Books, prepared individually for each experiment, are usually followed according to written instructions, however observations on crop performance at critical growth stages and farmer comments on the treatments under study are generally sketchy and without meaningful detail. The ARPT motorbike and occasional per diem allowances, which are the only incentives offered the Trials Assistants, often cause envy and dissension among other extension personnel at the field level, and there is a tendency for Trials Assistants to feel separated from both extension and research.

Recognizing that the success of ARPT on-farm experimentation in the Central Province depends to a large degree on the performance of the Trials Assistants and that they play an important public relations role within the farming community in explaining the objectives and treatments in on-farm trials, ARPT has responded to these problems by expanding the annual briefing session into a training program, establishing a more regimented supervision schedule by ARPT agronomists, and organizing a rotation system whereby Trials Assistants return to extension duties after three years. The continuous rotation of Trials Assistants requires constant attention to training and supervision, but it reinforces the research-extension linkage at the local level by involving extension workers directly in ARPT on-farm research.

5. Size of the Workload for Trials Assistants

It is widely accepted by FSR agronomists that the best means of reducing experimental error and improving precision in treatment comparisons is by maximizing the number of replicates of each experiment, particularly when farms are used as replicates. However, this leads to a decision between a larger number of experiments in more leverage areas in a wider range of crops or fewer experiments which are more carefully managed. Experiences in the Central Province have shown that an overly ambitious research program can result in high experimental errors, lost sites, and fewer visits to each site by the ARPT agronomist. Although the nature and complexity of the experiments determine the research workload, grouping the trials into clusters so that the Trials Assistant can visit several trials in one area one day and another group of trials in another area the next day, increases the total number of experiments that can be attended by one person. In general, ARPT Trials Assistants in the Central Province have difficulty supervising more than 15 sites without help from local extension staff.

6. Approaches to In-Service Extension Training

In-service training programs for extension personnel have been conducted by the RELO at the district, provincial, and national levels.

Given the existing structure of the Extension Branch, it was not possible to communicate within the boundaries of recommendation domains. A monthly ARPT Newsletter, entitled "For Your Information", was distributed throughout the province via District Agricultural Offices to camp staff. Follow-up studies showed that only about 50% of the camp staff were actually receiving the newsletter on a consistent basis. Other distribution approaches included mailing them to camp offices and attaching them to monthly paychecks. The newsletter is a vital source of information for the camp level extension worker, providing research updates, specialist articles, and dates of upcoming events (i.e. field days, agricultural shows, etc). Had the entire target audience received their copies, the cost of this activity would have been minimal in comparison to the number of beneficiaries (Table 4). However, in spite of the distribution problems, the newsletter offers great potential for disseminating ARPT recommendations in the future.

While field meetings (Field Days) for ARPT on-farm trials have not been the most cost effective extension training activity, they have been very popular with extension workers. ARPT provided the transport and lunch, with the tours starting and ending at the district Farm Training Centers. Separate Field Days were conducted for extension workers (in English) and farmers (in Icibemba). The location of long-term LIMA Improvement Demonstrations at the Farm Training Centers in each District provides a sense of continuity to the annual field meetings as the objectives and previous performance of the demonstrations are reviewed each year. In addition to serving as a focal point for dialogue between researchers, farmers, and extension workers, these demonstrations visibly tie ARPT to the extension training centers and to the functions they represent.

7. Communication with Farmers

The term "research" to an American connotates a series of specific activities and the use of analytical tools designed for the purpose of comparing treatments. However, there is no direct translation for the term in local Zambian languages aside from a general statement of "finding out". Since statistical tools are used to interpret experimental results in FSR/E, it is very easy to become confined within the boundaries of statistical terminology to express research findings to others (e.g. interactions, significant differences, etc.). Obviously, talking statistics to the general public, especially when several languages are involved, is not an effective form of communication. On the other hand, there is a danger in oversimplifying research results with terms like "best treatment" in an atmosphere of extensionists who are eager to hear recommendations and conclusive research findings.

The separate Farmer Field Days held annually in each district allow farmers to receive a general explanation from ARPT Zambians of ARPT trials and to ask questions. Farmers who are directly participating in ARPT research are in much closer contact with ARPT Trials Assistants and extension workers, and thus are in a better position to understand RM/RI experiments. The problem arises at the end of the season, when Farmer Group Meetings are called to explain ARPT research results and to outline a research program for the upcoming season based on these results. ARPT recognizes the need to inform the farming community on the progress and evolution of research efforts for which they are the ultimate beneficiaries, but has had limited success in addressing them directly.

8. Cooperation with other Development Projects

Several foreign-financed development projects co-exist with ARPT in the Central Province. The two major projects involve Integrated Rural Development with an emphasis on improving the effectiveness of the Extension Branch. ARPT has established constructive relationships with each project by the customary exchange of reports, attendance at field meetings, and in one case, the sharing of data from labor use studies. However, the most notable mutual efforts were made in the area of pooling funds for the construction of housing facilities for trainees at the Kabwe Regional Research Station and a joint undertaking to monitor yields from farmer fields. In the latter, ARPT provided instructions and survey forms for measuring yield components in several crops, while another development agency provided spring balances and tape measures for taking the field measurements.

CONCLUSIONS

The FSR/E effort in the Central Province of Zambia within the institutionalized structure of provincial ARPTs is in its fourth year of operation. Considerable success has been achieved to date in revitalizing the extension service morale through involvement in FSR/E activities. Intermediate ARPT outputs have taken the form of more effective extension recommendations in the area of crop husbandry, training of extension workers and research counterparts, and improved communications between research and extension. ARPT field days and training programs are eagerly attended by extension staff and many of the training techniques used at the district and provincial levels have been employed by trainees in subsequent activities.

Several operational difficulties have been encountered and addressed in the course of FSR/E implementation in the province (Table 5). Efforts to group farmers into target populations for which the same technology will be relevant have emphasized natural, social, and economic factors that distinguish farming systems but little attention has been given to the structure of the extension branch for transferring technology. This has serious implications for extension training. The ultimate success of FSR/E in the Central Province depends on ARPT's ability to develop a farming systems perspective at the camp staff level of the extension service. Camp staff must be instructed to differentiate farmer groups, apply general recommendations, monitor farmer practices, and feedback relevant information to modify extension messages. However, before camp staff can be reached, upper echelon extension staff at the national, provincial, and district levels must be exposed to the value of a farming systems perspective.

Mechanisms must be established to monitor the dynamic nature of farming systems and to determine production trends. Research strategies must delineate short and long-term outputs to provide a framework for monitoring progress in short-term foreign donor supported projects. The importance of extension involvement in the "testing stage" to screen promising technologies over a larger number of sites and to demonstrate the potential value of modifying a specific farming practice to a wider target audience, should not be underestimated. In short-term FSR/E projects there is often a tendency to rush through the "design stage" and give only token attention to extension testing, prefering instead to go straight into production scale farmer-testing. Experience in Zambia under abnormal rainfall conditions and with an extension service that lacks a sensitivity to a farming systems perspective would suggest a degree of caution in this approach.

Extension participation in FSR/E decision-making is fundamental to successful institutionalization at the regional as well as national levels. In Zambia, this has been implemented through the creation of Provincial ARPT Steering Committees, which consist of provincial and district extension representatives and are chaired by the highest ranking extension officer in each province. The incorporation of a full time Research Extension Liaison Officer on the ARPT staff in the Central Province has also facilitated communication between the two branches of the Ministry of Agriculture at the regional level and has provided a solid foundation for a combined effort in FSR/E. The ARPT in-service extension training activities, such as field days, subject matter training programs, and the monthly newsletter, have been well received and have helped construct a healthy research-extension linkage at the operational level.

In retrospect, the FSR/E team in the Central Province has been quite successful in addressing some of the problems it has encountered in its formative years. The research-extension linkage, development of short-term and long-term agronomic research strategies to overcome the specific production constraints of each farming system, and cooperative interactions with other regional development organizations are examples of success. On the other hand, the team is still struggling to cope with the issues of stratification of the target group within recommendation domains, multidisciplinary understanding within the ARPT provincial staff and between ARPT and commodity researchers, and monitoring rapidly changing farming systems. Rotations of short-term expatriate personnel as contracts expire and national counterpart staff as overseas training opportunities present themselves have exasperated attempts to maintain a unified FSR/E team spirit. New personalities also constantly appear in commodity research teams and within the extension branch hierarchy at provincial and district levels.

In the final anlaysis, FSR/E in the Central Province has matured significantly by learning from its own experience and by sharing experiences with other provincial ARPTs. Every FSR/E project in the world is faced with a unique series of problems and has a limited armory with which to do battle. However, the exchange of information on lessons learned through trial and error allows other FSR/E practitioners to feed off ideas and promising methodologies developed in other geographical areas. Networking is essential. It is hoped that this paper and the discussion it generates will provide insights that make FSR/E work elsewhere more effective.

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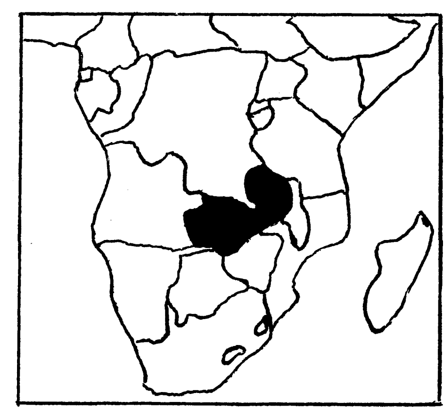
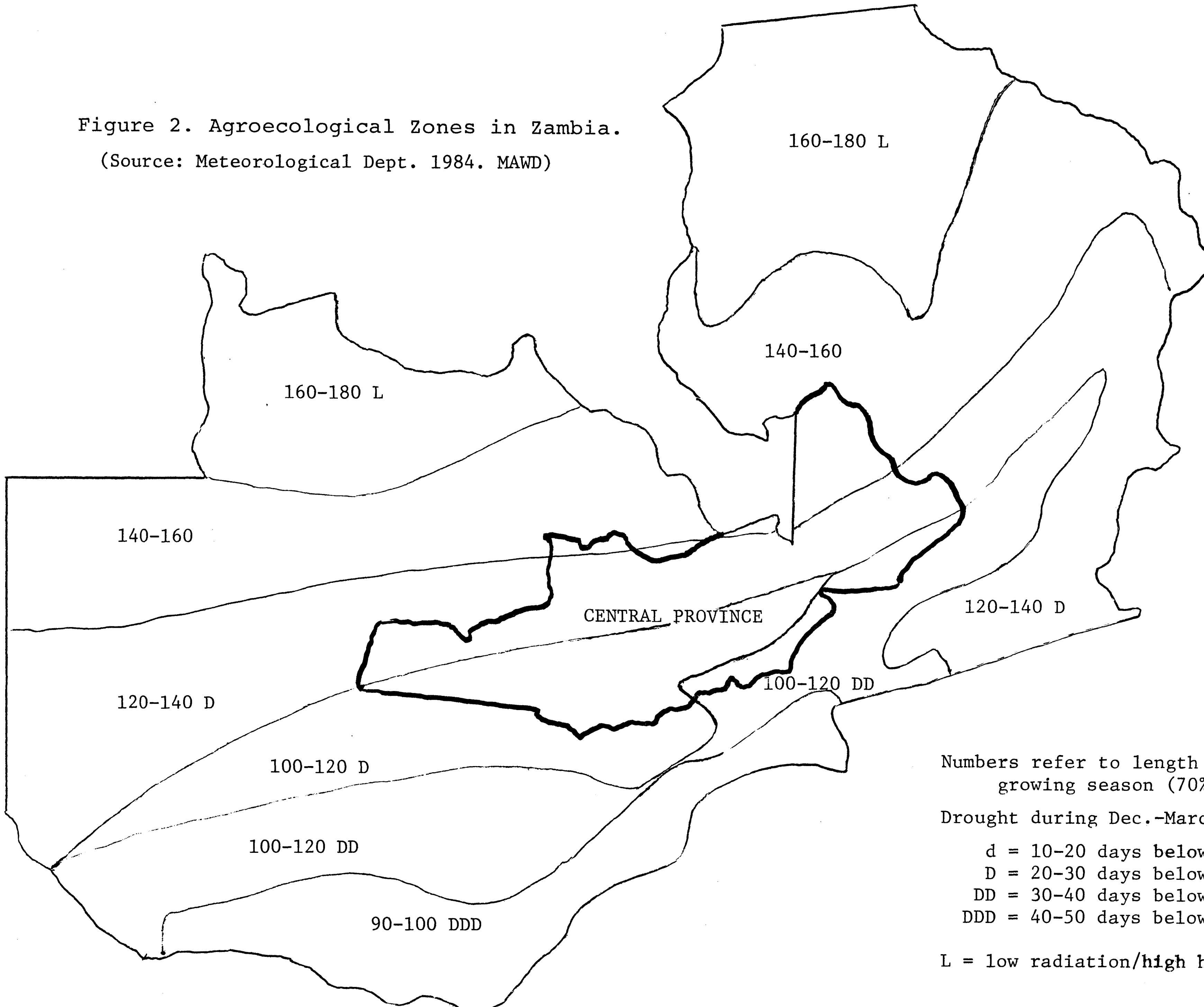


Figure 1. Location of the Central Province in Zambia.

Figure 2. Agroecological Zones in Zambia.
(Source: Meteorological Dept. 1984. MAWD)



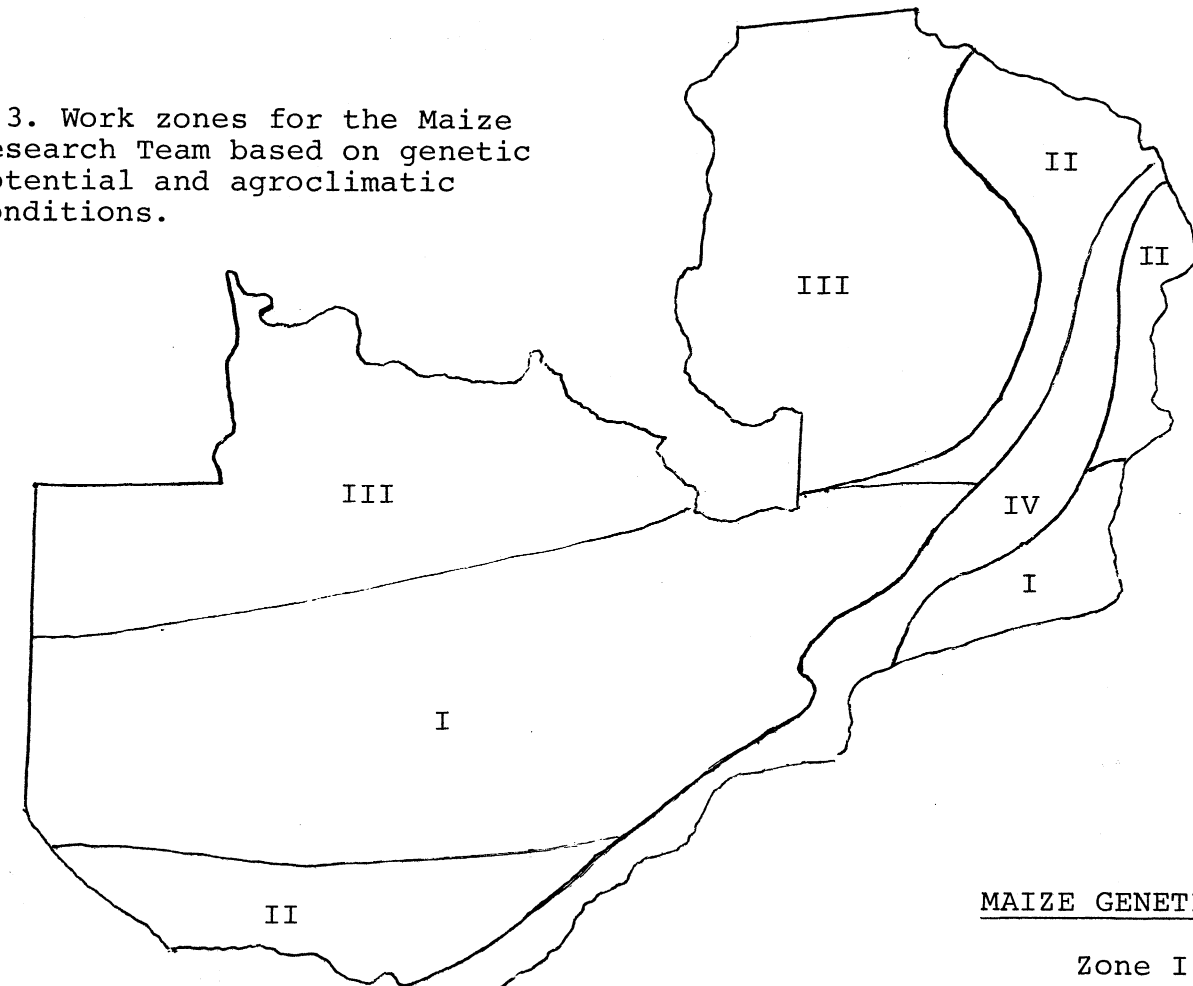
Numbers refer to length of growing season (70% prob.)

Drought during Dec.-March:

d = 10-20 days below 30 mm
D = 20-30 days below 30 mm
DD = 30-40 days below 30 mm
DDD = 40-50 days below 30 mm

L = low radiation/high humidity

Figure 3. Work zones for the Maize Research Team based on genetic potential and agroclimatic conditions.



(Source: Meterological Department. 1984. Suitability Map for Maize. MAWD. Mt. Makulu)

MAIZE GENETIC POTENTIAL ZONES

Zone I	High potential
Zone II	Marginal potential (Drought conditions)
Zone III	Marginal potential (Insolation limiting)
Zone IV	Low potential

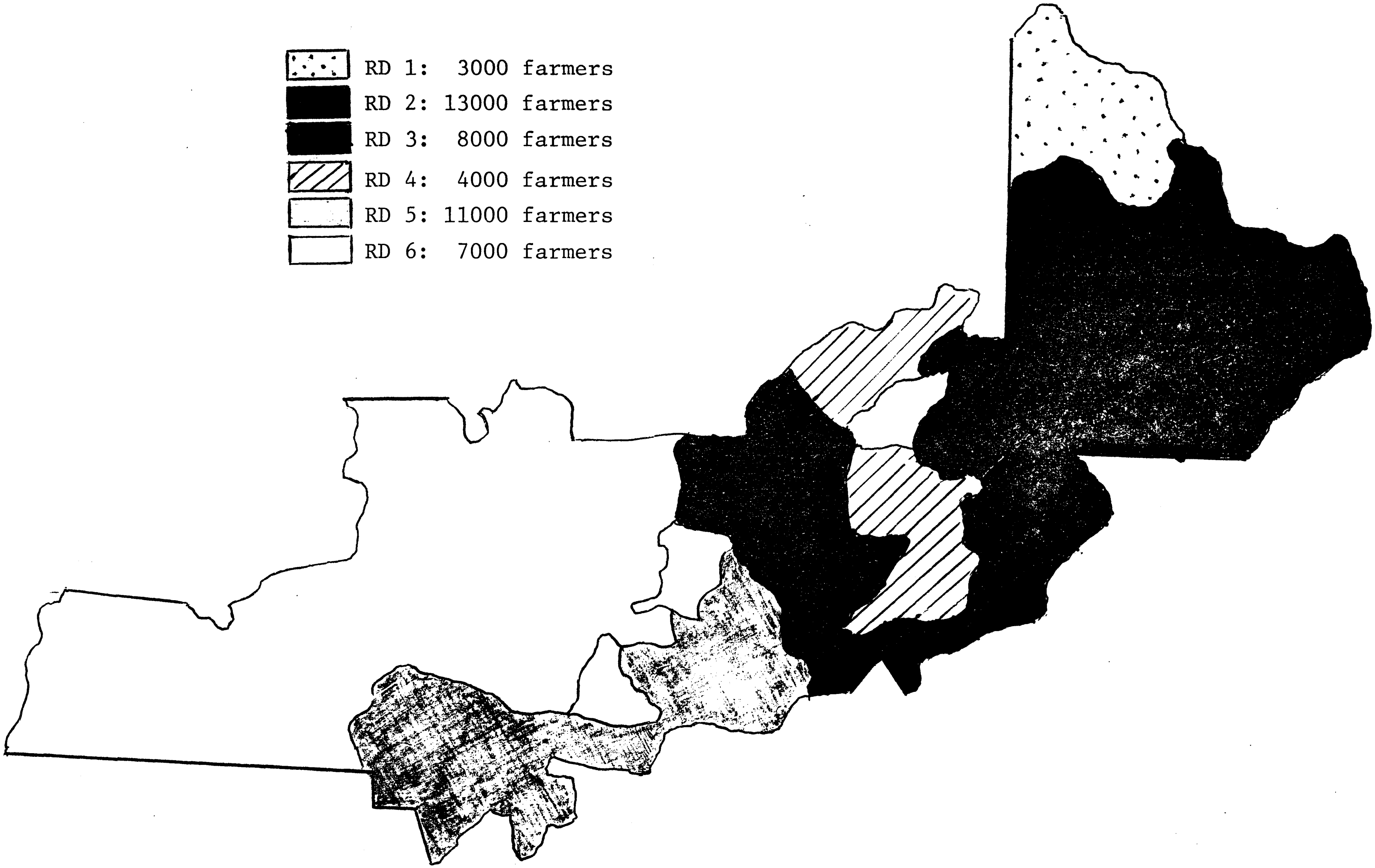


Figure 4. Recommendation Domains for Traditional Farmers in the Central Province.

(Source: Collinson,M.P. 1979. CIMMYT Eastern Africa Economics Program. Report No. 4)

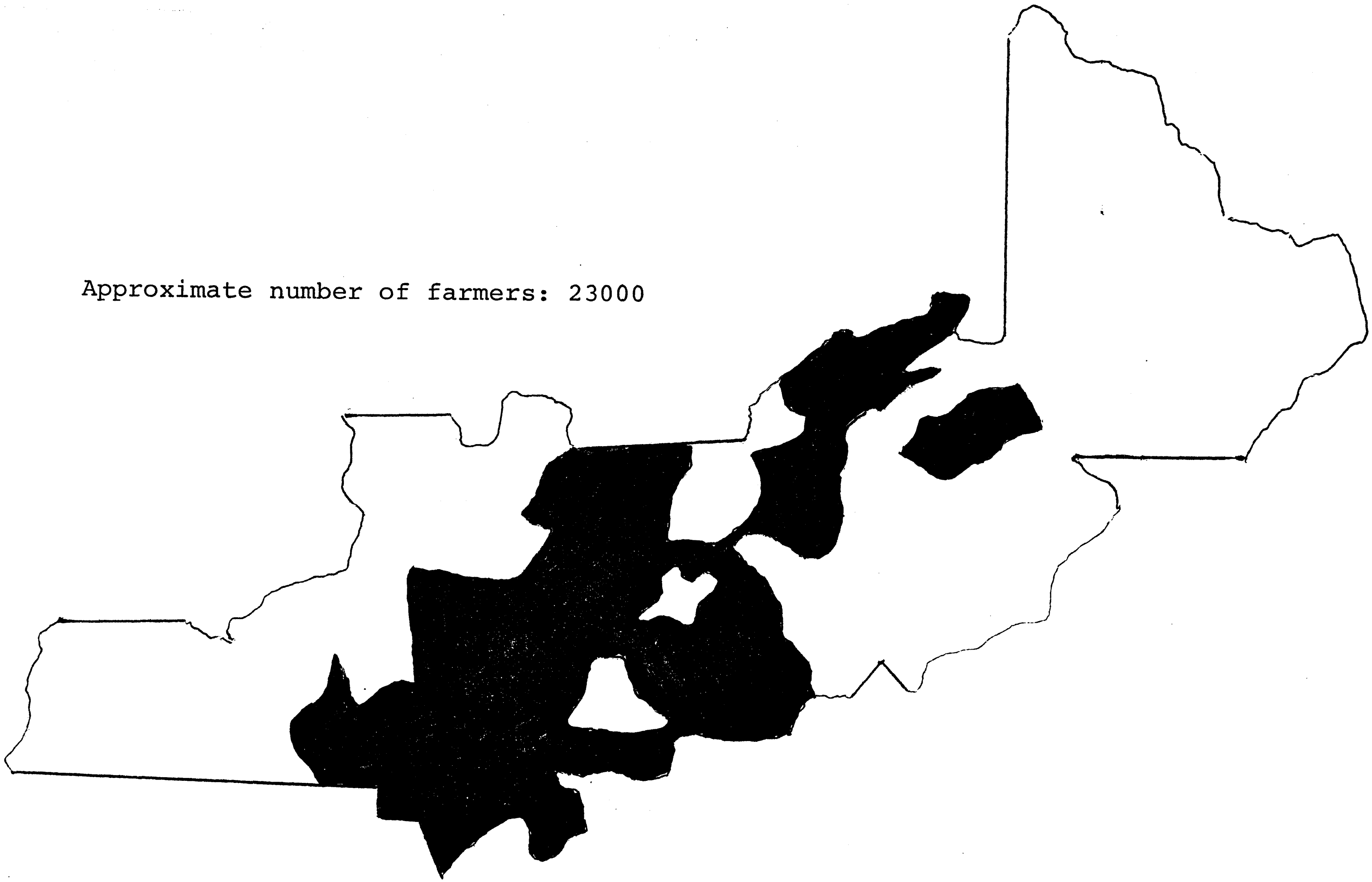


Figure 5. Recommendation Domain for Emergent Farmers in the Central Province.
(Source: Collinson, M.P. 1979. CIMMYT Eastern Africa Economics Program. Report No. 4)

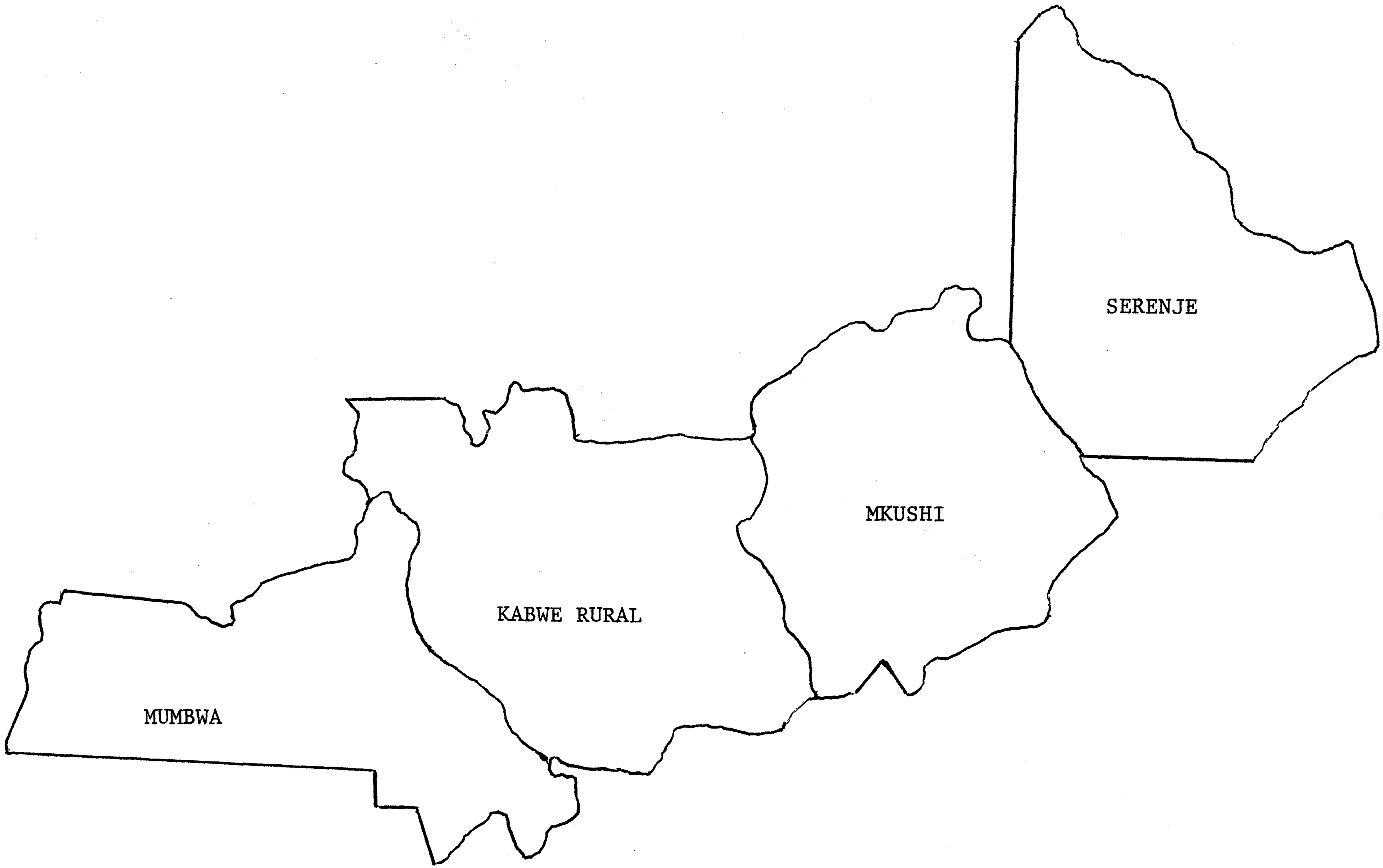


Figure 6. Political Districts in the Central Province, Zambia.

Figure 7. ARPT methodological steps (RM/RI to FM/FI) in the development and testing of appropriate technology.

TESTING STAGE

Farmer Testing
Production Scale (FM/FI)

Extension Testing
Demonstrations (RM/EI)

Research Testing
Verification Trials (RM/FI)

DESIGN STAGE

Exploratory/Levels Trials (RM/RI)

DIAGNOSTIC STAGE

Informal and Formal Surveys/Updates

Table 1. Comparison of zoning criteria for three Recommendation Domains in the Central Province with findings from subsequent findings

Domain	Power Source	Starch Staple	Cash Source	Cash Crops	Purchased Inputs	Hired Labor
I. Zoning Criteria						
RD 2	Hoe/Ox hire (34%)	Finger Millet Maize Beans	Maize Beer	10% had Sunflower	91% Maize Seed & Fertilizer	40% hired labor
RD 3	Hoe	Sorghum Finger Millet	Beer; Off-farm labor Sorghum/Chickens	10% had Cotton; 20% had Sunflower	10% Maize Seed & Fertilizer	None
RD 5	Ox/Ox-Tractor Hire	Maize	Maize Cotton/SF Cattle	20% had Cotton; 15% had S/F	100% Maize Seed & Fertilizer; Cotton pesticides	29% hired labor
II. Survey Findings						
RD 2	29% own oxen	Maize Cassava Millet	Maize Beer Beans	Sunflower	97% Maize Seed & Fertilizer	50% hired labor
RD 3	14% Hoe 44% Own Oxen 27% Hire Oxen 15% Hire Tractor	Maize Sorghum Millet	Maize Beer Sorghum	24% had Cotton 17% had Sunflower	81% Maize Seed 88% Maize Fertilizer	50% hired labor
RD 5	54% Owned Oxen 44% Ox & Tractor Hire	Maize	Maize Cotton Sunflower Cattle	79% had Sunflower; Cotton	89% Maize Fertilizer 93% Maize Seed	25% hired labor

Table 2. Price of fertilizer in relation to the market value of maize in Zambia.

Cropping Cycle	Fertilizer Price	Fertilizer Price Index	Market Value of Maize	Maize Price Index	Price Index Ratio Fert./Maize
	(Kwacha/Kg)		(Kwacha/Kg)		
1981/82	0.23	100	0.15	100	1.00
1982/83	0.30	129	0.20	136	0.95
1983/84	0.48	209	0.27	181	1.15
1984/85	0.54	232	0.31	210	1.10

Table 3. Farming System Characteristics by Power Source - TRD 3*
(Central Province)

Power Source	Average Cultivated Acreage	Average Maize Acreage	% Using F2 Hybrid Seed	% Maize Acreage Planted after 15 December	Amount Basal Fertilizer	Amount Top Dressing
	(has)	(has)	(%)	(%)	(Kg/ha)	(Kg/ha)
Hoe	1.58	0.94	11	27	110.3	120.1
Ox	3.42	1.75	34	22	109.0	112.7
Tractor	4.20	3.20	30	30	183.4	178.9

*Traditional Recommendation Domain No. 3

Table 4. RELO Extension Training Approaches in the Central Province.

Activity	Number Reached in 1983/84	Total Cost	Cost/Trainee	
		(Kwacha)	(Kwacha)	(U.S.$)
Newsletter	2000 (intended)	300.00	0.15	0.26
	1000 (actual		0.30	0.51
Training Courses				
a) National*	67	2910.00	43.43	25.54
b) Provincial**	30	2500.00	83.00	48.82
c) District**	160 (estimated)	4000.00	25.00	14.71
d) District + some camp	151	3730.00	24.70	14.53
Demonstrations#	175 (estimated)	500.00	2.85	1.68
District Field Days				
a) Extension workers	125			
b) Farmers	300	2145.88	4.42	2.60
c) Provincial extension staff (KRRS)##	60			
Total	2068	16085.88	7.78	4.58

*Communication and Teaching Skills Workshop
**Crop Husbandry Workshop
#One-half hectare LIMA Demonstrations at 4 Farm Training Centers and at the Kabwe Regional Research Station (KRRS).
##Includes extension workers and commercial farmers. The field visited both on-station and on-farm experiments

Table 5. Summary of Some of the Problems Encountered and the ARPT Response

Problem Encountered	Severity[1]	ARPT Response
Zoning without extension considerations	M	RELO must work within existing extension structure to teach FS perspective
Dynamic nature of farming systems	M	Annual monitoring; Establish production trends
Heterogeneity of target group within RDs	H	Stratify by power source, gender, degree of commercialization, credit use, etc.
Foreign donor need for measurable outputs	L	Develop short and long term research strategies
Extension involvement in testing stage	L	Extension managed demonstrations (RM/EI)
Weak CSRT technical backstopping	M	Prioritize leverage areas for each crop by information available and potential impact
Influencing policy makers	M	Via Provincial Steering Committee under control of Extension Branch
Accuracy of data collection	H	Trials Assistants training; Write Field Manual
Need for FS perspective in Extension Branch	H	In-service extension training at all levels
Communication with farmers	H	Farmer Field Days; Trials Assistant training;
Coordination with other develop projects	L	Involve in Field Days, share data, cooperate in demonstrations and surveys
Teaching extensionists to use flexible crop recommendations rather than specific receipes	H	Extension training at the camp level
Awareness of FSR/E developments elsewhere	M	Networking through FSSP, CIMMYT, USAID, KSU
Extension bias in Diagnostic Stage	L	Wider sampling; extension training
Coordination of FSR agronomists in different provinces within the same agroecological zone	M	Through CSRTs; Annual planning meetings

[1]Severity is a subjective ranking at three levels: High (H), Medium (M), and Low (L).

Conducting On-Farm Research by Extensionsists: An Approach to Effective Transfer of Technology

Federico Poey

Lack of effective communication between research and extension institutions in developing countries is often the most important limitation for the successful transfer of technology to small farmers. Attempts to integrate efforts through high level commissions and institutional agreements fail to achieve the objective. Common causes for their lack of integration include the administrative and sometimes institutional separation, their difference in personnel and budget magnitudes which usually favors extension, and the higher professional status which generally favors research.

Other factors that contribute to the gap between research and extension are summarized in Figure 1.

DOMAIN:	RESEARCH	EXTENSION
Clientele:	Extensionists	Farmers
Methodology:	Scientific	Teaching
Product:	Teck-pack	Farmer Utilization
Environment:	Ideal	Real
Activity:	Generation	Promotion
Collaboration:	Professional	Farmer
Attitude:	Specialized	General
Organization:	Intensive	Extensive
Academic:	University	Technology School

Figure 1. THE GAP BETWEEN RESEARCH AND EXTENSION.

Under the farming systems approach to research the separation between research and extension tends to aggravate; on-farm research is oftentimes taken as an invasion to the extensionists' realm because of the farmers participation and misunderstandings of the validation process which is interpreted as a demonstration activity.

To overcome these obstacles, an active involvement of extension in the later stages of on-farm research can eliminate or reduce many of the friction elements with research. By sharing the definition of the alternatives to recommend, a positive attitude of the extension units towards the farming systems approach to research should contribute to a more effective transfer of technology.

To accomplish this cooperation the following aspects need to be considered and/or implemented.

1. Training of a selected number of extensionists in on-farm research procedures that will team up with other research and social science specialists to form a field team.

2. The composition, location, objective and methodology of the FSR/E field team is summarized in Figure 2.

FSR/E FIELD TEAM

COMPOSITION:	Specialists from Research Specialists from Extension
LOCATION:	In Recommendation Domains
OBJECTIVE:	Develop Recommendations (for Extension) Feedback (to Research)
METHODOLOGY:	On-faım Research

Figure 2. FSR/E FIELD TEAM.

3. These teams should interact closely with station's full-time research specialists and with extension's main force in backing up their demonstration plots and other promotional activities.

4. A simple transfer plot design to be fully managed by farmers can be implemented both by the FSR/E team and extensionists as an added opportunity to improved communication between research and extension.

Under this arrangement, research relinquishes its usually unconsulted recommendation decisions to a joint research-extension mechanism with improved probabilities to be adapted by farmers.

An experience in Paraguay where the extension service is conducting adaptive research illustrates elements of the suggested approach.

An AID financed extension project called PTPA (Proyecto de Transferencia para Pequenos Agricultores) that was implemented in 1980 was originally conceived with a farming systems approach that included a team of multidisciplinary specialists assigned to each of 8 selected regions. The teams were to identify researchable problems and implement its realization with the farmer's participation. From the beginning, the concept clashed with the traditional criterion between the reasearch and extension departments increasing the already tense relationship of those departments. The project was then implemented on a centralized administration allowing the regional teams to define their researchable opportunities on personalized decisions, not generally related to the farmer's priorities. The limited number of trials conducted lacked the farmer's participation or were planted only at experimental station.

The correct concept was eventually implemented in February 1984 following recommendations from a review team requested to the Farming Systems Support Project (FSSP) conducted in June 1983. They included a decision makers' workshop on FSR/E held in December 1982 followed by an applied three week course for practitioners in January 1984. Also a farming systems specialist, Ing. Mario Ozaeta, perviously working with Instituto de Ciencia y Tecnologia - ICTA -, as head of a region in Guatemala and who had led the applied course, remained as a full-time consultant in the project. Research and xtension personnel participated in both events.

Figure 3 summarizes some of the on-farm research misunderstandings that prevailed prior to Ozaeta's arrival. They included contracted and adaptive research trials, pilot projects and demonstration plots. The contracted and adaptive research trials were defined by arbitrarily motivated decisions and implemented mostly on one location from where recommendations at a national level were to be promoted. The pilot projects and demonstration plots were similarly arranged and in no case were farmers involved.

OFR MISUNDERSTANDINGS

Contracted Research:

To Experiment Station
Arbitrarily Motivated
Inadequate Number and Design

Adaptive Research:

Inadequate Number and Design
Controlled Non-experimental Variables

Pilot Project:

Nonexperimentally Justified Projects

Demonstration Pilots:

Unsound Alternatives Compared to Local Checks
No Economic Analysis

Figure 3. ON-FARM RESEARCH MISUNDERSTANDINGS AT PTPA PROJECT PRIOR TO 1984.

Figure 4 describes the action promoted through the Farmings Systems Support Project - FSSP - at the request of the Paraguay USAID office.

FSSP ACTION

1. EVALUATION - June 1983.

2. Decision Makers Workshop - December 1983.

3. Applied Course, three weeks - January 1984.

4. Full-time FS Specialist contracted - February 1984.

Figure 4. FSSP ACTION THAT LED TO FSR/E IMPLEMENTATION.

In Figure 5, the main aspects that underlined these activities are summarized. It should be noted that a common leadership and continuity of purpose accounted for a gradual institutional and practitioners' acceptance of the new approach.

IMPORTANT ASPECTS

1. Continuity
   Same Leadership in Events
   Involvement in Nationals
   Maintain Contact Throughout

2. In Workshops:
   Regional Directors and Higher Hierarchy
   Promotion of FS Concept
   Prepare Courses
   Experienced Lecturers

3. In Course:
   Regional Specialists
   Conducted Sondeo
   Prepared Work Plan
   Experienced Instructors

4. FS Specialist
   Participated in Course
   Proven Experience
   Coordinates Action in regions, Sondeos, Work PLans, Specialized Courses and Seminars

Figure 5. IMPORTANT ASPECTS OF PROMOTIONAL EVENTS.

Beginning in February 1984, the farming systems approach was organized in each of the 8 regions of the PTPA project. Coordinated by Ozaeta and implemented by the regional leader previously trained, the action consisted of conducting a Sondeo followed by a reprogramming of 1984 activities. In each region a team of 5-6 multidisciplinary specialists, consisting of agronomy, animal production and/or veterinary specialists, an economist, an acting agronomist and a home economic person. Researchers from experiment stations participated in the Sondeo and will also participate at the presentation of results sessions.

On Figure 6, the work accomplished as of September 1984 is summarized.

WORK ACCOMPLISHED

- Sondeos in 8 Regions
- Work Plans in 8 Regions
- Adapt Budget to New Guidelines
- Training in Trial Installations
    - Field and Experimental Design
    - Field Book
    - Farmer Records
    - Statistical Analysis and Interpretation
- Collaboration with Research
    - Maize
    - Strawberry
    - Tomatoes
- Purchased Minimum Equipment
    - 8 Calculators
    - 8 Moisture Testers
    - 8 Scales
- Prepared and Established 151 Field Trials

Figure 6. WORK ACCOMPLISHED SINCE FEBRUARY 1984.

It should be mentioned that these activities are carried on selected areas of each region as pilot programs to be expanded in the future as resources and local expertise develops.

In Figure 7, a comparison of activities carried on before and after February 1984 dramatizes the number of on-farm trials conducted with the same personnel infrastructure and budget of the PTTP project.

ACTIVITIES

	1979-December 1983	1984
Contracted Experiments:		
(Station)	11	-
On-Farm Experiments:		
Crops	10	144*
Livestock	0	7
Courses and Seminars	2	3

Surveys:		
Formal (incomplete)	7	-
Sondeos	-	8

*By Crops: Maize 31, cowpea 28, cotton 18, pasture 14, banana 10, tomato 9, etc.

Figure 7. COMPARISON OF ACTIVITIES BEFORE AND AFTER FEBRUARY 1984.

Sondeos revealed some common researchable projects for all regions and many specific ones. Maize experimental varieties trials were set up in a common design in a total of 31 locations that will allow for combined analysis interpretation for stability of yields as well as for agronomic characteristics behavior in very different environmental conditions.

This experience shows that the logic of the farming systems approach to research and extension was well understood by national leadership and the local donor agency and that proper advice and guidance from the FSSP network resulted in a rapid adaptation of FSR/E methodology in a unique framework of an extension project.

1/ Paper presented at the Kansas State University Farming Systems Symposium, Manhattan, Kansas, October 7-10, 1984.

2/ Ph.D., President, Agricultural Development Consultants, Inc., AGRIDEC, Coral Gables, Florida.

TRIALS AND ERRORS: USING FARMING SYSTEMS RESEARCH TO REACH FARMERS WHO ARE OFTEN NEGLECTED

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INTRODUCTION

In many African countries extension programs for women focus on home economics. Often the clientele for these programs are rural women who are engaged in agricultural production activities as well as in domestic and reproductive activities. Because of the emphasis on home economics, and particularly on a narrow definition of home economics as cooking and sewing, these women farmers do not receive the training on crops, livestock, and farm management that will help them gain a livelihood and assure the food security for their families. The notion of scientific agriculture for men and scientific home economics for women is part of a model used in the United States and other developed societies that has been transferred to developing countries (Mead 1973; Gladwin and Staudt 1983; Gladwin, Staudt, and McMillan 1984). An assumption of the model is that women are considered as helpmates on the farm, or as farmer's wives who may be interested in poultry raising and small vegetable gardens for household consumption, but who are not farmers in their own right.

This paper examines programs for women in Malawi that until recently put women in the "neglected" farmer category because of the emphasis on home economics rather than on agriculture. It examines how a Farming Systems Research (FSR) approach that utilized farmer-managed demonstrations and trials assisted in including women farmers in agricultural programs. In addition, the paper attempts to distinguish between problems that affect smallholders in general and problems that are gender specific.

Malawi is a country where the government is committed to increasing the agricultural production of farmers in the smallholder sector (NRDP 1977). It is also an area where women are heavily involved in smallholder farming, doing 50-70% of the farm operations (Clark 1975; Spring, Smith and Kayuni 1983). Recent studies show that women are increasingly moving into full-time farming as men become part-time farmers because of off-farm wage activities (Kydd 1982; Spring, Smith and Kayuni 1983; Spring 1984). Up until recently, Malawi's Ministry of Agriculture (MOA) had the idea that women's extension programs should focus on home economics almost exclusively. Table 1 shows that training courses in 1981-82 for rural women at day and residential centers consisted of from 75% to 84% home economics subjects, while courses for rural men consisted of from 88% to 93% agricultural subjects. The extension staff who offered these courses and did other extension work was composed of approximately 1800 men and 150 women. The male extensionists received about 75% of their two year training in agriculture, while the women received 78% of their 6 month or one year training in home economics. Most of the agricultural training for women extensionists focused on poultry raising and vegetable production. In 1981 the MOA changed the designation of the home economics section to women's programs with the hope of increasing agricultural services to rural women (Spring 1983).[1]

It was during this change that the Women in Agricultural Development Project (WIADP) funded by the Office of Women in Development, USAID operated in Malawi

(Spring 1985). The Project was conducted from 1981 to 1983 and aimed at documenting women's and men's involvement in smallholder agriculture. Using a FSR approach, it ascertained problems facing women farmers as client groups, assisted the Women's Programs Section of the MOA to reorient its direction from home economics to agriculture, and worked with farmers, extension agents, and research personnel to develop workable communication patterns and solutions to problems.

In terms of FSR projects the WIADP assisted in sondeos and intercropping trials that were conducted by the Farming Systems Analysis Section of another USAID funded project on Agriculture Research and conducted sondeos and trials on its own (Hansen 1981; Hansen and Ndengu 1983). This paper focuses on soybean demonstrations carried out during 1981-82 and trials conducted in 1982-83 in the Lilongwe Rural Development Project (LRDP).

The LRDP, one of the first development projects in Malawi, was begun in 1968 under World Bank funding. The LRDP is one of five projects in the Lilongwe Agricultural Development Divison (LADD), itself one of eight contiguous agricultural divisions in the country (NRDP 1977). People in the LRDP constitute a mix of farmers. There are farmers at subsistence level; those who obtain varying amounts of income from agriculture; and those who seek wage labor in nearby Lilongwe, the capital city, or who work on agricultural estates in other parts of the country. People primarily monocrop maize, groundnuts, tobacco, beans, and sweet potatoes under rainfed conditions with the average landholding being 4 acres per household (Kinsey 1973; Lele 1975). A 1981 sample survey showed that 20% of the households were headed by women (NSO 1982) with 39% of these female heads being married to men who were away from the family farm (Spring 1984).

SOYBEANS: A NEW COMMODITY FOR SMALLHOLDERS

For many years, soybeans were grown commercially in the estate sector for the bean and as a green manure. However, production of the crop in the smallholder sector was negligible. In 1981, the Food and Nutrition and Women's Programs Sections of the MOA chose to introduce the crop via female extensionists to women in home economics classes. Their aim was to increase fats and proteins in the Malawian diet. Sixty female extensionsts who attended a National Refresher Training Course were taught recipes for soybean milk, porridge, coffee, snacks, relish, scones and other baked goods (Spring 1981). Several months later, the WIADP came across a woman extension agent who had introduced the soybean recipes to her home economics class of sixty four women. However, since she had not received agronomic information, she was unable to teach the women how to grow the crop properly. She was planning to give the women a handful of seed to plant.

The WIADP wondered if the errors of excluding the technical information about growing the soy crop, of giving women only a small amount of seed, and of thinking that women were doing light gardening instead of field work could be remedied.[2] The WIADP posed some questions for study: Were women interested in learning correct husbandry practices? Could they participate in agronomic demonstrations and trials? Were they just helpers or domestic workers rather than farmers in their own right?

The WIADP asked the extension agent to call the women who had attended the class for a meeting where soybean husbandry practices would be demonstrated.

Fifty six of the sixty four women attended. In order to ascertain what the women knew about growing beans in general and soybean in particular, they were questioned about their cultural practices relating to these crops. Their involvement in other staple and cash crops, livestock enterprises, and their experience with credit and inputs were queried along with their household labor patterns. It was found that the women were farmers who grew unimproved maize, groundnuts, pumpkins, sweet potatoes, beans and indigenous vegetables. Half of them cultivated hybrid maize; some planted cowpeas, groundbeans, sorghum, sugar cane, exotic vegetables, and tobacco. The cropping patterns coincided with the patterns delineated by Hansen during his sondeo. The women worked alone (if unmarried or if husbands had migrated for work) or with their husbands either sharing crop operations or being responsible for specific operations.

The women were given demonstrations and information as to how to cultivate soybean by the WIADP and male extension staff. This included information on plant spacing, use of fertilizer and inoculant, weeding, signs of readiness for harvest, and storage. Some aspects of the demonstrations utilized a hands-on approach; for example, bamboo stalks for measuring spacing between rows, ridges, seeds and planting depth were prepared by the women.[3] The seed was inoculated with rhizobium and the farmers went home with seed, low nitrogen fertilizer, measuring sticks and instructions. The soybean rhizobium inoculum that is prepared at the research station in Malawi is only viable for 2 to 3 days and it was anticipated that the rains would start that week; but when the rains were delayed, the farmers had to be called back two weeks later to reinoculate the seed. Thirty nine farmers returned for the reinoculation; the others had already planted the seed in dry soil.

Six to eight weeks later, a sample of 23 of the 59 demonstration farmers were visited in their fields and observations on the growth of the plots were made with the assistance of the extension staff. The farmers selected were questioned as to when they planted, their husbandry practices and other aspects of their farming system.

In half of the married households, the wife supplied nearly all the labor on the soybean plots; husbands helped with the plots on the remainder even though they had not attended the instruction sessions. Unmarried women (only 9% of this sample) did all their own work. When questioned as to proper soybean husbandry practices, 75% of the famers in the sample knew the correct spacing, half knew which fertilizers were appropriate, all farmers understood the correct number of weedings and 75% knew which animal manures to use if no commercial low nitrogen fertilizer were available. Less than half grasped the function of the rhizobium inoculum although two-thirds understood how to prepare it by the slurry method (see below). Farmers laid out the demonstrations in a variety of ways and spacing and plant populations varied.[4]

Yields were taken in April 1982 using two plots from each demonstration. Table 2 shows the average yield for a sub-sample of 11 farmers and can be grouped into three yield categories of high (2,530 to 2,900 kg/ha.), medium (1,160 to 1,400 kg/ha.) and low (320 to 660 kg/ha.). The reasons for the yield differences are most likely due to variation of plant spacing, inoculation and soil fertility.

After harvesting the demonstrations, the WIADP interviewed farmers in another project who had been growing soybeans for some years in order to obtain a greater perspective on farmers' knowledge and cultural practices. Both men and women were growing the crop and their experiences allowed some comparisons. It was found that the men became interested in growing soybeans as a result of taking agricultural training courses or because of their work experiences. The women learned through home economics courses or from relatives. None of the farmers knew of the recommended rhizobium inoculant or that fertilizers should be low in nitrogen; they said these topics were not discussed in the training courses. The farmers received their seed at a training course. The seed usually was not inoculated and yields were low. The men received two to five times as much seed as the women. Most of the women consumed the crop in the first year and did not save any for seed. Some of the men had seed for subsequent plantings. In farm operations on the crop, wives helped 80% of the male farmers, and husbands helped 50% of the female farmers in growing the crop; however, women always threshed and cleaned the seed. No conscious rotation pattern was known although most grew maize alternately with soybean. Farmers were interested in the crop mainly as a food for home consumption primarily for the porridge, milk, fried snacks and flour to make baked goods. People did not like the cooked beans because they require long cooking and do not mash well. Two farmers used soybeans for feeding dairy cows or chickens. Some of the men were attempting to grow the crop for sale, but experienced marketing problems because the government market was not available in the area and farmers did not consider the price favorable.

RESULTS FROM THE FIRST CYCLE OF SOYBEAN DEMONSTRATIONS

Based on observations, interviews and discussions with the extension staff and with the farmers, a number of problems were discerned. The first difficulty noted was that many farmers and extension agents were having trouble understanding research station recommendations (especially the use of low nitrogen fertilizer with inoculated seed) for cultivating soybean. The extension circular was too technical and was based on trials carried out on soils that may have had the rhizobium already established. Second, the proper type of rhizobium bacteria is not indigenous to the soil. Thus, there is a need for sufficient quantities to be prepared and to be timely for planting. Distribution problems so that smallholder farmers as well as estates could receive the inoculum had to be solved. In particular, the LRDP and the LADD lack refrigeration in their development units and the transportation of viable inoculum was a problem. A third problem was the small size of the soybean plants. This was related to lower than optimum soil fertility as well as the need for inoculant. The fourth problem was an error in planning and targeting farmer populations. Women farmers needed to be taught husbandry practices and technical information concerned with production. Women extension staff needed to receive adequate training to teach women how to cultivate a new crop. Male extension staff had to be willing to teach groups of women in their areas either as a supplement to the classes of the female extension staff or in their own agricultural classes and village meetings. Fifth, inoculated seed and the amount distributed to class participants, especially to women, was too little.

The WIADP took the following actions. A simplified version of the recommendations for growing soybeans was produced with an English and vernacular (Chichewa) version distributed to extension workers of both sexes as well as to the demonstration farmers. In addition, a syllabus for teaching a course on the crop to farmers was written. The topics covered included history, uses, recipes, botany and general agronomy. Finally, female agents received instruction in soybean agronomy and recipe preparation from the WIADP and the faculty of the agricultural college.

SOYBEANS TRIALS TESTING METHODS OF INOCULATION IN 1982-83

Considering the problems of distributing viable inoculum and being able to plant the seed within several days after inoculation, improved methods of maintaining viable inoculum were needed. Although this problem has been solved elsewhere using other technologies, the WIADP was constrained to use the existing research station methods since the method was working in the estate sector. One possibility then was a granular method where the inoculum was mixed with moist sand so as to prolong its viability before distributing it to farmers.

Three trials were designed to test different methods of inoculation. They were: no inoculation; the standard 5% sucrose slurry method of coating the seed; and the granular method of rhizobium inoculation. Three objectives for the trials in 1982-83 were specified by the WIADP and the LRDP project staff. The first was to compare the growth of soybeans as affected by the different treatments. The second was to help popularize soybeans in the smallholder sector. The third was to provide an example of how to organize women farmers with extension staff in order to field test ideas derived from agricultural research stations and to solve problems identified by working with farmers.

In December 1982, twenty women farmers participated in planting trials at four demonstration centers as well as in planting trials in their own fields under the instruction of the WIADP agronomist (Smith 1983) and local male extension staff. A short questionnaire was asked of each farmer regarding her experience with soybean, other crops and inputs. To begin the trials, farmers were taught how to form the desired spacing, inoculate the seed in the granular method, and plant the seed. Each farmer received the necessary materials in order to plant her own trial the following day. The local extension staff were requested to draw a diagram of each trial so as to be able to locate each of the three treatments. Because the trials were to be completely farmer managed, it was decided to have the same order of treatments for each trial: 1) no inoculum 2) inoculum with sand, and 3) inoculum with seed. Standard randomization techniques were not used due to the chance of confusing the farmers.

RESULTS FROM THE SOYBEAN TRIALS

About 6 weeks after planting, each soybean plot was evaluated for nodulation at the time of flowering. At this time it became evident that the first objective of the trials would not be successful, that is, the two methods of rhizobium inoculation could not be compared. None of the treatments in the trials had successful nodulation, even though it was the period of maximum nodulation for the soybean lifecycle. The reason for the lack of nodulation is not positively known. One likely cause was the lack of viable rhizobium bacteria within the inoculum packets, probably due to a failure of the refrigeration room at the research station where the packets of inoculum are stored after being produced.

In spite of the lack of recorded nodulation, it was decided to harvest some of the trials to see if treatment differences were noticeable. The average yield for all plots was 640 kg/ha with a standard deviation of 170 kg/ha. The low yields achieved in 1982-83 are probably explained by the lack of nodulation in all three treatments and are similar to the yields achieved by demonstration farmers whose seed did not have viable inoculum the previous year. In summary, the experiment was not successful at distinguishing differences in nodulation and yield among the three treatments, and therefore, failed to solve the major growing problem that farmers and extension staff experienced. The failure was due to a general lack of nodulation, which was probably the result of defective inoculant. The failure of the experiental aspects were probably the fault of the researchers, not of the farmers and the extension staff.

The second objective of helping to promote soybeans was successful since the trials of all cooperating farmers did mature a crop, the only soybeans being grown in LRDP that year. The third objective of demonstrating how to organize women farmers with extension and research staff to field test new ideas also was successful. Not only did the extension staff assist in organizing women farmers for agricultural research and extension activities, but a more accurate method of instructing farmers in agricultural technologies was devised. Most farmers were able to repeat the differences between the three inoculation methods. The women were instructed in a laboratory approach, in which each person was forced to actively participate in planting the demonstration prior to her own trial.

FURTHER ACTIONS AND CONCLUSIONS

Many of the questions posed concerning women's involvement in agricultural services have been answered by the demonstrations and trials reported on here. The staff of the LADD and the LRDP learned that women were interested in agricultural subjects if given the opportunity. The staff realized that women could participate in extension demonstrations and research trials. They saw that women were farmers who needed agricultural information, in addition to information about recipes. The staff realized that interest in agricultural topics could be generated by home economics subjects, but because there were few female extension agents, there needed to be other ways to provide agronomic information to women. The larger and better trained male extension staff were able to work with women farmers and to provide regular extension services to them. Both the development project management and its field workers could reach a variety of client groups and they could make adjustments in their programs. The staff also realized it was possible for extension workers to be retrained in terms of subject matter and in methods of dealing with clients. As a result of this new way of thinking, some actions were taken. Thirty percent of the places in the LADD's agricultural courses for farmers were reserved for women. The next refresher course for women agents included information on soybean agronomy, as well as on the preparation of soybeans, and in fact, the agricultural content of the refresher courses for women agents was increased. In addition, it became possible for women agents to attend some of the refresher courses held for men, essentially integrating the two groups for the first time. After the trials, the WIADP prepared an extension circular entitled "Reaching Female Farmers Through Male Extension Workers" that was printed by the MOA (1983) and distributed to all extension staff in the country. The circular legitimated the male staff's work with women farmers in terms of farmer visits, demonstrations, clubs, and credit programs and offered techniques that the male staff could use to work with women. The WIADP helped design new reporting formats for the LADD's extension workers and project management that measured extension contacts to both women and men; previously the forms did not differentiate sex of farmer. All these changes may be pointed to as part of the effect that the WIADP and the demonstrations and trials had on the LADD and the LRDP.

What about the errors that occured? There were several categories of error: technical, structural, and situational. The technical kinds of errors can occur during any farming systems research project. First, the farmers might not truly understand the planting instructions and layout, as was the case in the demonstrations the first year. Other family members not present during the instruction sessions might do some or all of the work. This was found to be the case in other trials in Malawi in which husbands were selected as trial farmers, but where, in fact, the wives did much of the work. Second, the primary technical error in the second year was with the technology. The inoculant was defective and this resulted in the major problem for smallholders not being solved during that planting season. Research now has to consider the problem again. Third, once technical errors occur, farmers might be hesitant to participate in subsequent farmer-managed trials or to follow extension recommendations.

Another group of errors were structural. First, because of certain assumptions and inappropriate models already in place, errors in targeting the appropriate groups of farmers were made. Men and women were given differential training. Women were not targeted as farmers or as trial participants, but rather were targeted for their domestic roles only. Hence, they had reduced access to new technologies and their farming problems were not known. Second, soybeans were popularized through a course in cooking and nutrition and a demand factor was created, but the production end was not set up. Little or no seed was available, inoculant and the proper fertilizers were difficult or impossible to obtain; the commercial aspects of smallholder production were not fully addressed. These aspects also affected men. Farmers were intrigued with the new crop, but the technical support was lacking. Extension had difficulty understanding research recommendations, and researchers did not know the problems experienced by the farmers and extension workers. Researchers were committed to particular methods of planting and of inoculant preparation and administration that were problematic for smallholders.

The final type of error concerned the mistake made by some Malawians and some expatriate technical assistants of thinking that the WIADP was <u>only</u> interested in soybean production or that the WIADP staff thought that soybeans were a priority crop for research. In fact, the soybean demonstrations and trials were only a small part of the WIADP's activities and were chosen because of the MOA refresher courses (Spring 1985). The WIADP was attempting to show that some problems were gender specific and some were not; the soybean demonstrations and trials provided a vehicle for this attempt. The topic was interesting to the WIADP, because of the problem between training in home economics and agriculture for women. Soybeans had been selected by the Women's Programs and Food and Nutrition sections of the MOA to improve diet, but the production aspects in terms of the smallholder had not been considered. (Fortunately, the confusion was resolved when the WIADP prepared better information about its work and disseminated this to people in research and extension.)

Finally, it is important to point out the successes and changes that occured as a result of the events described here. First, as noted above, it was shown that women were agriculturalists and interested in new technologies. Second, a precedent for extension and research interacting with each other and with farmers was set up, and technical information was rewritten with the farmer in mind. Third, the method of instructing farmers in planting trials by doing demonstrations first, and by being corrected as they went along, was noted as alleviating the major sources of farmer errors. In sum, the purpose of farming systems research is to correct errors and to improve farmer productivity, income and quality of life. But FSR only works if the errors can be admitted openly and if the appropriate corrections can be made.

FOOTNOTES

1. Male and female extension workers are now being trained at the new Natural Resources Colleges. The curriculum for the female workers is being changed to include more training in agriculture. However, the curriculum at day and residential training centers for rural women has not yet been revised.

2. The WIADP was located at the major agricultural research station in the country where soybean trials were conducted annually, where inoculant for soybean was made, and where the technical circular on soybean had been written.

3. The recommendations that had been prepared by the agricultural research station were used; planting on ridges was followed because it was the government recommendation.

4. For plots without luxurious top growth, the canopy did not reach full ground cover and the ridge spacing was too far apart. Insects were a minor problem among the plots with good growth because termite damage occured after pod formation. But where the plants were widely spaced, farmers experienced pest problems.

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TABLE 1 BREAKDOWN OF CLASSROOM TIME FOR MALE AND FEMALE FARMERS TAKING AGRICULTURAL AND HOME ECONOMICS COURSES AT DAY TRAINING CENTERS, RESIDENTIAL TRAINING CENTERS AND FARM INSTITUTES (percentages)*

SUBJECT MATTER	Day Training Centers		Residential Training Centers		Farm Institute	
	Male (Agri)	Female (Home Ec)	Male (Agri)	Female (Home Ec)	Male (Agri)	Female (Home Ec)
CROPS	48	19	44	16	33	8
LIVESTOCK	13	6	20	6	50	8
FARM MANAGEMENT	27	0	22	0	10	0
TOTAL AGRICULTURE	88	25	86	22	93	16
HEALTH & NUTRITION	12	45	66	49	3	52
CLOTHING	0	30	0	23	0	27
LEADERSHIP	0	0	8	5	4	5
TOTAL NON-AGRICULTURE	12	75	74	78	7	84

* Source: "Syllabus for Farmer Training Centres of the Department of Agricultural Development," Ministry of Agriculture, n.d.

TABLE 2 YIELD CHARACTERISTICS FROM ON-FARM SOYABEAN DEMONSTRATIONS IN EPA 2 OF LILONGWE RDP IN 1981-81.

Yield Class	Farmer's Name	Soyabean Yield	Plant Population	In-Row Plant Spacing	Innoculated Twice
		-Kg/ha-	-Plants/M -	-cm-row/plant-	
High	Chembe	2,900	30	7	Yes
High	Unit Centre	2,530	26	9	Yes
Med.	Bau	1,400	32	6	Yes
Med.	Benesi	1,210	28	7	Yes
Med.	Kazola	1,200	14	16	Yes
Med.	Baitoni	1,160	27	8	Yes
Low	Davisoni	660	20	9	No
Low	Chinoko	590	9	24	No
Low	Kabwalo	460	18	11	No
Low	Chauya	400	18	10	No
Low	Kabvala	320	11	18	No

INSTITUTIONALIZATION

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INSTITUTIONALIZING FARMING SYSTEMS RESEARCH: THE CASE OF FARMING SYSTEMS RESEARCH IN NORTHERN NIGERIA

G. O. I. Abalu
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I. INTRODUCTION

Because of the failures of national and international efforts at alleviating poverty from the low income countries of the developing world, there has been an evolution of development thinking and experience which now emphasizes the following:

(1) The small farmer remains the pivot of developmental activity in most of these developing countries.
(2) There is a necessity to re-examine national planning approaches in these countries to ensure that "development from below" is efficiently supported by "decision making from above" (Dams, 1981).
(3) The breakthroughs in science which brought about advances in the agriculture of the developed countries of the world have resulted in an increased emphasis on specialization which has inevitably channelled agricultural research in developing countries into progressively more restricted problem areas which in turn has been accompanied by an undesirable decrease in communication both between and within disciplinary areas.

The above thinking and experiences imply that future and existing development programmes for the agricultural and rural sectors of developing countries should focus more on the dynamics of small scale farm operations with a more holistic and interdisciplinary understanding. This fact highlights the need for new research orientations for developing agriculture in the third world and improving the welfare of the citizens who inhabit it. The required approach would need to refocus and re-orient research specifically to the small farm sector, benefiting from past <u>elementalist</u> efforts where necessary, but drastically altering past research and development strategies in favour of developing integrated sets of technologies which are relevant to farmer situations and circumstances. Farming Systems Research (FSR) is now receiving a lot of attention and interest as having considerable potential for providing the needed impetus in this direction.

II. WHAT IS FARMING SYSTEMS RESEARCH?

A system may be defined as a set of interrelated parts linked together in a functional manner such that the various components interact with each other, thus reflecting the characteristics by which the system as a whole is identified. The systems approach to the solution of farm problems in third world countries gained considerable world wide attention beginning in the mid seventies as a result of the persistent inabilities of these countries to meet their food and raw material needs.

The three principal elements that distinguish FSR from traditional agricultural research are the fact that (Rohrbach, 1980):

- *it involves an explicit attempt to understand the farm, the farmer, and the farm environment as a system of interdependent parts;
- *it initiates the research process with an attempt to analyse the characteristics of representative target farmers and target villages; and
- *it permits the entire process of research, including the analysis of the farming systems, the technology development and testing, and the verification of the results, to be carried out by interdisciplinary teams of social and biological scientists.

Theoretically, the processes involved in FSR should be viewed as concerned with the interrelations of all the interacting components which make up the farming systems in an area: the land itself and the structure of farms and field imposed on it, the climatic and soil fertility influences which operate, the labour resource and how it is used, the capital available for farm improvement and the relationships with input delivery, marketing and extension services, social structure, etc. In practice, however, this is far too vague and there is need to focus on delimiting the constraints which operate in a precisely definable farming system by designing and testing technologies which would alleviate these constraints (Fisher et al., 1980).

III. STAGES IN FARMING SYSTEMS RESEARCH

There are four distinguishable stages that are relevant for the implementation of an effective FSR programme at the National Agricultural Research Institute of a Third World country. The outline of these stages are presented below. It should, however, be emphasized that the stages are not necessarily mutually exhaustive, nor are they equally important for all institutes for all areas. The particular stage or combination of stages that are relevant to a particular national agricultural research institute or for a particular area would depend on what information and research results are already available.

Diagnostic Research

This stage of the FSR process can also be called exploratory research. It is aimed at understanding the agricultural problems in a particular area and identifying the key agricultural constraints that are responsible for inhibiting rapid increases in production on farms in the area. This stage of the research is usually carried out very quickly, lasting anywhere from a few weeks to a few months, but certainly with a duration not exceeding one year. The primary objective of the diagnostic research is to quickly gather information about farming problems and constraints in an area by visiting and talking to farmers right on their farms and in their homes.

On the basis of the research carried out in this stage, it would be possible to come up with a tentative description of the farming practices farmers follow in a particular area and a good understanding of why the farmers in the area follow these practices. Because the farming problems in an area are complex and interdependent, it would be desirable for the diagnostic research to be undertaken by an interdisciplinary team. This team should normally comprise, but not necessarily limited to, an agronomist, economist, and sociologist. By the time the team finishes its work, it should come up with concrete and practical suggestions of what needs to be done to remove the problems and constraints they have identified for the area. These suggestions together with a description of the problems and constraints identified for the area are then taken to the research station for the design of solutions.

On-station Research

The research to be carried out in this stage which may also be called Technology Design Research, is aimed at putting together a set of recommendations that stand a good chance of removing the constraints that have been identified for the area and, hence, solving the agricultural production problems of the area. Quite often these recommendations are already available at the research stations, and it is just a matter of putting them together in an innovative and relevant manner. At other times the possible solutions to the problems identified may not already exist at the research institute. In this case, it would be the responsibility of the institute to direct research efforts that concentrate on finding solutions to the identified problems and constraints.

On-farm Research

At this stage of the research process, the research activities are carried out right on the farmers' farms to test and verify the effectiveness of the recommendations that have been proposed earlier on at the research stations. The primary objective here is to see if the recommendations would actually eliminate the problems and constraints that have been already identified as being the main reasons why agricultural production cannot be increased rapidly in the area.

Mass Adoption Activities

What goes on at this stage is not really agricultural research as such, but an action programme aimed at ensuring that the recommended practices that have been put together and tested on a small number of farms can be replicated over a large number of farms in the area.

It is obvious that it would be impossible to achieve mass adoption of improved recommended practices without operational and effective national or state agricultural support services and institutions. It is for this reason that it is extremely important for the FSR programmes of National Research Institutes to be properly aligned to those of the agricultural development process already in motion in an area.

IV. FARMING SYSTEMS RESEARCH EXPERIENCES FROM NORTHERN NIGERIA

Agricultural research traditions in Northern Nigeria, go back to 1922, when Samaru served as a regional research station and as the headquarters of the Department of Agriculture of the Northern Provinces. Actual research in Samaru started in 1924 with the appointment of technical staff (the first being a botanist). In 1957 agricultural research became the responsibility of the Research and Specialist Division of the Ministry of Agriculture of the Northern Region of Nigeria. The Institute for Agricultural Research (IAR) was established in 1962 with the transfer of this Division from the Ministry to Ahmadu Bello University (ABU).

Since then the focus of research at IAR has been moving gradually from multidisciplinary undertakings to interdisciplinary endeavours. In this respect, three distinct but interrelated stages can be identified.

The first stage emphasized multidisciplinary research. Before the establishment of IAR, research was mainly concentrated on technical problems, i.e. on the physical and biological aspects of farm problems within a multidisciplinary framework, with little or no coordination between the technical scientists and with a conspicuous absence of the social science disciplines related to agriculture. An almost similar situation continued after the establishment of IAR in 1962 till 1965 when the Rural Economy Research Unit (RERU) was established.

The second stage involved a gradual appreciation of interdisciplinary research. Originally, research at IAR was mainly organized on a department basis which served as a nucleus for both teaching (for the Faculty of Agriculture) and research (for IAR). Staffing and funding both from the Faculty and IAR (which incidentally came from different sources) were merged at the departments level. Research priorities were mainly determined by the departments concerned, while coordination and cooperation between the physical, biological, and social scientists was limited and was mainly confined within the boundaries of individual disciplines. However, interdisciplinary focus was not completely absent. It was provided in the form of an umbrella by the governing bodies of the Institute, namely the Board of Governors and the Professional and Academic Board. Research programmes are drawn up by the sub-committees of the Professional and Academic Board, which are mainly organized on crop basis. These committees are interdisciplinary in orientation and encourage an interdisciplinary approach to the solution of farm problems.

RERU (later the Agricultural Economics and Rural Sociology Department) was represented in all the above research committees. This helped to provide a social science perspective to the understanding of the technical problems confronting each research committee. In addition, this unit particularly used an interdisciplinary approach in its research programme, drawing on the discipline of rural sociology, geography, and agricultural economics. However, the technical scientists of the Institute did not often actively involve themselves in the research programmes of the Department and RERU. This was a serious gap which needed to be closed with the passage of time.

The third stage involved a major effort to reorganize research at IAR. In 1975, ABU was federalized. Correspondingly, a new statute for IAR (1976) stressing the need for FSR following an interdisciplinary approach defined the present role of IAR as follows:

"To conduct research into the development of farming systems which involve crops of savannah ecological zones and result in the maintenance or in improvement of the soil resources, and especially in the production and products of sorghum, millet, maize, wheat and barley; cowpeas and soybeans (in coordination with other Institutes); groundnut and sesame and other oilseeds of economic importance; cotton and other vegetable fibre of economic importance; tree and horticultural crops, and shall in particular conduct research into ....the technical, social, and economic integration of cultivation of the crops into farming systems in different ecological zones and their impact on the economy."

Thus the new statute provided the necessary framework to reorganize and revitalize research along interdisciplinary lines by removing the Institute from a rigid departmental structure to more dynamic crop based programmes. The necessary interdisciplinary communication between programmes was achieved through Research Review Committees (RRC's) identified for each programme. Each programme is headed by a Leader and the RRC which he/she presides over is comprised of at least a breeder, agronomist, soil scientist, crop protectionist, agricultural engineer, agricultural economist/rural sociologist, and extension specialist. Attendance of RRC meetings is open to all IAR research staff. The RRC prepares research projects for the approval of the Professional and Academic Board and draws up research plans which reflect the priorities prescribed by the Governors.

The Farming Systems Research Programme (FSRP) is at the centre of this major reorganization at IAR as all the research activities of the other programmes have a direct bearing on its activities.

V. OBJECTIVES OF THE FSR PROGRAMME

The overall objective of the FSRP of the Institute is to provide a good understanding of the farmer, his/her farm, and the total environment in which they operate, as a system of interdependent parts with a view to evolving improved agricultural technologies which are relevant to his/her felt needs and problems.

This broad objective is being achieved through a number of sub-programmes operating within the following set of procedures:

*Identify the constraints operating to limit output of a particular farming system in the area of responsibility of the Institute.
*Evaluate, on the basis of existing information, possible

technologies which might overcome the most important constraint(s) of farmers in the area.

*Test, usually on farmers' fields, the technologies which appear to be appropriate and then either
- reject the technologies and try something else, or
- modify them and try again, or
- accept them and propose the necessary institutional and social action to facilitate their adoption (extension, input delivery, extension, marketing, social reorganization, etc).

*Hook up the successful technologies into an on-going Agricultural Development Project or Programme to achieve mass production.

*Monitor the adoption process and either
- continue to modify the technology as necessary, or
- be prepared to try something else if despite the existing on-farm research results, the technology is not widely adopted, or
- identify and propose solutions for the next most important constraint if the technology is being adopted.

VI RESEARCH SUB-PROGRAMMES

To facilitate the achievement of the general objective of the programme, its activities are being carried out under a number of sub-programmes, each with a coordinator. The present structure of the programme and its sub-programmes are discussed below.

Diagnostic Studies Sub-programme

The activities of this sub-programme are aimed at providing an understanding of relevant farming systems and agricultural problem areas with a view to identifying the key constraints that must be removed if agricultural production in the area is to be significantly increased and the welfare of the farmers meaningfully improved.

The project areas in this sub-programme are as follows:
- Exploratory surveys
- Other surveys
- Data systems

The exploratory survey has the following specific objectives:

(1) Identify the important cropping systems in different ecological zones in the mandated research areas of the Institute.

(2) Describe these systems with respect to:
   (a) Crop composition and intensity.
   (b) Cultural and agronomic rationality.
   (c) Economic and social logic.

(3) Utilize the knowledge so obtained in shaping cropping systems work at the Institute.

The relevant areas of emphasis include but are not necessarily limited to the following:

(1) Soil and rotational aspects: type of soil, length of cropping and fallow.
(2) The cropping patterns: arrangement of crops in time and space.
(3) Cultivation practices: power source, tools used, timing and phasing of farming operations.
(4) Fertility maintenance: manurial, fertilizer, and other practices used to maintain fertility.
(5) Labour use: source and profile, family or hired? labour requirements in relation to the season, priorities for labour allocation.
(6) Other inputs: source and use.
(7) Harvesting practices: when, how, and why?
(8) Pests and diseases: types, occurence, effects and control measures applied.

Although major emphasis is placed on the above aspects in the surveys, serious consideration has also been given to other relevant items in the farming systems whenever possible. Items of importance in this regard include:

(1) Storage and utilization of crops and crop residues: subsistence requirements, marketable surplus, marketed surplus, utilization of residues, insect pest and disease problems in storage.
(2) Produce and input prices.
(3) Institutional factors: agricultural development projects, extension programmes, credit facilities, input delivery systems, government policies, etc.
(4) Food consumption and preferences.
(5) Population: settlement pattern, population densities.
(6) Local industry and non-farm occupations.

From time to time there arises demand for fairly restricted types of surveys to identify and provide answers to specific constraints and problem areas. For example, a particular weed problem or insect problem could arise on which very little documented knowledge exists. It becomes necessary to embark on a quick survey of the problem to produce the required knowledge on which subsequent research work would be based. While the general procedures to be followed on these types of surveys are quite similar to those used on the more orthodox exploratory surveys discussed earlier, the precise procedures followed varies depending on the particular problem area under consideration.

Another area in which a broad based research strategy that cuts across the whole programme is needed is in the development of appropriate methods of data collection, processing, and analysis. Because FSR is a relatively new type of research strategy, there is need to evolve relevant and effective procedures of data collection, processing, and analysis in support of the overall objective of the programme. Appropriate procedures on data collection, processing and analysis need to be developed and standardized. To this end, a project area concentrating on evolving appropriate data computing systems has also been built into the diagnostic sub-programme.

On-station Studies Sub-programme

Studies carried out in this sub-programme are designed to examine the range of strategies that are thought to be relevant in dealing with the constraints identified in the diagnostic studies sub-programme, as well as other constraints which may have made themselves known through other processes.

Ideally most of the basic information needed in this sub-programme should be available from the body of existing knowledge. It is however quite reasonable to expect that there may exist situations where the needed knowledge would have to be generated from scratch. In any case, the major emphasis of studies in this sub-programme is centered around testing possible improved cropping systems into which productive technologies can be fitted. The systems of direct relevance to this sub-programme include but are not necessarily limited to; mixed-cropping systems, sole cropping systems, and irrigated cropping systems. Consequently, the project areas under this sub-programme include:

- Mixed cropping systems
- Sole cropping systems
- Irrigated cropping systems
- Other systems

On-farm Studies Sub-programme

This sub-programme concerns itself primarily with evaluating promising strategies arising from the work of researchers in the on-station studies sub-programme, other programmes of the Institute and other research institutes in and outside the country. Research in the sub-programme is designed to test recommendations originating from all these sources. Particular attention is paid to those recommendations and strategies which may be useful in removing the constraints faced by farmers under the jurisdiction of the Institute. It is expected that by removing these constraints, desirable and acceptable changes would be produced in the existing farming systems in the area.

The recommendations and improvements being subjected to evaluation are normally arrived at through a careful evaluation of the range of constraints and problems actually facing farmers. In other words, on-farm studies carried out in this sub-programme are, whenever possible, based on previous research efforts in the design stage in the on-station sub-programme. Furthermore, during on-farm studies researchers are encouraged to, as much as possible, discuss suggested improvements and strategies with the farmers themselves and with the relevant extension agents operating in the area.

The research projects in this sub-programme are either researcher-managed or farmer-managed, depending on the level of farmer involvement in carrying them out.

The project areas under this sub-programme are as follows:

- Improved mixed cropping systems
- Improved sole cropping systems
- Improved irrigated cropping systems
- Mechanization systems

Village Level Studies Sub-programme

The farming system is influenced by institutions and structures. These institutions and structures, which are established to support or influence the farming system, usually consist of collective actions which control, limit, or liberate the actions of farmers. These include marketing, credit, input delivery, extension, and social organization. To be effective, these institutions and structures must be so organized and structured that they are capable of adequately responding to improvements in the farming system. Marketing channels, for example, must operate in such a way that they do not restrict inter farm and inter regional exchange of the increased production forthcoming from an improved farming system. Credit institutions must be responsive to the increased cash flow needs of farming families who are willing to adopt improved technologies. Ready access by all farmers to the improved inputs that have been recommended is a crucial requirement for the adoption and maintenance of high productivity. Effective social organization would ensure that the benefits accruable from improvements in the farming system are not concentrated in a few hands but reach a large number of people in the rural community, thus ensuring widespread development.

Whether or not food production and the welfare of farmers can be raised through improved technologies will depend on the establishment of a whole range of effective institutions and social structures or the reform of existing ones to support improved farming systems. Since the studies in this sub-programme involve institutions and structures, they normally cut across farms located in different parts of an area. They can be said to be village or country wide, since their impact permeates the rest of society. Because these studies deal mainly with policies and structured changes, they are usually macro-oriented and involve more social scientists than technical scientists.

The studies carried out in this sub-programme are principally aimed at identifying institutional and social constraints operating in the farming system in the area and finding solutions to these constraints. The results of the studies carried out in this sub-programme are therefore, meant to provide information to policy makers, managers of services and infrastructures, and other administrative representatives who are in a position to initiate the institutional and structural reform which are considered necessary for the successful incorporation of improved farming systems. In this regard, prototype institutional and social arrangements are experimented with, usually on a small scale, and the results and implications of these results submitted to the appropriate authorities. For example, different extension methods, input delivery systems, credit schemes, etc., are subjected to experimentation with the aim of evolving an appropriate set for the prevailing circumstances and situations faced by farmers.

The project areas of this sub-programme are:
- Marketing
- Finance
- Input delivery
- Extension
- Social organization

VII. LIMITATIONS OF FSR IN NORTHERN NIGERIA

From the preceding discussions, it is obvious that there are a number of limitations of the FSR strategy as presently being institutionalized in Northern Nigeria. The most glaring of these is the omission of the livestock sub-system from the programme.

The livestock sub-system is crucial in understanding the complete farming system of an area. Furthermore, the crop production sub-system should be seen as being part of a larger household economic diversification strategy involving other sub-systems such as livestock and non-farm activities.

Then why the omission of the livestock sub-system? The problem is actually a structural one arising out of the fact that national agricultural research in Nigeria is organized along separate crop and livestock lines with each national research institute having a mandate for a prescribed number of crops or animals. Cooperation between the institute responsible for livestock production and those responsible for crop production and coordination of their research programmes and strategies might help in solving the problem. This is, however, not yet the case.

The other major limitation of the FSR programme in Northern Nigeria is that it appears to be gender insensitive. This omission is actually by default rather than by design. The research environment of the Institute is largely Moslem, where the activities and obligations of men and women appear to be clearly defined. The man provides food, water, firewood, housekeeping money and shelter for the family and gifts at festival times, while the woman provides labour for food preparation, child bearing and rearing and general domestic chores. In principle she is not expected to work on his farms or fetch water (Longhurst, 1980).

The above arguments are, however, untenable and do not provide sufficient explanation for the lack of an active gender content in the programme. First of all, the argument that women do not engage in farm work is a myth, as there now exist considerable evidence to the contrary. Secondly, it is known that almost all social transactions in the area have, as foundation, an intricate web of social linkages (Longhurst, 1980).

The inevitable conclusion here, therefore, is that the inability of the FSR programme in northern Nigeria to capture the role of inter household linkages and intra household relations into the research process is a serious omission which needs to be rectified. This is the more critical, as a sound understanding of important inter household linkages and intra household relations is a critical prerequisite for projecting both the short and long term effects of intervention strategies aimed at improving upon farming systems.

However, the framework for a gender sensitive FSR programme is already in place and functioning at the Institute. What is needed is a conscientious effort to actively capture the role of inter household and intra household relations into the overall research process.

In this regard, an important starting point is the movement away from the tradition bound, atomistic and facilitating concept of "household units" or "family units" to more appropriate concepts and boundaries for research, analysis, and action. This would be accomplished if it is recognized that the most appropriate and convenient "unit of data collection" may not necessarily coincide with those of observation, analysis, or intervention.

VIII. CONCLUSION

There is presently considerable anxiety over the deteriorating food situation in the developing countries of the world. There is now some expectation that the national agricultural research centres in these countries can contribute towards reversing this trend and achieving the development of their overall economies by reassessing their research strategies and reorganizing their research structures.

A Farming Systems Research approach lends itself well as an effective research strategy for increasing agricultural production and improving the welfare of the farming communities in these countries. Practical experiences from Northern Nigeria suggest that the conceptual framework of FSR with its interdisciplinary focus is a useful approach for improving the production of small farm families.

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INSTITUTIONALIZATION OF FSR&E IN BOTSWANA: CURRENT PROGRAMS AND ISSUES[1]

D. C. Baker and J. A. Hobbs

INTRODUCTION

Institutionalization of FSR&E in national agricultural ministries has proven to be more difficult than was anticipated a few years back. In each country where FSR&E is being tried as an organizing framework for agricultural research and extension activities, the approach has had to be adapted to a unique institutional environment. Several factors influence which approach might be most appropriate in a given national setting. We would postulate the following are among the most important:

1. the role of agriculture in national development;
2. structure of the agricultural sector;
3. historical experiences with research and extension;
4. experiences with donor funded FSR&E projects; and
5. the range of major problems currently affecting performance of agricultural departments (not just technology development problems).

This paper reviews each of these factors in Botswana and highlights implications for the structuring of FSR&E activities.

"Whether to pursue a FSR&E approach" is not a major issue in Botswana. There is currently strong support for FSR&E in the Department of Agricultural Research (DAR), but FSR&E may eventually die from inertia unless key administrators and field staff in the Ministry of Agriculture (MOA) are convinced of its value. The farming systems approach should have the 3-5 years it needs to develop a constituency of supporters throughout the Government of Botswana (GOB). For now, the key issues are (a) what form should an institutionalized FSR&E capacity take and (b) what are requirements for effective research-extension liaison.

AGRICULTURE AND NATIONAL DEVELOPMENT

Agriculture is the most important sector of Botswana's economy (MFDP, 1980). While it is not the largest sector in terms of contribution to GDP, over 80% of rural households are involved in agricultural production activities. A viable agricultural sector is necessary to stem a growing tide of migrants to towns and large villages

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[1]This paper is available upon request from: ATIP, Ministry of Agriculture, Department of Agricultural Research, Private Bag 0033, Gaborone, Botswana.

and to reduce the foreign exchange burden caused by importing food to feed a rapidly growing population.

The importance of agriculture is well recognized in Botswana, in terms of contribution to national product, food supplies and as a residual employer. The 1979-1985 National Development Plan mandated an agricultural development emphasis on arable production, limited resource farmers, and communal area livestock development. The increased emphasis on arable productivity represented a significant policy change, even though development funds for livestock programs still exceed those for arable production programs. Cattle historically have been the backbone of the rural economy. However, many households do not have cattle and the previous development emphasis on livestock production had severe equity implications. Equally important, food grain imports have been averaging in excess of $20 million annually since 1976, not to mention a growing dependence on food aid, reaching more than $10 million during the last 2 years (Sigwele, 1984).

The importance attached to the dual objectives of agricultural improvement (equity and food self-sufficiency) led to an expanded allocation of public resources to the Ministry of Agriculture (MOA) during the 1979-85 National Development Plan. Still, financial and trained manpower resources available to the Ministry of Agriculture continue to be extremely limited (Litschauer, 1980). Not unexpectedly, there has been little progress toward the goals envisioned for agricultural policy in the 1979-1985 National Development Plan. If anything, after 3 years of drought and a phasing down of donor funded agricultural research[2], realization of the goals lies more distant in the future.

The current National Plan ends next year. The 1985-1991 National Plan calls for a continued emphasis on arable production but, reflecting impact of an on-going drought, stresses measures to increase total production. As a result, several production systems are targeted for improvement: under irrigation and in floodplains as well as in dryland farming; for medium resource farmers as well as the low resource farmers targeted in the current plan.[3] Demands on agricultural research and extension can be expected to increase correspondingly. FSR and close

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[2]Three donor funded agricultural research projects responsible for a large portion of current research, including 2 of the 4 major farming systems projects, are being phased out. None will last beyond the coming cropping season.

[3]The potential for irrigation is limited in Botswana. Irrigation projects would likely require major capital investment and would be centered either in the freehold sector or in the northwest of Botswana. In either case, the number of producers benefiting would be small. Thus, expressed interest in irrigation and medium resource farmers represent a subtle but significant shift in national policy toward an increased emphasis on production goals, even if at a cost in terms of rural equity.

research-extension liaison are explicitedly identified as major vehicles for agricultural improvement (Sigwele, 1984).

AGRICULTURAL SECTOR OVERVIEW

Characteristics of the agricultural sector structure are presented in Table 1.[4] There is a very small freehold sector comprised of 360 farms which accounts for a disproportionate share of area cultivated, total food crop production, and cattle offtake. A minor proportion of government research and extension activities are oriented toward the freehold sector, despite its contribution to total production. This reflects a political judgement that the predominantly white freeholders can and should be largely self-sufficient in gaining access to capital resources and technological recommendations.

Table 1 highlights the dominance of livestock in Botswana's agricultural economy. The national cattle herd is estimated to be 2.4 million and this is down from estimates of 3 million before the current drought. These figures can be compared to a population of around 1 million people. Farms with cattle have on average 40 head. The relative wealth and security provided by substantial cattle herds importantly influences farm management stgrategies of Batswana. MOA programs must take this into account, as well as two less promising facts:

1. nearly 30% of households have no cattle and many others have very few cattle, and
2. annual offtake from cattle herds is extremely low.

The offtake figure in Table 1 is around 10% but this was following a second year of drought. If the drought ends, offtake figures over the next 4-5 years could be even lower as farmers try to rebuild their herds.

As is true throughout much of Africa, smallstock and poultry are owned by most farmers and represent an underexploited opportunity for farm productivity improvement.

Crop Production

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[4]Figures in this and the next table are based on a national agricultural census conducted annually. The survey is a joint effort of the Agricultural Statistics Office of the Division of Planning and Statistics in the Ministry of Agriculture and the Central Statistics Office in the Ministry of Finance and Development Planning. The sample frame used for the survey is the 1981 Botswana Population Census Frame (the first year was based on an earlier population census). One-third of freehold farms were randomly selected. Each year, approximately 2,000 traditional farms are selected in multi-stage sampling with a probability of selection in each area proportional to the number of dwelling units.

Sorghum is by far the most important crop in Botswana. Approximately 90% of farms growing crops plant sorghum and the area planted to sorghum mixtures accounts for much of the area planted. Maize and various beans, particularly cowpeas, are grown by most households, as are various types of melons, watermelons, and sweet sorghums.

Total production of the major food crops is extremely low, as can be seen in Table 2. Even in the best year of the four presented, 1981, total production of all four categories of food crops combined was under 50 kgs/person living in Botswana. Yield figures for even the fairly normal seasons of 1980 and 1981, just over 200 kgs/ha of sorghum, reflect what many farmers might expect to harvest but this can range from 0-600 or 800 kgs/ha.

The sequence of seasons in Table 2 shows the susceptibility of crop production to low and unreliable rains. Average annual rainfall is around 500-650 mm. in the areas producing the bulk of arable crops, with a unimodal distribution concentrated between November and March. Periods of drought take place nearly every year but total rainfall and rainfall distribution were particularly poor in 1982 and 1983, resulting in almost complete crop failure. Figures of 80-100 kgs. of sorghum and 12-15 kgs. of beans per farm during 1982 and 1983 are only as high as they are since some farmers in some localities were quite lucky.

Crop production trends hold two key implications for FSR&E activities in a country were arable productivity improvements are a major objective of agricultural development policy.

1. Rural Batswana would be foolhardy to try to rely on crop farming. In fact, crop farming is a less important income source than livestock, traditional beer brewing, and remittances for a majority of Batswana farming households. Public and private resources devoted to arable productiuvity improvements have high opportunity costs relative to returns likely in arable production, even with improved practices.

2. Cropping results obtained in any season are largely beyond control of individual farmers. As a result, most farmers follow a minimal input approach to crop farming.

Farm Practices

Farming practices are quite similar throughout Botswana, although there is enough variation to be taken into account in the Ministry of Agriculture's research and extension programs. Still, the problem is more one of finding any alternative sets of practices, rather than location specific adaptation of technologies.

Promotion of animal traction is not an issue in Botswana, as it is in many African countries. Nearly all land is mechanically ploughed and has been since the mouldboard plough was introduced in the early part of the century. Most draft power is provided by cattle (64% of households), usually teams of six to eight.[5] Tractor (24%) and donkey (10%) traction are rapidly becoming major sources of draft power. Private contract services account for most of the tractor traction used. The potential associated with an increased use of tractors, such as earlier ploughing and deep ploughing, is of major interest to the MOA. Donkeys may also have some advantages relative to large teams of untrained oxen, and are an important component of a national farm capital loan program. Despite limited importance nationwide, donkeys have nearly completely supplanted cattle traction in 10-15% of villages. The whole farm system implications of shifts in draft power is an important area of research.

A majority of farms rely on traction they own, but 44% either hire traction or obtain it through family help or various forms of resource exchange or sharing agreements. Ownership is important since non-traction owners cannot control the timeliness of ploughing vis-a-vis planting rains. Timely planting is one of the major determinants of plant stand establishment, which is in turn a major determinant of cropping outcomes (ATIP, 1983). Essentially all recommended changes in cropping practices derived from experiment station research have required that farmers have control over draft resources. Research on solutions for non-traction owners has only been considered important in the last 5 years and the extension service has yet to make a significant reorientation toward non-owners.

Nearly all crops are broadcast seeded (91% of farms) and most seed is planted in mixtures (70% of sorghum and maize seed: 87% of cowpea seed). This is remarkable in light of extension efforts for over 30 years (ARS, 1959) to encourage farmers to row plant. Improvements in planting methods remains a top priority for research and extension officers but no one has yet demonstrated to farmers' satisfaction that "improved practices" are really improvements.

Very few farmers use fertilizers, either manure (5% of farms) or chemical (3% of farms). Manure application is an extension recommendation but is not a priority topic. Most cattle in Botswana are kept on communal grazing areas, often some distance from farmers' fields, and it is not considered practical to collect and apply the quantities of manure necessary to achieve a significant response on a whole field basis.

Few Batswana farmers weed more than once (8% of farms) and many farmers will not bother to do a single weeding unless a sufficiently promising plant stand is achieved. The amount of weeding done is a classic case of farmers making intraseasonal adjustments to anticipated cropping outcomes. Multiple weedings, as a means of improved soil cultivation, as much as for reducing weed burdens, is another long standing research-extension recommendation which farmers view as being of questionable value.

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[5]These figures, referring to the 1982-83 cropping season, are drawn from ASU & CSO (1984).

RESEARCH AND EXTENSION IN THE MINISTRY OF AGRICULTURE

Agricultural research and extension activities, and interaction between extension and research workers in Botswana, have generally been less effective than government and agricultural administrators wished them to be. In an attempt to improve these the organization of the Ministry of Agriculture, particularly of the extension section, has undergone many changes over the years.

Historical Perspective

Initially all agricultural and livestock activities of the government were centered in Mahalapye. The first research/extension officer posted to the Department of Agriculture (in 1926) was a Dairy Inspector. This officer of the Dairy Division was assigned a dual responsibility: finding best management practices for dairy production and persuading local farmers to adopt them. His activities involved trials and demonstrations on local farms.

In 1935 all government agricultural endeavours were incorporated into a Ministry of Agriculture and the Dairy Division was renamed the Agricultural Division. The following year the first Agricultural (as opposed to Livestock) Officer was appointed. The new Officer began work by planting crop observation trials. Early research investigtaions consisted of trials and demonstrations on farmers' fields in the Mahalapye area. Later, more precise studies were undertaken on land controlled by the research organization: the Morale Pasture Station and the Mahalapye Experiment Field.

Over the years, additional staff members have been appointed and agricultural services have been expanded. Meanwhile, research and extension have grown farther apart.

By the mid-1960s, the Division of Agriculture had been split into two departments, Agriculture and Veterinary Services and 10 units had been established in the Department of Agriculture. Research was undertaken in many of these units and many were involved in extension activities. Administrators and most senior staff, including specialist extension officers, were headquartered in Mahalapye. The main experiment station was located at Mahalapye but research activities were decentralised, with 8 experimental unit fields distributed across the country. Similarly, extension personnel were posted to 12 district offices.

In 1966, the Ministry was moved to the new Capitol, Gaborone. Research and related activities moved to Sebele, 10 km north of Gaborone, in 1967. Work at Sebele from 1968 to date has included variety trials of dryland crops, soil fertility and crop rotation experiments, soil moisture studies and entomological investigations (Gollifer, 1979).[6]

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[6]The Dryland Farming Research Scheme (DLFRS), established in 1971 at Sebele, has been the backbone of arable research activities in Botswana over the past 15 years. Studies have been made of tillage methods, planting dates and plant populations, moisture conservation, crop physiology, crop protection, and implement design and construction. DLFRS will end after the coming season.

Since 1970, livestock research has been conducted under auspices of the Animal Production Research Unit. While a limited program of range management research had been conducted since the 1930s, there was little information at independence in 1966 on which to base extension advice for the country's livestock sector (APRU, 1980). APRU's first priority has been improvement of beef production through breeding. Its general emphasis has been development of a technical basis for commercialization of the beef industry. Little attention has been given to herd owner objectives, communal area management practices or to motivations in livestock raising (Behnke, 1982).

By the late 1960s and early 1970s it was clear that the Agricultural Extension section was not accomplishing its mission in a satisfactory way and, separated physically from agricultural research activities, liaison between extension and research deteriorated. Agricultural extension activities were being carried out by several sections in the MOA. There was great overlap and much confusion.

In 1975, after an exhaustive study of the Ministry structure, functions, and activities, especially extension, the Ministry was reorganized into four departments: Animal Health (veterinary), Agricultural Research, Agricultural Field Services (extension), and Cooperatives. A Division of Planning and Statistics and the Botswana Agricultural College were also included. This remains today the basic organization of the MOA.

Current Organization of the MOA

The major units responsible for research and extension activities are the Departments of Agricultural Research (DAR) and Agricultural Field Services (DAFS), respectively. Some sections of the Division of Planning & Statistics (DPS) conduct on-farm research but this research generally is not to support technology development and dissemination.[7] The DPS, attached to ministry headquarters, is far removed administratively from the DAR and DAFS.

The Department of Agricultural Research (DAR) consists of a Division of Arable Research, an Animal Production Research Unit, an Estate Management Unit, and a Laboratory Services Unit. At present, the primary location for field research is the Content Farm at Sebele, where the main experiment station is located. Sub-stations are located at Goodhope, Mahalapye, Motopi, and Moshu. Experiments are also conducted by a mobile soil fertility unit on farmers' fields. The Animal Production Research unit conducts research on 18 MOA farms spread throughout the country. Three FSR&E projects, carrying out studies and experiments on farmers'

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[7]The Farm Management Unit conducts an annual farm management survey of approximately 165 farmers. The Agricultural Statistics Unit conducts a less intensive national agricultural survey each year of a large sample of randomly selected farmers. The Rural Sociology Unit has been quite active in village level research, particularly on the subject of local institutions.

fields in four of the five major agricultural regions, are under the direction of the Chief Arable Research Officer. (The fourth FSR&E project, working in the remaining main agricultural region, is located in the Department of Agricultural Field Services.)

The Department of Agricultural Field Services (DAFS) contains four major divisions: Animal Production, Crop Production, Land Utilisation, and Agricultural Management Associations. An Agricultural Information Section, servicing the entire MOA, and a Field Section are also included. The latter is the major field operations unit in the Department. The above divisions and sections of DAFS, particularly the Field Section, are responsible for all direct farmer contact by the MOA, except that done by Animal Health and Cooperatives. These two units retain their own extension staff.

On paper the organization is a good one. Chains of command are spelled out clearly. Extension work is funnelled through the village-level worker who is best acquainted with problems of the area and with the needs and desires of individual farm families. Technical information is provided to field workers (in principle) by regional specialists, who are expected to keep up-to-date in their subject matter areas by reading, observation, contact with outstanding farmers, and with research workers. Unfortunately, as is discussed below, the research and extension departments do not function as is envisoned on paper.

CURRENT FSR&E PROJECTS

This section presents an overview of the four major FSR&E projects in Botswana. The overview of each project is necessarily selective: each project has been active for multiple seasons and has involved efforts of numerous field officers and support staff. Moreover, foci of research and methodologies of each project have been evolving over time. Attention will be centered on approaches to FSR&E as these relate to eventual institutionalization of FSR&E in Botswana.

Evaluation of Farming Systems & Agricultural Implements Project (EFSAIP)[8]

EFSAIP, started at Sebele in 1976, was the first multidisciplinary project specifically mandated to test agricultural technologies on farmers' fields in Botswana. The project was not conceived as a farming system project. The original objective was to test under farm conditions the possibility of reducing animal draft team size by use of a multi-purpose tool carrier. The tool carrier was compared with the extension recommended system of mouldboard ploughing and row planting, and to the traditional broadcasting system.

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[8]This section is based on Brown et al. (1983). Information on recent EFSAIP activities is available in EFSAIP (1984).

Within a couple of seasons, the orientation of EFSAIP shifted to a systems perspective. A main impetus to the shift was failure of the target technology, the tool carrier, to reduce draft power inputs when used under farmer conditions. The project objective was modified toward development and testing of alternative machines and cultivation practices. At this stage, system description/diagnosis became an important project activity.

EFSAIP is unique among the FSR&E projects due to use of both research station and farmer field trials. The project continues to be located at Sebele, where technology design, prototype fabrication and testing take place. Farm trial work is carried out with cooperating farmers in adjacent land area.

EFSAIP has pioneered use of the extension service in the dissemination phase of their program. After promising farm trial results with row planter and plough-planter (a planter unit mounted on a plough) units, initially designed by the EFSAIP agricultural engineer, a country wide testing program was established in cooperation with the extension service. Through this program, more than 100 of each unit have been made available to ADs throughout the country to use in trials/demonstrations on farmers fields.

1984 is the last season for which EFSAIP is funded. Currently, it is planned that EFSAIP will leave behind two residual units: a farm machinery unit running an implements workshop and a small farming systems unit comprised of an agronomist. The agronomist will be supported by local ADs, thereby institutionalizing a linkage with extension. It is expected that these units will soon be staffed and financed from the recurrent budget of DAR.

Integrated Farming Pilot Project (IFPP)[9]

IFPP is the most distinctive approach to FSR&E in Botswana, combining elements of both the farming system approach and the integrated rural development (IRD) approach which was popular in the 1970s. Also, IFPP is the only FSR&E project institutionally located in the extension service. IFPP officers have on-line extension positions for the Pelotshetlha District where the project is located. Six project ADs act as research assistants as well as extension agents.

Phase I of IFPP started in 1975. Initially, the project had two aims:

1. to test under on-farm conditions new systems of cultivation developed by research, and

2. to pilot an integrated approach to rural development.

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[9]This section is based on Hunter (1983) and IFPP (1983).

IFPP provided the extension situation under which farmers tried out recommendations. As a pilot development project, efforts were undertaken to create a favorable environment for farmers to modify their farming practices. For example, project ADs were assigned 1/2 to 1/3 as many farmers as other ADs and had 1/10 to 1/50 as much area to cover. In addition, several activities were supported which increased farmer welfare directly as well as improved circumstances for technological change.

Despite favorable circumstances, IFPP found, as did EFSAIP, that many advantages envisioned for MOA recommendations did not work out. Little progress was made in modifying recommendations since IFPP only worked with farmers trying proposed packages and therefore had no comparative basis for designing modifications or alternatives. However, IFPP was able to identify lack of draft power and machinery, unfenced land, and a need for more reliable sources of drinking water as possibly greater constraints than failure to adopt new dryland farming methods. These conclusions were an important factor influencing design of a national farm capital subsidized loan program (Purcell, 1982).

Phase I of IFPP ended in March 1981. There was a substantial reorientation of the project during Phase II. In Phase II, descriptive and diagnostic research has received much increased priority. Farmer participation has been expanded to take account of the on-line extension responsibilities of the project. Implements testing has been deemphasized relative to evaluating flexible management strategies and IFPP is leading the way nationwide in communal area livestock research.

Phase II of IFPP will run until March 1985. Several positions held by IFPP officers will be absorbed into the DAFS field section for the Southern Region. The extent to which these positions will be redefined to have regional responsibility, rather than continue to focus on the current project area, has not yet been worked out.

Experiences of IFPP point out difficulties of defining solutions for general improvements in rural income and farmer welfare, as opposed to the narrower task of defining solutions for improving agricultural productivity. Three particularly key issues facing the MOA in evaluating the IFPP experience are:

1. Can the country afford to concentrate a comparable level of resources into relatively small, progressive areas and, even if this is possible, is it the best long run development strategy?

2. Would more progress have been made toward agricultural improvement goals if the project had not had such a broadly diffused development program?

3. While infrastructural and institutional development are needed components of the development process, should responsibility for for these tasks be assumed by MOA FSR&E activities when other ministries otherwise have responsibility for efforts in these areas?

These questions are not easy to answer for IFPP since, unlike IRD projects in other countries, IFPP does have a strong production systems component which could, in principle, lead to self-financing development.

Agricultural Development Ngamiland Project (ADNP)[10]

Phase I of ADNP started in 1979 with the following objectives:

1. to design, develop and promote appropriate agricultural technological packages for different socioeconomic farmer groups, paying particular attention to resource poor farmers, and
2. to provide useful information about circumstances of farmers in particular, areas which could be of vital importance to other agencies.

With a dual mandate of technology development and farming systems policy perspective, ADNP was the first project in Botswana to be established as a farming system project. Phase I was oriented toward system description and diagnosis. System diagnosis focused on arable management practices, draft availability and importance of non-agricultural income activities.

Phase II, which focused on technology development and dissemination, started in 1982. During Phase II, ADNP activities have been concentrated on the Communal First Development Area (CFDA) which covers three villages in Ngamiland West. Integration of ADNP into a CFDA framework is a distinctive feature of the project.

CFDA is a development approach being pursued by the Ministry of Local Government and Lands. The concept of CFDAs is based on an assessment that there is a need for comprehensive development efforts to be targeted in selected communal areas (Brown, 1982). A CFDA is identified in each administrative district where integrated rural development packages are designed and implemented with a goal of raising rural incomes and creating jobs.

The role of ADNP in the Ngamiland West CFDA is to design and test improved technologies with different groups of farmers in conjunction with the extension service. Also, ADNP meets with other CFDA personnel on a regular basis in an effort to help formulate policies for the CFDA and establish priorities for support system development. The key distinction between approaches being followed by ADNP and IFPP is that ADNP is providing an FSR&E component to an existing government development program rather than subsuming a range of development activities into a FSR&E project.

ADNP is scheduled to continue until 1986, when the CFDA program in Ngamiland will end. Unlike the situation faced by other FSR&E projects

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[10]This section is based on Maphanyane et al. (1983).

in Botswana, ADNP deals with two distinct farming systems: melapo farming, which is based on use of floodplains after flood water recedes, and dryland farming. Also, unlike farming systems elsewhere in Botswana, farming in Ngamiland is dominated by maize and many farmers rely on crop production as their primary livelihood.

Agricultural Technology Improvement Project (ATIP)[11]

ATIP, started in 1982, is the first FSR&E project initiated with an explicit goal of improving the capacity of the MOA's research and extension departments to develop and effectively extend farming systems recommendations. Several component activities contribute to this purpose:

1. An agricultural economist has been based at the Sebele research station to strengthen the capacity for multidisciplinary analysis of research results and to provide an input into planning at MOA headquarters.

2. An agronomist has been appointed to a newly created position of Research Extension Liaison Officer (RELO) to help strengthen linkages between research officers in DAR and extension personnel in DAFS.

3. Two FSR&E teams have been established: one based in Mahalapye with a mandate to cover the Central Agricultural Region and one in Francistown with a mandate to cover Tutume District in the Francistown Agricultural Region.

4. 22 person-years of long term training, and opportunities for short-term training, are being provided for MOA officers, with a view toward reducing trained manpower constraints in the MOA as well as leading to a permanent capacity for FSR&E.

During the first two years of the project, ATIP concentrated on technology development and improvement of research-extension linkages. Long term training commenced for six individuals. Six additional MOA officers are receiving on-job training as counterparts to ATIP personnel.

The core of the project is the two FSR&E field teams. Each team is comprised of an agronomist and an agricultural economist. In addition, an animal scientist is based in Francistown, with a mandate to conduct research in both project areas. The Mahalapye team was established first in 1982. The Francistown team began research in 1983.

The two ATIP FSR&E teams set independent research agendas, but with a substantial commonality in research methodology. Both teams:

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[11]Additional information on ATIP objectives and research approach is available in ATIP (1983, 1984).

1. give priority to whole farm studies, involving a multiple visit resource use study and field technical monitoring;
2. focus research on target groups defined in terms of endogenous human circumstances rather than institutional or technical circumstances;
3. use a semi-case study approach to facilitate a detailed longitudinal understanding of farmers' problems and objectives;
4. rely on special subject technical and interview surveys to generate information on particular problems or subject matter topics in a time and cost efficient manner (taking advantage of the project's three micro computers); and
5. are exploring a wide range of system interventions, with an emphasis on modified tillage-planting systems, via trials with varying levels of researcher and farmer involvement.

ATIP is institutionally linked to the extension service in two ways. Foremost is the RELO. The RELO has pursued several efforts to improve research and extension linkages.[12] Second, the FSR&E field teams are linked with DAFS, DAR, and the Division of Planning and Statistics (DPS) through secondment of officers to ATIP. The FSR&E teams also have given priority to developing informal liaison with extension at the regional level. These efforts have included the following:

1. DAFS officers are kept informed as to ongoing activities and have visited on-farm trials on many occasions.

2. Extension agents have been informally and formally interviewed in order to gain their perspective on farmers' problems, constraints on AD effectiveness and priorities for research.

3. A seminar on contributions of the farming systems approach to ADs was presented to ADs in the Central Region at an in-service training course (Baker and Norman, 1983).

4. Plans have been finalized to cooperate with the Central Region Crop Production Officer in an ATIP designed tillage-planting scheme to be implemented by six selected ADs. This represents an exploratory step toward incorporating ADs into the final state testing of technologies.

PROBLEMS AFFECTING INSTITUTIONALIZATION OF FSR&E

FSR&E is not viewed by MOA administrators in isolation from the

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[12]The primary activities of the RELO have been: (a) repeated visits have been made to each DAFS regional and district office; (b) a survey was administered to all research and extension officers to gain insight as to problems and opportunities for promoting improved linkages; and (c) a farming system workshop was organized to explain the objectives and methodologies of FSR&E to DAFS fields officers (Hobbs, 1984).

entire range of activities of the MOA. The eventual fate of FSR&E and the format to be taken in FSR&E activities depends on contributions FSR&E activities make to solutions for the entire range of problems and issues facing the MOA. This section identifies several key problems which are likely to affect the future of FSR&E in Botswana.

Lack of Research Recommendations

Crop research investigations were started in Botswana nearly 50 years ago. In spite of a long and active research program, research findings have been minimal. Because research results have been limited, crop production improvement strategies suggested by extension to farmers have not changed much over the last 30 years or so.

The lack of progress in generating new recommendations for the extension service holds three key implications for FSR&E:

1. FSR&E is not likely to identify changes in practices which will significantly increase farmer productivity in a reasonable short time frame. As a result, FSR&E must seek ways of gaining credibility and support of top MOA administrators other than usual promises of quick results (Norman and Baker, 1984). Each FSR&E project has decided it is necessary to invest a large amount of time and resources into system monitoring in order to identify sources of variation in system performance. On-going systems description and diagnosis is like to be a permanent feature of FSR&E in Botswana.

2. The extension service has been communicating incorrect or partially correct messages to traditional farmers for so long that neither these farmers nor extension agents are likely to be receptive to FSR&E recommendations. Much effort will have to be put into dissemination stage activities and extension agents will have to be kept informed and active in the technology development process in order to generate enthusiasm for FSR&E recommendations.

3. Lack of recommendations reflects lack of possibilities. FSR&E recommendations are likely to pertain to minor modifications of existing recommendations, to increase the likelihood of benefiting farmers. The level of benefit still may not be great in many years. Thus, the FSR axiom of concentrating on improved practices offering net benefits of 30-50% are irrelevant in Botswana. No clear rule of thumb exists to direct research, whether toward leverage points having higher potential returns, but unlikely to be implemented by farmers, or minor changes with minor impacts in most years, but ones that can be more easily tried by farmers.

Shortage of Research Funds

Botswana has a small population and is not a wealthy country. Funds for development, although greater than those available in many low income countries, are not sufficient to do all that could, or should, be done. Shortage of funds for research has restricted the range of research projects that have been undertaken and has curtailed funding that can be assigned to each. This has usually meant that numbers of staff have been low and activity in each area is often inadequate.

Shortage of funds has prompted the GOB to search for donor agencies willing to support needed research projects. When this happens some good work is accomplished but partial control over research priorities passes from Batswana staff to that of donor agencies. The fact that past FSR&E projects have been funded by donor agencies has been of great financial benefit to Botswana. The fact that this has meant compromising MOA control over research activities has not eluded MOA administrators.

FSR&E projects are in a position where they have to demonstrate benefits of the FSR&E approach to justify donor agency influence, even where nearly 50 years of prior efforts have not done so. To the extent concrete results are not apparent to MOA administrators, the farming systems perspective and current calls for close research and extension liaison could be rejected without adequate trial as part of a broader movement to gain control over national development efforts. On the other side of the coin, the ephemeral interests of donor agencies are notorious. FSR&E could be abandoned by donor agencies before FSR&E activities in Botswana have had time to develop an "institutionally location specific" model of FSR&E which is within the recurrent budget and manpower constraints of the GOB.

<u>Preponderance of Expatriate Staff</u>

Because of Botswana's shortage of trained manpower, particularly those with university degrees and post graduate qualifications, the senior posts of the DAR are filled largely with expatriates. A 1980 study showed 66% of posts in the MOA were localized, but that only 38% of top professional posts were Batswana and only 23% of posts in Agricultural Research were localized (Litschauer, 1980). The only alternatives to a largely expatriate senior research staff in Botswana would be (a) to put less qualified people with little or no research experience into senior positions, or (b) to reduce research activity drastically.

Dominance of research by expatriates can have unfortunate effects on the research process and on development in general.

1. Expatriate officers initially are not as familiar with the major agricultural problems as a local officer should be.

2. Expatriates are less familiar with the language and customs of Batswana and cannot as easily become acquainted with the situation facing farmers as a local researcher can.

3. Since many expatriates stay relatively short periods of time, they may leave before their increasing knowledge helps and before projects they initiate have reached a fruitful stage. Research may lack continuity.

4. Where these officers are supplied by a donor agency, they usually are working on a pre-arranged project that is relatively difficult to amend or modify.

   Accordingly, unanticipated conditions that arise between project implementation and completion cannot be studied, no matter how important they may appear to be.

At this stage in Botswana, it would be difficult - if not impossible - to institutionalize FSR&E field teams, even if funding problems could be overcome. There are too few Batswana with sufficient training to design and implement farming systems programs. For this reason, institutional inflexibility stressing establishment of separate FSR&E units and FSR teams is likely to work against the possibility of institutionalizing a farming systems approach in Botswana. In the foreseeable future, competent individuals with advanced disciplinary training will be needed to staff top administrative positions and Sebele basic research programs, rather than be sent to do adaptive field research in particular localities.

The lack of trained manpower introduces another issue in the stationing of MOA officers. If an individual is one of few with advanced training, he or she is unlikely to accept assignment to a small town or village while colleagues with comparable training are living in Gaborone and quickly working their way up the administrative ladder.

Typology of Farm Experiments

In an ideal FSR&E world, proven component technologies are available from experiment station research which can quickly be combined into two or three best bet packages to be screened in on-farm trials. Farmers play a role from the beginning of the adaptive research process and as soon as possible carry out farmer managed and farmer implemented tests (FM, FI). The ideal situation does not exist in Botswana.

Three circumstances suggest researcher managed and implemented trials (RM, RI) and researcher managed, farmer implemented trials (RM, FI) will need to play a relatively greater role in FSR&E than FM, FI trials in Botswana.

1. Personnel in all the FSR&E projects agree that differences in endogenous circumstances of households dominate technical and exogenous human (institutional) circumstances in determining the set of farming practices used by a household. It would be impossible to screen technologies for all the possible combinations of household endogenous circumstances.

2. There is a long history of research on sub-stations. Sub-station research already provides information on trial results under different rainfall and soil patterns. This research is less expensive than would be location specific research on farmers' fields.

3. Farmers cannot be expected to provide controls necessary to evaluate relationships between circumstances and outcomes. Optimal conditions for planting are limited in most years and farmers naturally give priority to their activities rather than researcher initiated activities. Years can be lost by researchers when farmers fail to put in trials when and how instructed. Approaches leaving most management to the discretion of farmer shave not been successful in getting farmers to "control" even the one or two experimental variables that constitute the core of a trial.

The main implication of the above for FSR&E is that an efficient research resource allocation strategy will leave responsibility for fitting technologies into the circumstances of particular types of households to village extension workers. An "up-the-ladder" orientation would also mean extension agents have to be closely integrated into the technology screening process so they will understand advantages and disadvantages of each technical change for households with different endogenous circumstances.

Extension Approaches

The main activity of early extension workers in Botswana was demonstration in farmers' fields.

In 1964 the Pupil Farmer Scheme became the established mode of agricultural extension. In this approach, each Agricultural Demonstrator (AD) concentrated on improving the practices of about 25 farmers. In order to qualify for the scheme a farmer had to own a plough and draft oxen, and needed some destumped land.

The scheme's concepts were sound and participating farmers did become much more productive with time, but recommended technologies rarely spread from pupil farmers to their neighbors. Also, ADs were often too busy with their pupils to spend time with other farmers. This meant that extension workers had influence on a very small segment of the total farming population.

With an apparent need to broaden the clientele of ADs, the thrust of the extension approach was changed in the mid-1970s. ADs now are required to work with groups of farmers whenever possible. Different approaches are used for communicating extension messages to the entire farming community, including demonstrations, speaking at village meetings, and participating in village groups.

Although change away from the Pupil Farmer Scheme may have been needed, the loss of contact with and response from progressive farmers had a psychological effect on many ADs. They lost enthusiasm for their work and some never gained it back. Moreover, most ADs continue to work primarily with more progressive farmers, but do so less effectively than they did when the Pupil Farmer Scheme recognized the advantages of doing so.

FSR&E activities might facilitate adoption of an extension approach which is in between the Pupil Farmer Scheme and the community-at-large approach. The "recommendation domains" concept in FSR methodology calls for identifying solutions for groups of farmers facing the same key problems and having similar exogenous and endogenous circumstances. If potential solutions can be found for a few easily identified RDs, extension workers can be instructed to work with representatives of each domain.

To enable a move toward a RD or target farmer approach in extension, FSR personnel, Sebele researchers, DAFS and the Division of Planning & Statistics will need to agree on an RD framework which reflects (a) farmer circumstances, (b) existing and potential production technologies, and (c) national objectives for the agricultural sector.

Lack of Training of Extension Workers

Most extension workers in Botswana are not adequately prepared for their jobs. It is difficult to get well trained manpower to support the development work that needs to be done; untrained individuals are more easily overwhelmed and therefore less likely to engage in a range of activities promoting a range of solutions for a variety of targeted farmer categories. Additional steps must be taken to do the best possible job of training extension workers before they begin their service. In addition every opportunity must be taken to increase their expertise as they work on their jobs.

Formal training is likely to continue to be a major constraint. Certificate holders (Agricultural Demonstrators and Agricultural Supervisors) have a minimum of academic training, three years of secondary schooling or less, and their professional training is short and superficial. Even specialist officers in the regions and at headquarters are seldom specialists by either training or experience when they start their work in the Department.

It appears that the best hope for developing a better trained cadre of extension workers is to establish a good in-service training program. For this to take place all levels of staff must undergo training so that senior officers will be able to train newer or lower level of staff. Because they are: (a) involved in research and extension, (b) have close contacts with experiment station researchers, extension field workers, and farmers, and (c) generally have advanced disciplinary training. FSR&E personnel can gain tremendous visibility and credibility by leading the way in developing appropriate in-service training courses.

Lack of Personal and Professional Support

The morale and efficiency of individual extension workers is low. Extension workers blame this on lack of support for their field activities. Inadequate housing, poor or no extension equipment, insufficient transport, little supervision, and poor opportunities for advancement are but a few of the complaints commonly heard from ADs and field officers.

Some complaints arise because funds are lacking to run the extension service, but some, if true, must come from lack of interest or dedication on the part of administrative personnel in DAFS. The main purpose and function of all administrative and specialist staff in extension should be to train and support field workers (ADs and ASs) in the work they need to do. However, there seems to be little interest in this type of activity in the DAFS, and even if there were interest, funds to address many AD complaints are lacking.

Until steps can be taken to improve the working and living conditions of extension agents, there will be a morale problem and inefficiency. While successful FSR may generate enthusiasm among ADs for their work, a more important lesson for FSR personnel is that they should have minimal expectations for the contributions of ADs to technology development and monitoring for the foreseeable future. Even efforts to stimulate discussion among ADs over farmers' problems and potential solutions may be seen as one more burden rather than an acknowledgement of AD expertise.

Burden of Regulatory and Other Non-Education Activities

The major responsibility of agricultural extension workers should be non-formal education of rural people. Unfortunately, there is a tendency for many individuals and organizations inside of and outside of government to look on field extension agents as a handy source of labour ready to undertake a great variety of activities. These activities may help farmers and may actually be good programs, but non-education activities reduce the agent's time to do the job he or she needs to do. Drought relief supervision, organizing and supervising work-for-food programs, measuring acreages for ploughing subsidies, dispersing seed, etc, are all useful activities, but they leave extension workers with little or no time to perform their essential function as agents of change.

When useful FSR&E screened packages become available and extension agents have a good set of practices to promote, many other chores will have to be taken from them so that they can do their job. Of course, the question remains as to who else will perform the various required service and regulatory activities now performed by extension agents.

Isolation of Research Officers from Extension Workers and Farmers

The Department of Agricultural Research is located at Sebele, with most senior researchers housed there. The Department of Agricultural Field Services is headquartered in Gaborone. DAFS regional and district staff are dispersed throughout the country. Field workers often are located in rural areas far from district and regional offices. Accordingly it is difficult for research workers to meet extension administrators, and even more difficult for researchers to meet extension workers and farmers. Lack of contact has two major effects: research workers may not study the right problems, and solutions developed by research may not be transferred to the farmers.

Steps taken under the four FSR&E projects have made substantial contributions toward improved research and extension liaison. But FSR&E

personnel represent a minority of DAR and DAFS officers. The continued isolation of a majority DAR researchers from the rest of the MOA, and from farmers, does not suggest there is much room for optimism regarding the priority placed on research and extension liaison. For the present, FSR&E personnel need to explore ways liaison might be better accomplished among all research and extension officers, not just those engaged in FSR&E activities.

CONCLUDING COMMENTS

The harsh and unpredictable climate of Botswana makes it difficult for research and extension workers to develop and disseminate recommendations, and hazardous for farmers to invest labour or capital in "improved" practices.

Despite the difficult challenge facing research and extension workers, agricultural research and extension activities, and interaction between research and extension workers, have been less effective than they could have been. Repeated reorganizations of the Ministry of Agriculture have failed to establish an effective approach for research and extension. In fact, research and extension have grown farther apart over the years.

The FSR&E approach holds promise for overcoming some of the problems facing the MOA in Botswana. It was fortuitous that two on-farm arable research projects, involving both research and extension activities, and with close ties with farmers during all stages, were initiated in the mid-1970s. As the farming system philosophy caught on worldwide, two additional projects were designed for and accepted by Botswana. Thus, Botswana has been able to accumulate valuable experience with alternative approaches to FSR&E.

Results of the four FSR&E projects to date have been mixed. The goal of identifying improved farming practices for limited resource farmers, and translating recommendations into improved farmer productivity, remains elusive. Nevertheless, the projects have demonstrated there are several potential advantages to be derived from FSR and close research-extension linkages in Botswana.

The challenge facing the MOA is to identify a model for FSR&E activities. The four current FSR&E projects have provided valuable insights as to alternatives for institutionalizing FSR&E, but no single project provided the best approach. Based on the collective experiences of current FSR&E projects, it appears unlikely the long run character of FSR&E activities in Botswana will involve either special projects or institutionally distinct FSR&E teams. Rather it likely will have three features:

1. an addition of officers having complementary disciplinary skills, particular economics, to DAR;
2. institutionalization of on-farm research, most likely as a supplementary activity to an overall effort to decentralize research by adding professional staff to sub-stations; and

3. formalization of three sets of linkages: (a) among key administrators in different departments and divisions of MOA headquarters; (b) between regional and headquarters subject matter specialists in DAFS; and (c) among regional subject matter specialists in DAFS, regional ALDEP officers, and DAR regional research officers. Responsibility for seeing the formalized linkages are active would be the primary duty of the Research Extension Coordination Unit.

Ultimately, FSR&E must be more than a cost effective approach for bringing farmers into the technology development process. FSR&E activities must demonstrate a contribution to the entire range of problems affecting performance of the Departments of Agricultural Research and Agricultural Field Services. The goal is to institutionalize an improved capacity to plan and evaluate both technologies and MOA research and extension programs, based on insights from the farming systems approach and experiences with FSR&E projects, even after donor funding of the projects has ended.

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Table 2. Area and Production Trends of Major Crops: Traditional Sector, 1980-1983.

Crop	Year	Production Total (m.tons)	Production Per Farm (kgs.)	Yield Per Hectare Planted (kgs.)	Yield Per Hectare Harvested (kgs.)
Sorghum	1980	27,170	471	191	215
	1981	26,500	440	195	224
	1982	3,700	77	41	103
	1983	4,445	102	35	131
Maize	1980	6,885	141	92	167
	1981	16,415	334	202	306
	1982	3,500	95	67	282
	1983	4,005	123	70	257
Millet	1980	2,270	152	134	159
	1981	1,820	97	92	144
	1982	450	32	28	132
	1983	435	44	27	69
Beans	1980	1,780	53	76	144
	1981	2,550	68	98	176
	1982	400	12	20	118
	1983	190	15	9	64

Sources: Ministry of Agriculture, Division of Planning & Statistics, Agricultural Statistics Unit and Ministry of Finance & Development Planning, Central Statistics Office 1981, 1982, 1983, 1984.

Table 1. Farm Structure: Traditional Versus Freehold Sectors, 1983.

	Traditional	Freehold	All	Freehold as % of Traditional
Total Farms	82,000	360	82,360	0.4
Area (hectares)	305,600	25,000	330,600	7.6
Land area per Farm with Land	5.0	166.7	5.4	---
Food Crop Production (m.tons)*	9,075	5,350	14,425	37.1
Farms with Cattle	58,300	345	58,645	0.6
Cattle	2,407,300	410,700	2,818,000	14.6
Cattle per Cattle Farm	41.3	1,190.4	48.1	---
Cattle Offtake	230,400	171,200	401,600	42.6
Smallstock per Farm	11.0	126.9	11.5	---
Chickens per Farm	8.1	833.3	11.7	---

* Includes Sorghum, Millet, Maize, and Beans.

Sources: Ministry of Agriculture, Division of Planning & Statistics, Agricultural Statistics Office and Ministry of Finance & Development Planning, Central Statistics Office, 1984.

INSTITUTIONALIZING FSR/E: THE INDONESIAN EXPERIENCE

Jerry L. McIntosh

INTRODUCTION

The gradual development of farming systems research in Indonesia started with some multiple cropping experiments conducted during the rainy season, 1970, at the Central Research Institute for Agriculture (CRIA), Bogor. These on-station multiple cropping experiments were similar to those carried out at IRRI. The pioneering research at IRRI by Dr. Bradfield and the ensuing training courses stimulated interest in looking at traditional as well as introduced, intensive multiple crop systems. However, it was soon realized that this on-station research simply served as a demonstration and that more useful information could be obtained from monitoring and studying existing patterns under farmers' conditions in farmers' fields.

In the following years, more research was conducted in several locations in farmers' fields in cooperation with the Directorates of Techniques, Production and Extension, all sister organizations within the Directorate General of Agriculture. Based on this interest and research, USAID and the Government of Indonesia developed a CRIA/IRRI Cooperative Project to provide technical assistance for training, equipment, and supplies and expatriate technical support. It was decided that on-farm research involving intensification of crop production in lowland rice producing areas on Java and evaluation of the production potential and stability of upland rainfed transmigration areas in South Sumatra were the principal goals. The main objectives of these research efforts were to increase crop production in ways that were acceptable to farmers. Consequently, in addition to interdisciplinary biological research (agronomy, breeding, entomology and physiology) economic research was determined to be a necessary component. For example, farmers in Indramayu had previous experiences in growing sorghum after rice. The crop was biologically feasible and produced well, but unfortunately no markets existed. On the other hand, there was little known about the agricultural practices, marketing channels and economics of small mixed farm systems in Lampung.

In 1975 IDRC provided additional support for cropping systems research through IRRI to CRIA. In 1976 the Directorate General of Transmigration became interested in our research and provided funds for cropping systems research in several new transmigration sites. Later, these activities increased further through support of other cooperating agencies and sites were established in Provincial Development Project (PDP) areas in Central Java and Nusa Tenggara Timur (NTT), in the Citanduy Upper River Watershed Project in West Java and in rural development projects in Yogyakarta and Central Java. There have been or presently exist at least 40 cropping/farming systems research sites, just within the Food Crops and Soils Research Center (Figure 1). The research programs vary from one site to the other depending on the respective site characteristics and needs. Within each site, the research program changes with time as research progress changes the needs.

The initial cropping systems research program has developed several alternative cropping patterns for different agroclimatical and edaphological conditions. In general, it is our feeling that the primary thrust of the cropping systems research has been carried out. There will always be a need for improvement of technology, but much of this can be done through routine commodity and disciplinary research. However, since farmers deal with many components in their farming systems, the interaction of the cropping systems with other components of the farming systems must receive more research emphasis if we are to really help the farmers. Therefore, this research has become pragmatic and oriented more toward farming systems. But it is <u>focused</u> research in that only the most important combinations of components of the farm systems are studied at one time. Consequently, even though animal and perennial crops are identified as parts of this farming systems that need some further research to improve the stability of food crops, production for food subsistence is still a necessity for many small farms.

Cropping/farming systems research in Indonesia has responded to development needs and policy decisions. In the following sections some of the research activities, accomplishments, and objectives are used to illustrate the development processes and support the main purpose of this paper, which is to show how the research was organized and implemented institutionally and to suggest some improvements.

ORGANIZATION

In the early years (1970-1973) the research organization was very simple. There was only a small Multiple Cropping Group within the Corn and Sorghum Agronomy Section of the Central Research Institute for Agriculture (CRIA). CRIA was the research center for food crops under the Directorate General of Agriculture (food crops). During this period joint activities between the Multiple Cropping Group and a group at the Directorate of Techniques (the same level as CRIA, under the Directorate General of Agriculture) carried out cropping systems research in almost all provinces in Indonesia. Early in 1973 the CRIA/IRRI Cooperative Project was started and a cropping systems specialist/agronomist was assigned to work at CRIA.

At the first Indonesian Workshop on Cropping Systems, held in September 1973, it was agreed to strengthen and widen the number of agencies involved to include the Directorate of Extension, Directorate of Economics and the Directorate of Production (all at the same level of CRIA, under the Directorate General of Agriculture). The working group was formalized and a program was established during this workshop. The primary cementing agent for holding together this ad hoc group was provided through short term as well as long term training at IRRI and other places. Consequently, the research started in 1973 was carried out by an interdisciplinary group, with leadership coming from corn agronomists within the CRIA. This research expanded considerably in 1975, when technical assistance was received from IDRC through the

CRIA/IRRI Cooperative Project. The research was further expanded in 1976, when funding was received from the World Bank through a CRIA/Transmigration project. By 1978 there were 25 research sites in Java, Sumatra, Kalimantan and Sulawesi, all within the CRIA research system.

Even though no national coordination was formally established to organize the cropping systems program within CRIA or CRIFC (Central Research Institute for Food Crops, after 1980), a program leader for cropping systems research was informally recognized. His coordination role was channeled through the cropping systems working group which has informally organized annual meetings (there have been 7 workshops) and provided the forum for coordination. During these workshops the previous research, development, and extension activities on cropping systems were evaluated and new programs were discussed. The actual activities were conducted by different institutions and agencies.

Within the past 5 years, scientists from other research institutes working with other agricultural commodities have taken part in the working group. Consequently, the organization changed from a Cropping Systems to a Farming Systems Working Group. Scientists from universities and other ministries are unofficial members of the Working Group and usually participate in the meetings.

These developments have all been in line with organizational changes in the research institutions. By 1978 the Agency for Agricultural Research and Development (AARD) became operational, and the research needs for agricultural development become more diversified. All research in the Ministry of Agriculture came under the administrative direction of AARD. In 1980, CRIA changed to CRIFC (Central Research Institute for Food Crops), and six semi- autonomous research institutes were organized under its framework. Each institute was given a specific research mandate (Table 1). Within each institute, cropping systems research exists as a sub-project of the research and development programs. This kind of decentralization was carried out for all of the Research Centers in AARD. On the other hand, the research administration was centralized. This permits more direct institutional back stopping necessary for Farming Systems Research from all of the research disciplines and agricultural commodities.

Figure 2 illustrates the organization of the Ministry of Agriculture and shows the agencies responsible for research (AARD), extension (AETE), and action programs (Directorate General). Figure 3 shows the organizational framework of AARD. In effect each Center may carry out systems research through its research institutes. The components of the farming systems may be studied and developed as need and opportunity exist. Within CRIFC, a concerted effect has been made for the past 12 years to carry out Cropping Systems Research in the major edaphological land areas of Indonesia. More recently all of the research centers concerned with agricultural commodities (food crops, animal husbandry, fisheries, industrial crops, and forestry) have started similar programs but adapted to meet their special needs. The concept of interdisciplinary research in the various research centers is illustrated by the vertical columns in Figure 4. Together all these components (represented by centers) make up a farm system that may be studied through Integrated Mixed Farming Systems Research and Development (horizontal arrow, Figure 4). This kind of research is usually carried out in specific target areas. The target areas may be selected by researchers based on scientific reasoning but more likely are selected by policy decisions and development activities.

The farming systems research approach widely used in Indonesia is shown in Figure 5. The general format of this diagram is similar to that of farming systems research diagrams from other countries and parts of the world. The details vary because of need, starting point, government structure and policy. Phases I and II of Figure 5 involve site description and identification of problems for the target area.

It is assumed that some technology is already available (Technology Transfer In) but is quite limited. It is further assumed that some on-site trials, tests, and studies will be required to help identify priorities for research and systems to be tested. Design and testing of farm systems in a partial or holistic fashion is carried out in Phase III. It should be pointed out that these first three phases may be carried out in chronological order or simultaneously, depending on the situation. In many farming systems programs Phase IV may be carried out by a joint research extension activity or exclusively by the farming systems research project. In Indonesia, however, where the extension services are well developed, particularly in food crops, Phase IV as well as V are carried out by the extension and implementing agencies. It is imperative that formal and informal contacts be made with the local farmers, extension services, and other government agencies to gather ideas, data, and seek support for all phases of the research and finally for implementation. This approach is illustrated in Figure 6. Finally research technology developed in one target area may be transferred wholly or in part to other areas having similar soil, climatic, biologic, and socioeconomic conditions. Figure 7 compared to Figure 5 (Phase IV) shows how as much as two years of time may be saved through this process.

In summary, systems research in agriculture in Indonesia exists with different levels of complexity. Each institute may carry out systems research relevant to its research mandate. These components may be studied together in the context of a project at the center level or holistically at the AARD level, as need and judgment indicate.

Past Cropping/Farming Systems Research

The cropping systems research program that was started in 1973 has developed on-farm research capability and has successfully developed stable and sustainable cropping patterns that are acceptable to farmers for the major land areas in Indonesia. This research effort has been interdisciplinary and integrated with other government agencies through on-site research, workshops, and training activities. Gradual adoption of research findings by farmers has increased year by year. But implementation of the technology in the 1982-83 crop year through BIMAS, INSUS, and OPSUS programs for the major land areas represents a major breakthrough for the wide scale adoption and transfer of new technology (Table 2).

The principal objectives of the cropping systems research have been to develop technologies that will permit use of marginal or under utilized lands and more intensive cropping patterns for existing and productive agricultural areas. These technologies must be economical and acceptable to farmers. Methodology for the research include assessing within selected target areas the existing socioeconomic situation and potential for agricultural production; designing and testing of improved cropping patterns; evaluating and monitoring of on farm trials; transferring of technology to appropriate government agencies for multi-locational trials and pilot production according to methodology outlined in Figures 5 and 7. Research has been conducted in the major lands areas in Indonesia.

Lowland Rice Areas

The greatest potential for immediate increases in food crops production exists in lowland areas which have enough infrastructural development to support intensified agricultural production efforts. Consequently, under these circumstances, where considerable irrigation and drainage efforts have been made, cropping systems research has been able to develop technologies to further intensify crop production. In a similar fashion, but to a lesser degree, we have developed more intensive systems for rainfed areas. The strategies used have included introduction of early maturing and improved crop varieties, direct seeding of rice, reduction in turn around time between successive crops, and improved crop management techniques. To facilitate research in the field and direct research to more specific research issues, these land areas were usually partitioned according to water availability into the following:

Categories for study

- Irrigated lowland
  - Full - 10 months or more
  - Partial - 7-9 months or 5-7 months

- Rainfed lowland
  - Humid areas
  - Drought prone

On-site research was carried out in six sites in West Java, Lampung, East Java (Madura) and South Sulawesi. The initial and most comprehensive research was in the Rentang and Jatiluhur irrigation systems in Indramayu. Inspection of the area indicated that usually only two rice crops were grown in the 7-9 months and fully irrigated areas. Usually only one rice crop was successfully grown in the areas with less irrigation. If a second crop was planted, water shortages drastically reduced yields. On the other hand, the practice of direct seeding of rice, on aerobic soil and then allowing the field to flood as the rains increased (gogo rancah) was being developed by the extension service on rainfed areas in Indramayu. This practice permitted some intensification even without irrigation (Tables 3 and 4).

Cropping systems research successfully showed how these systems could be further intensified through use of earlier maturing crop varieties, use of gogo rancah in partially irrigated and rainfed areas, and reduction in turn around time. Component research developed more appropriate fertilizer rates and methods of application, insect control measures, and weed management.

The rotation pattern of "lowland rice - lowland rice - legume" was successfully and profitably grown in 7-9 months irrigation categories. A combination of gogo rancah rice and lowland rice in the pattern "gogo rancah - lowland rice - cowpea" permitted the production of three crops in one year where previously only one crop was grown in the other areas which received only 5 months or no irrigation.

The adoption of this technology was slow from 1973-1977. The longer maturing Pelita varieties, which were vigorous and high yielding varieties of good quality, were widely accepted by farmers. But because of late maturity only one good crop could be grown per year in the partially irrigated and rainfed areas. Farmers were reluctant to change to earlier maturing varieties until they were forced to change during the brown plant hopper epidemic in 1977. The introduction and use of IR36, which has a field duration on only 90 days when transplanted, removed much of the risk for intensifying cropping patterns. Consequently, after adoption of earlier maturing varieties, rice production has drastically increased, because two crops can be grown with little risk in irrigated and partially irrigated areas. One good crop can be grown in the rainfed areas. Programs for production of legume crops after rice are being implemented. These include soybeans in the irrigated areas, mungbean in partially irrigated areas and cowpeas in the rainfed areas. The major constraint to widespread and rapid adoption is availability of sufficient quantities of viable and vigorous seed of adapted varieties.

Upland Rainfed Areas

The second major target area for cropping systems research was the rainfed uplands that were being used for transmigration project development in Sumatra, Kalimantan, and Sulawesi. Generally these areas receive enough rainfall, adequately distributed for year around crop production, but management constraints have prevented stable and sustainable food crops production. There have been soil management, pest and disease, and socioeconomic problems that transmigrant farmers could not easily overcome by themselves.

The initial research showed that the existing cropping patterns could be simplified and made more productive by growing crops in rows, use of moderate rates of fertilizers, and returning crop residues to the soil directly or as manure. The technology developed in Central Lampung has been found to be applicable with some modifications for the humid areas of Western Indonesia where the rainfall is greater than 2000 mm per year and where there is no distinct dry season. The basic pattern of corn plus upland rice interplanted with cassava (corn + upland rice + cassava), however, is applicable and can be used throughout Indonesia. In the more humid areas the cassava is planted in rows placed two to four meters apart (depending on the market for cassava). One or two legume crops (such as peanut or peanut followed by cowpea) may be planted between rows of cassava after the harvest of the rice. In the drought prone areas of Eastern Indonesia, where there is a prolonged dry season, the cassava may be planted at random and interplanted with a drought tolerant crop such as cowpea.

This technology has been widely accepted by farmers and is now incorporated within the BIMAS production programs. Justification for expansion of transmigration programs in the rainfed upland areas was based to a large extent upon the initial data from cropping systems research in Central Lampung and the successful transfer of technology through on-site cropping systems research to other areas of South Sumatra, South Kalimantan and Southeast Sulawesi (Tables 5 and 6).

Tidal Swamp Areas

Barambai, South Kalimantan was selected as the initial target area for cropping systems research in the tidal swamps. The tidal swamp ecology varies considerably from place to place. The degree of infrastructural development also varies. Barambai was chosen as an initial target area because some stability has been imposed by drainage, land clearing, and settlement activities through the transmigration program. It was felt that new technology could be directly transferred to other land areas with similar descriptions and which were being used for transmigration.

In the initial surveys it was observed that indigenous farmers grew rice and other food crops, but that they invariably built raised beds and introduced perennial crops such as coconut, clove, coffee, and citrus. The rice varieties used were many times photoperiod sensitive, required several transplantings and took 7-9 months to mature. Introduction of earlier maturing rice varieties, improved fertilizer practices, and acid tolerant secondary crops permitted more intensive and productive crop production in the lower bed. Longer term studies are needed to demonstrate techniques for production of perennial crops and development of the raised beds. But from field observations and theory, it was concluded that gradual development of the raised beds by adding soil to the sides of the beds each year would not only reduce the labor constraints faced by farmers but would also permit gradual leaching of the sulfurous compound from the soil added to the beds. This research technology has been included in pilot production programs jointly carried out by the food crops research and extension agencies in South Kalimantan. The prospects for transfer and widescale use of this technology are very good (Figure 8).

PRESENT FARMING SYSTEMS RESEARCH

The cropping systems research program has developed methodology and a core of personnel that can design and carry out on-farm research. The linkages with other commodity research groups and government agencies have been developed. Gradually farming systems research capability that is holistic has developed. In order to conduct research efficiently and effectively, it is still appropriate to identify and conduct research on specific research issues that involve only two or three commodity groups or research components. For example, in the upland rainfed areas, food crops agriculture is necessary but usually limited to only a part of the land area owned by a farmer. The farmer finds difficulty to use more than 0.75 hectare of land for food crops production if only family labor is available. Extra power is needed if more land is to be cultivated for these crops. Usually production of food crops in excess of family consumption needs is not the most suitable use of the land. Labor shortages, risk from drought, pests and diseases, erosion, and marketing problems limit the attractiveness of food crops production. Yet most farmers own more than two hectares of land. How should this land be used? These are valid research issues, especially since the basic cropping systems for subsistence have been developed.

Crop/Livestock Research

Much technology has been developed for perennial crops. Present farming systems research strategy encourages the introduction of perennial crops into the farm systems gradually, as planting materials become available and as the farmers identify locations on their land where these crops fit. The major research thrust, however, involves the crop/livestock combination. Suitable on-farm research will be carried out to develop more stable and nutritious animal feed supplies. Animal health problems will be studied and controlled. Some research has been carried out in Lampung and South Sumatra in transmigration areas. However, longer term research is being planned that requires longer duration than can be carried out in the farmer's field.

Upper River Watersheds

Throughout Indonesia, settlements have flourished in the intra-mountain regions. The climates within these areas are moderated by higher elevations and proximity to the high mountains. These settlements have been stable and have flourished. Populations have increased and settlements have gradually moved onto lands that are too steep for stable and sustainable agriculture. Many of the lands are suitable only for forests and sources of water for rivers. Loss of the forests has exacerbated problems with flooding, erosion, and siltation during the rainy season and drought during the dry season.

AARD has collaborated with watershed projects in the Citanduy and Solo river systems and in Yogyakarta. These farming systems studies have also provided methodology and experiences for more comprehensive research. In particular research with cropping systems, bench terraces, and forage management has provided the technological base for expansion programs for soil and water conservation. These initial and limited efforts also provide the background needed for further research.

Basically, the traditional cropping patterns in both areas are similar and consist of a mixed cropping of corn, upland rice, and cassava. However, in Gunung Kidul the farmers also plant peanut after the rice harvest. The productivity of these traditional cropping patterns may be increased with better management and use of improved varieties. Better management includes the use of soil and water conservation practices by terracing and planting of forage grasses on the terrace risers. Brachiaria at Citanduy and setaria in Yogyakarta grow well on the risers even during the dry season. Further studies are needed to determine the most effective management practices for use of the forage grasses either for large or small ruminants.

Pests and diseases were found to be the major limiting factor for growth and yield of crops in the upper watershed areas studied. Crop varieties may also react differently to varying degrees of slope and elevation. Consequently, further studies are needed to develop crop yield stability in these upper river areas.

DIRECTION AND STRATEGY FOR FUTURE RESEARCH

Cropping Systems Research

The main thrust for cropping systems research in Indonesia has been made. Methodology has been developed, staff have been trained (approximately 150 research and extension workers have been sent to IRRI and other places for training, workshops, and monitoring tours in cropping systems alone over the past 10 years) and systems research carried out in all the major ecological areas of Indonesia. These efforts have been well executed and have received wide acclaim. However, this research has identified many specific component studies that need attention, and there are problems for maintaining support and coordination as administrative and personnel changes take place.

Coordination. Cropping systems research is basically the responsibility of the research institutes for food crops. These six regional institutes have their own research mandates and develop their own research programs.

Consequently, with time each institute will develop its own cropping systems program designed to meet the individual research mandates. The institutes and their mandates are given in Table 1.

For the most part these mandates are based on an edaphological breakdown of land areas in Indonesia. Each institute can and should develop cropping systems research suitable to their area and mandate. There is no need to use such terms as "rice based" or "palawija crop based" cropping systems research, but to simply carry out relevant cropping systems research. If the research is done well, the focus will be right also. To make this research as efficient and effective as possible, it would be useful to strengthen the National Cropping Systems Working Group that has functioned over the last 10 years and formalize the periodic Working Group Meetings. The intent is to provide a technical advisory group to give direction to the coordinated research. The organizational structure could be as shown in Figure 9.

Specific component studies. As has been pointed out, the basic cropping systems research has been completed for the major edaphological land areas in Indonesia. The objective of the research has been mainly for food self sufficiency. Unless there is a major production breakthrough or change in the economics of food crops production and marketing, this objective will not likely change. But even with this limited objective there are constraints. There are problems with yield stability from one crop season to the next and sustainability of production over time. That is a problem particularly for the upland rainfed areas and the tidal swamps. In general, however, the major problem is to increase the cash income of the farmers. This will involve better use of land and development of alternative farm enterprises, as will be discussed in the next section on farming systems research. Some urgent research needs are suggested as follows:

A. <u>Varietal improvements</u>

- All crops
  - More tolerance to acid soils (A1)
  - Earlier maturity
- Upland rice
  - Blast resistance
  - Brown plant hopper resistance
  - Fast early growth, droopy leaves
  - Integrated Pest Management (IPM)

B. <u>Soil conservation</u>

- Upland, humid areas
  - Continuous land cover
  - Terracing - evaluation of different approaches
  - Waterways and impoundments
- Upland, drought prone areas
  - Continuous land cover
  - Alley cropping and terracing

C. <u>Soil fertility and management - long term</u>

- All upland areas
  - Soil characteristics related to crop performances
  - Lime x phosphorus studies
  - Organic matter management
- Tidal swamp areas
  - Soil characteristics related to crop performances
  - Evaluate systematically the raised bed-furrow bed system

D. <u>Pest management</u>

- All areas
  - Weeds, broadleaf (borreria)
  - Pod borers
  - Integrated pest management for blast and hoppers

E. <u>Farm implements</u>

- All upland areas
  - Seeders
  - Cultivators
  - Weeders

Uniform systems trials. We do not know the long term effects of intensive cropping nor the relationship between soil fertility and soil analyses and crop responses, particularly on soils in upland areas. We need to establish a transect of sites across Indonesia in the upland red-yellow podzolic soil areas to evaluate over a five to ten year period the effects of intensive cropping, soil fertility, and management practices. This kind of research has begun through the Fertilizer Efficiency and Cropping Systems Working Groups within the Centers for Soil and Food Crops Research.

A. Lime x phosphorus studies on intact and scraped (remove top organic layer ±cm) soils
   - Minimum input
   - Medium input
   - High input

B. Residue management studies
   - Remove
   - Return all
   - Supplement

C. High management plots - demonstration and yield potentials
   - High soil fertility
   - Fully terraced
   - Intensively cropped

D. Complete soil and plant analyses as required
   - Develop rationale-common methods
   - Correlation

Transfer of technology. Even though there has been more than ten years of cropping systems research and development, there is still much confusion concerning data, publications, guidelines, and/or recommendations. There are many reasons for this. We must plan the research better and improve the research quality so that it is more convincing to ourselves, colleagues, and clients. Site descriptions and abstracts, as shown in Appendix I, need to be further developed and stored, so that research results may be more easily disseminated. References of all reports, seminar papers, and published documents need to be compiled and computerized to permit quick retrieval (Appendix II).

In order to hasten technology transfer, cropping/farming systems research must improve the quality of research, develop more systematic means for discussions (workshops), and increase and improve research publications.

a. Improve quality of research
   - Coordination as has been stated
   - Improve precision of experiments
   - Improve data collection and characterization

b. Workshops
   - Discussion and concensus among working group members

- Planning and policy
- Where have been and where to go
- Analyze and discuss results of research

c. Research publications

- Complete
- Readable
- Authorized

Farming Systems Research

The usual farming systems in Indonesia are composed of several components. These components may be referred to as sub-systems and may be studied separately, for example, as cropping or animal systems research. On the other hand, the study of the whole farm with all its activities, would be called holistic farming systems research.

The initial work in Indonesia was pragmatic and largely directed by policy and circumstances. But gradually the research that started with intensification of lowland rice and long term soil fertility and management studies in Central Lampung has evolved and some projects that are being conducted by AARD are broad based farming systems research studies. Considerable experience has been gained and approaches developed to carry out effective farming systems research in the various land areas of Indonesia. There is a continual need for more effective coordination and planning.

Coordination. Farming systems research is basically the responsibility of AARD, just as cropping systems research is a responsibility of the various research institutes for food crops. In a similar fashion, we may consider cropping systems to be one component of the farming systems. The same relationship holds for the systems research from the other centers which represent commodities (Figure 4). Forestry, which is now a separate ministry, must also be a part of the farming systems research consortium, together with its soil conservation unit (P3DAS), and must be considered along with the other research groups. It is likely and even necessary that each center or research institute carries out its own systems research as it develops the technology to meet its mandate. But at some point it is useful and very important that all the relevant centers, agencies and universities work together in one project or geographical area. How can this work be administered and technically coordinated effectively?

Figure 10 shows an example of an organization framework for a Farming Systems Research Project. This is a large, long term project that will require a full time project leader and several senior staff from the various research centers. In many instances this kind of administrative and technical organization is necessary for area development projects. On the other hand, for other target areas it might be better to develop smaller research projects that are more narrowly focused. Broad based and holistic farming systems research can be very difficult to manage and may be inefficient. It may be better to build on past cropping systems research, and add complexity one step at a time.

In general, the objectives or goals given in Table 7 are relative for research in new transmigration areas in Indonesia. The degree to which we have accomplished the initial goals for subsistence determines what we do next. If these goals can be easily attained and the farmers desire more income and are not fully using their land and labor resources, another production component (agricultural enterprise) may be added to the system. There are several factors that farmers must consider when adding other agricultural activities to a subsistence (cropping) system. Usually in upland transmigration areas the decision to add depends on the following situations:

- Little opportunity for off-farm labor
- Family labor is not fully and efficiently utilized
- Land available is not fully utilized.

The actual farm enterprise added usually involves livestock or perennial crops or a combination of both. A research proposal for crop/livestock research has been developed to address some of the research issues involved for the Batumarta Transmigration Area. This proposal represents the "limited farming systems approach" that appears to be most efficient for most situations in Indonesia (Figure 11). We usually consider that farm families will, on their own, develop a home garden and gradually add perennial crops to the system. This process can be greatly simplified and assisted by research and development of relevant technology. Government assistance through production programs such as the nucleus estate programs being developed for rubber and oil palm can provide the quantity of production that is necessary many times to overcome processing and marketing constraints. Consequently, coordination is not only a prerequisite for effective research but also for technology transfer and implementation. Furthermore, we must realize that research and development activities are continuous processes and may never be developed to everyone's satisfaction. Policy and economic situations usually determine end points.

<u>Target areas and research issues for FSR&D</u>. The division of assignments among the various research institutes of CRIFC are done according to edaphological land areas (Table 1). This is an effective way of providing for research coverage and efficiency. These target areas may be partitioned further as needed. For example, the tidal affected land areas may be divided into direct, indirect, and drained tidal swamps. Each has characteristics that require special attention. For more general farming systems research the same target area divisions may be used but with additions as needed. One addition presently under consideration is the upper river watersheds.

It must be understood that each center is responsible for component and systems studies that relate to its speciality. For example, the cropping systems research and organization that has been described in this paper is or may be one example of a kind of research each should be doing. In an integrated farming systems project all or some of these components must work together. There is no need for one national farming systems project that covers all areas and conditions. There may need to be national coordination, as mentioned in the previous section, but research in each specific target area or division thereof may have its own project management unit and project leader. Specific administrative and technical responsibility must exist if a project is to be effective. It is assumed that systems research in each center will provide much relevant component technology for target area research. However, this will not preclude further research on site.

Generally the target areas for integrated farming systems research in Indonesia are as follows:

- Tidal Swamp Areas
- Palawija Crops Areas
- Upland Rainfed - Drought Prone Areas
- Upland Rainfed - Humid Areas
- Lowland Rice Areas
- Upper River Watershed Areas

Research approach. The first five broad target areas given in the previous section coincide with the research mandates of five of the research institutes for food crops. The upper river watershed areas fall within each of these five target areas, but it is logical that the major research thrust be carried out by one institute. The upland Agriculture and Conservation Project that is being developed, however, will play a major role in addressing the research needs of these areas and will likely be administered by a project management unit directly responsible to AARD (Figure 10). Each of these target areas may be further partitioned into areas that require special attention or needs -- for example, farming systems and technologies needed for upper river watershed areas that differ according to erodibility of soil, steepness of land, development of infrastructure, and ownership of land will not be the same. Also, a drained tidal swamp area settled with transmigrants is vastly different (ecologically, biologically, sociologically and economically) from an indirect tidal swamp that has been settled for many decades by indigenous people.

Farming systems research should follow the basic format that has been successfully used for several years by cropping systems research in Indonesia and modified for farming systems research (Figures 5, 6 and 7). These diagrams show the basic strategy for farming systems research, including the interfacing with pilot production and implementation programs and the concept and value of technology transfer in saving of research time and effort. Figure 4 shows the interdisciplinary nature of farming systems research and the relationship of integrated mixed farming systems research with usual commodity oriented systems research. Figure 6 illustrates how farming systems research must be integrated (linked) with the other government agencies and farmers (including existing private enterprise) through all the farming systems research and development phases. These linkages are vital, especially for identification of research problems and for subsequent implementation of results.

These are general descriptions of activities and intentions of farming systems research. For Indonesian conditions, there are some specific research activities and approaches that need emphasis because of the natural conditions, stage of development, and the availability of technology for the specific target areas.

a. Ex ante analysis. After target area and site selection and as part of the site description process, a complete *ex ante* analysis of existing and predicted farming systems should be completed. Through this analytical process many unviable systems may be rejected and the more robust systems identified for further evaluation. To do this, considerable background information and data are needed. Collecting these data is a logical function of the agro-economic studies team involved in site description. There is a need for the National Farming Systems Working Group to collect these data and reach a consensus among relevant scientists for the accuracy of the data. This background information is needed for the different agricultural enterprises, such as food, vegetable, and perennial crops and for fish, poultry, and animal husbandry. The data should include the following, which specifically relate to food crops but may be easily adapted to include perennial crops and livestock (including fish and poultry).

Suggestions: Data to be collected and verified for general use are:

- Management practices and labor requirements
  - Land preparation (plowing, terracing, and cultivation)
  - Planting (spacing, seeding rates, and varieties)
  - Fertilizer practices (rates, placement, and timing)
  - Pest and disease management
  - Harvesting
  - Post harvest (drying, storage, and transport)

- Costs of production
  - Labor (from above)
  - Inputs (from above)
  - Credit

- Expected yields
  - Individual crops (time as well as yields)
  - In combination (monoculture and intercrop)

- Expected sale prices

- Expected profit or loss from year to year until stable system is developed
  - Crop or agricultural enterprise
  - Whole system

b. Field laboratory. Much of the information needed for the *ex ante* analysis is available from routine activities and publications of the various research centers of AARD and the Directorate's General of the Ministry of Agriculture. It should be reiterated that farming systems research and development does not replace nor supercede the routine research and development activities of the Ministry of Agriculture. In order to develop more appropriate technology for farm systems for the different edaphological areas of Indonesia, more direct effort and interaction of researchers with farmers and their circumstances is needed. This has been done through on-site research that is a routine part of cropping systems research. Within Indonesia, where so many different conditions exist (edaphological, sociological, and institutional), the gap between routine commodity and disciplinary research in research centers and on-site research in farming systems may be wide. For cropping systems research (a part of the farming systems), this has not been a problem.

On-site research for farming systems is not likely to be effective if there is insufficient technical and staff support from the research centers. Unfortunately, frequently the support that is available is fragmented according to discipline and commodities.

There is a need to provide a research environment for technology development that closely resembles the farming systems in which the technology will be used, but which permits more experimentation over a longer period of time under the researcher's control than can be managed through on-farm research. The relationship among research centers, on-site research and farming systems field laboratories is shown in Figure 12.

Suggestions:

Support the development of farming systems field Laboratories in which relevant component and systems technology may be developed and evaluated on an interdisciplinary, comprehensive and longer termed basis for the major edaphological areas of Indonesia where existing facilities are not adequate or appropriate. The objectives would be:

- to provide a central location for more efficient collection, evaluation, and transfer of appropriate component technology,

- to provide an opportunity to conduct long term experiments on topics such as, land clearing, perennial crops, soil conservation, water control, fertilizer efficiency, crop residue management, crop/livestock and stability, and sustainability of different farming systems and land management,

- to provide an environment for conducting interdisciplinary farming systems research before technology is transferred to farmers.

c. On-site Farming Systems Research. This kind of research must be on-farm and not as long term and comprehensive as that in the field laboratory. Since the methodology for cropping systems research and basic technology for cropping patterns and management have been developed for many agricultural areas, new studies will in most areas, concentrate on the development of stable and sustainable mixed farming systems. The research will focus on the components which appear most relevant, with the intent of making better use of farmer labor, reducing risk, and improving soil and water conservation practices. Since past research on cropping systems has developed relevant technology for that component, new projects will in most cases emphasize animal, pasture, and perennial crops research. The order depends on field conditions on-site.

Suggestions:

Except for special circumstances, the farming systems research follows the sequence outlined below:

- Develop subsistence from food crops
  - Develop appropriate cropping systems
  - Produce calories needed
  - Determine minimum labor and land requirements

  Rationale:

  Except for lowland rice, food crops tend to have high risks for production and marketing and tend to have high labor peaks and seasonal demand for inputs.

- Develop cash income and minimize risk through diversification
  - Off-farm labor
  - Crop/livestock
  - Crop/livestock/perennial crops
  - Speciality crops

  Rationale:

  Diversification permits better use of land and labor resources and provides more market opportunities. Sequence of agricultural enterprises to study and eventually include in a farming system depends on the situation. Neither researchers nor farmers are able to cope with adjustments in all components at one time. Most likely sequence would be as shown above.

Linkages. Developing countries (in many instances) do not have a strong private sector. It is important that public institutions in these countries make greater efforts to see that the mechanisms for flow of technology and feedback are more highly developed and institutionalized. In this way, the problem of communication between institutions can be solved. However, there is still a problem of communicating with the farmers and learning their needs. In many instances this requires on-site research. One of the reasons for cropping/farming systems research is to solve these research and research dissemination problems.

Figures 5 and 7 illustrate the phases of a cropping systems research project in a selected target area. Linkages are established among farmers, research, extension, and other government agencies as each carries out their responsibilities within the project activities. The relative proportions of the work load distribution between research (FSWG) and the other responsible groups is illustrated in Figure 6. The important point, with respect to linkages that needs to be emphasized, is that closer and more constant contacts are necessary if farmers' needs are to be communicated to researchers and other government institutions and technology is to be effectively transferred from researchers through extension to farmers. Informal contacts and cooperation at the field research and extension levels can be established easily, particularly if the staff are experienced and mature. The problem is how to insure these contacts if these staff are young and inexperienced. How can we be certain that the linkages are established in the research phases I, II and III and in the transfer and implementation of phases IV and V?

a. Linkages in research phases. The cropping/farming systems research strategy (in Indonesia) has emphasized the importance of maintaining close contacts with the extension services. This has been done informally in each target area simply because more formal approaches were too difficult to negotiate because there was no felt need nor precedent. Experienced cropping systems staff have been very effective in maintaining contacts. Where funds have been available through projects, special training sessions may be carried out for local field extension staff. Since these contacts are made at the field level and because of the organizational structure of extension, the transfer of technology to higher echelons and other areas does not always take place effectively.

Within the Asian Cropping Systems Network, some collaborating countries have used more formal approaches. For example, in the Philippines linkages between research and extension and other implementing agencies are sometimes formalized by a Memorandum of Agreement (Denning, 1981). This approach serves at least two purposes: 1)provide a systematic procedure for identifying and involving the relevant institutions needed for research and implementation; and 2)to encourage commitment and follow through by these institutions.

b. Linkages in the transfer phase. The input of research in this phase of research and development varies from country to country. In Indonesia the Directorate of Food Crops Production has the responsibility to plan and execute field trials and pilot production programs. In other countries in Southeast Asia much of this activity is carried out by the research organizations. The effectiveness of the linkages and mechanisms for strengthening the transfer process in Indonesia, again, depends upon mutual understanding of institutional objectives and activities. Seminars, workshops, and program reviews in which staff from the different agencies and institutions can interact serve this purpose. The Cropping Systems Working Group has made considerable effort to include staff from the Extension Services, Directorate of Production and Research in in-country, and foreign training programs. The existing transfer agencies have been able to carry out their roles, but there appears to be a need for more formal arrangements.

The Cropping/Farming Systems Working Group has seen the problems associated with informal research/extension linkages and the routine transfer processes. Technology transfer for single crop commodities (such as rice), pest control, or fertilizer management is much easier than for cropping systems. Changes or modification of systems many times involves not only biological sciences but also, economics, sociology and marketing. Consequently, all of the relevant government agencies that are related to these components of the system must play some role in the transfer process. How each is involved and their specific role in transfer and implementation is a legitimate research issue. In some instances, particularly where there has been little experience, it may be argued that pilot production projects, in which all of the relevant agencies are involved, should be carried out. The Upland Agriculture and Conservation Project that is being implemented in Indonesia (Figure 10) will have a complementary expansion (implementation) program to test and transfer new technology.

c. Linkages in implementation. The production programs in Indonesia and the Philippines have been effective. Once the technology has been developed and transferred, these programs have proceeded to implement production programs. The colleageual contacts and routine meetings of program and research experts have provided much of the scientific backstopping needed. Are more formal arrangements needed?

At this stage in the research and development processes, precipitous changes in directions, recommendations, and instructions should be avoided. To provide for continuous flow of technical information, a system whereby extension specialists are administered and officed with research staff would be helpful. Perhaps researchers should be administered and officed with extension.

Technology transfer to similar areas. Field laboratories and on-site research activities are expensive in terms of personnel, funds, and time. It is not feasible nor necessary to carry out detailed farming systems research within all the various land areas in Indonesia.

There are two effective ways to improve efficiency for the development and use of technology.

a. Research coordination. This term has been used many times in this paper and will be used again to emphasize the importance of providing a format by which researchers have some feeling of research priorities but are not constrained by boundaries. Coordination can provide the framework that encourages collaboration but does not prohibit some competition. It discourages repetition of preliminary and shallow research and provides a mechanism for transfer of technology among scientists.

b. Site description and transfer of technology. Systematic socio-economic, soil, and biological descriptions of research sites provide the basis for technology transfer to target areas with similar conditions. Figures 5 and 7 illustrate the mechanism for this kind of technology transfer. It is not necessary to repeat all the research phases of a farming systems project in each target area. It is especially important in a developing country to make efficient use of research funds.

Suggestions:

- Organize a National Farming Systems Working Group similar to that for Cropping Systems (Figure 9) and provide for periodic group meetings and publication of data.

- Develop a systematic procedure for site description and format for presentation of data so that all members of the Working Group understand each other's work (Appendix I).

- Develop linkages for informal technologic transfer.

CONCLUSIONS

- Existing bureaucracy is usually comprehensive
  - Try to work within it.
  - Comprehensive FSR&E project may be competitive.
- Systems research is generally accepted
  - It may appear inadequate but output may be good.
- Institutionalization of FSR&E not always necessary
  - Many times it is better to work on project bases.
- Holistic approach is important for understanding farm systems in target area
  - It may be better to limit experimentation to critical but manageable components of a system.
- The major thrust of cropping systems research has been carried out in many countries
  - Work on research issues identified.
  - It is better to let existing bureaucracy take over if able.
- Make better use of existing data for *ex ante* analyses
  - Minimize time and expense factors.
- Good site descriptions and rapid publication facilitate technology transfer
  - Simplified research brief may be computerized for reference and use.
  - Internationally accepted terminology would be required.
  - International organization needed.
- Abstracts are needed for research papers that may never get into prestigious journals
  - International organization needed.
- Farming Systems Research is exciting and rewarding
  - But try to maintain professional competence in some discipline.

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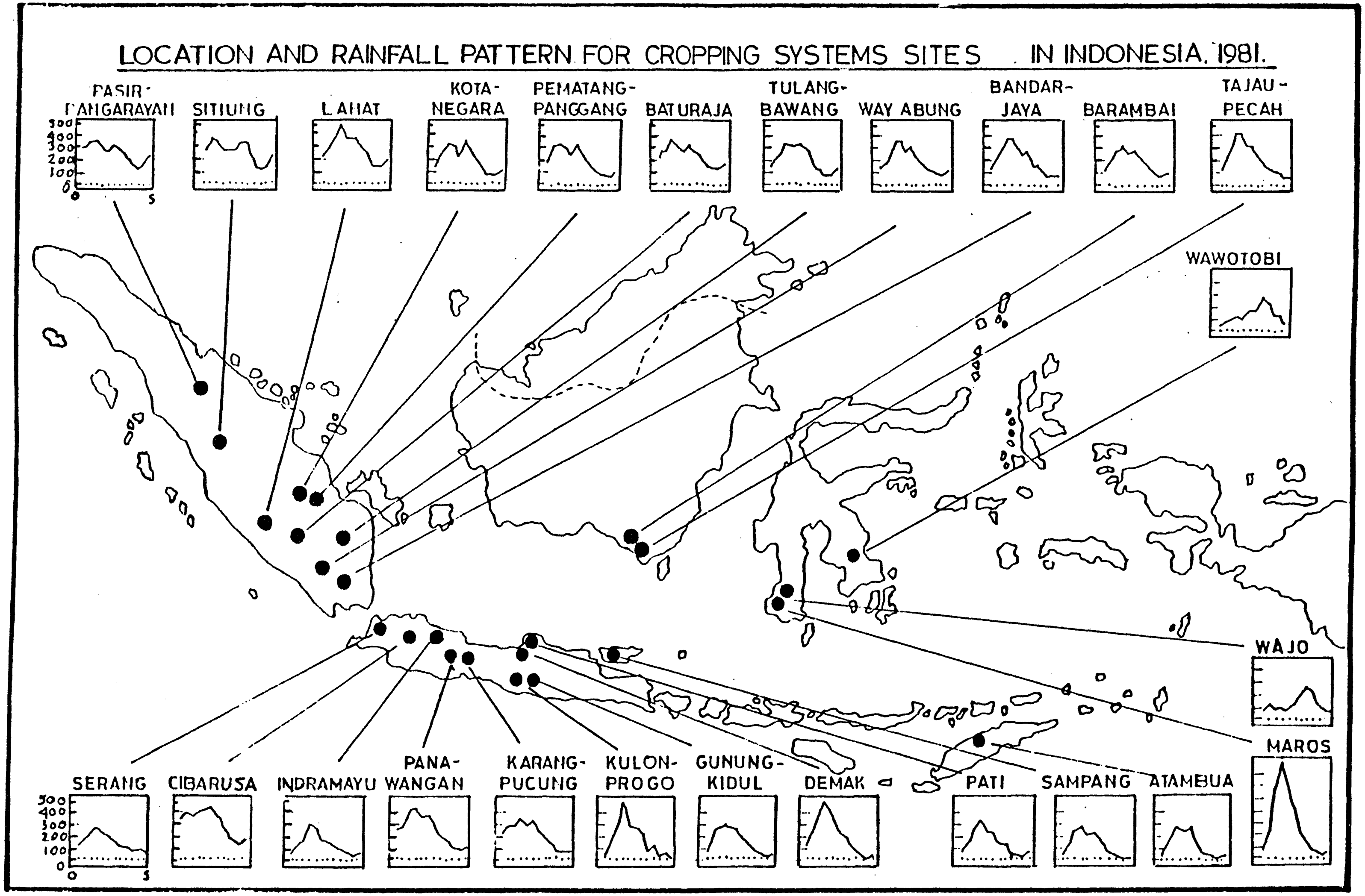
Figure 1.



LOCATION AND RAINFALL PATTERN FOR CROPPING SYSTEMS SITES IN INDONESIA. 1981.
PASIR-PANGARAYAN
SITIUNG
LAHAT
KOTA-NEGARA
PEMATANG-PANGGANG
BATURAJA
TULANG-BAWANG
WAY ABUNG
BANDAR-JAYA
BARAMBAI
TAJAU-PECAH
WAWOTOBI
WAJO
MAROS
SERANG
CIBARUSA
INDRAMAYU
PANA-WANGAN
KARANG-PUCUNG
KULON-PROGO
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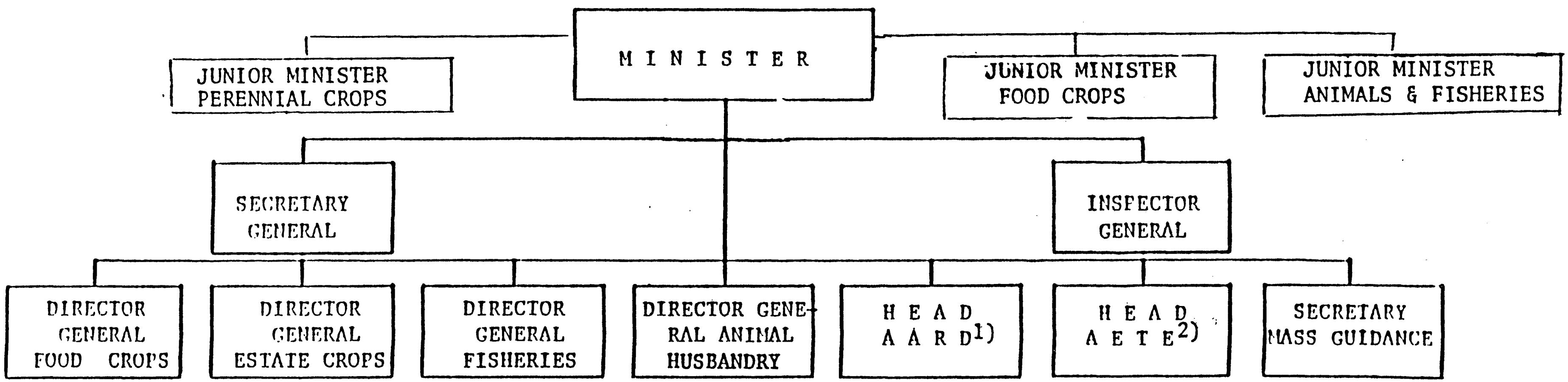
MINISTRY OF AGRICULTURE



1) Agency for Agricultural Research and Development.
2) Agency for Agricultural Extension, Training and Education

Figure 2. Organizational arrangement of the Ministry of Agriculture

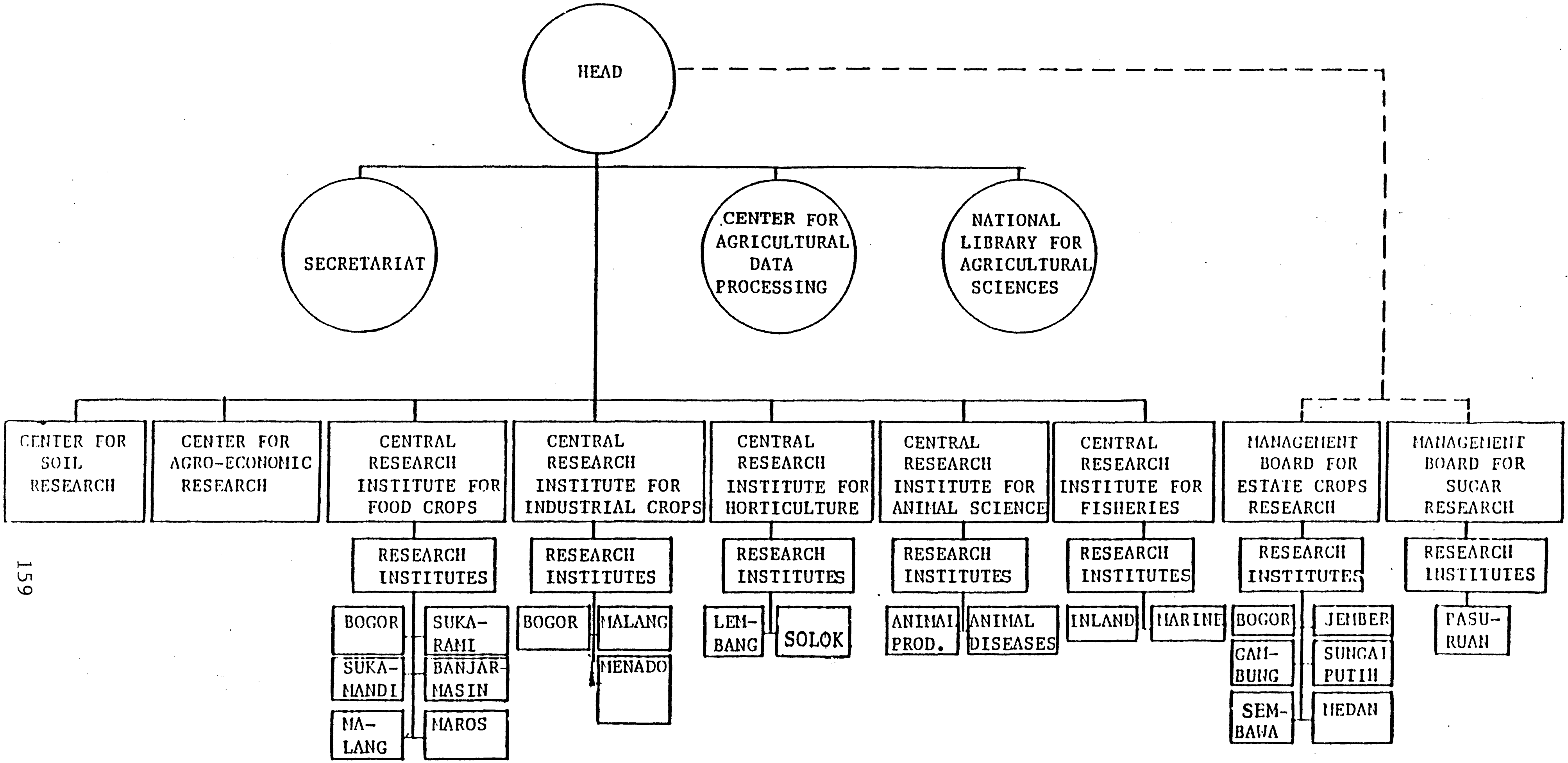
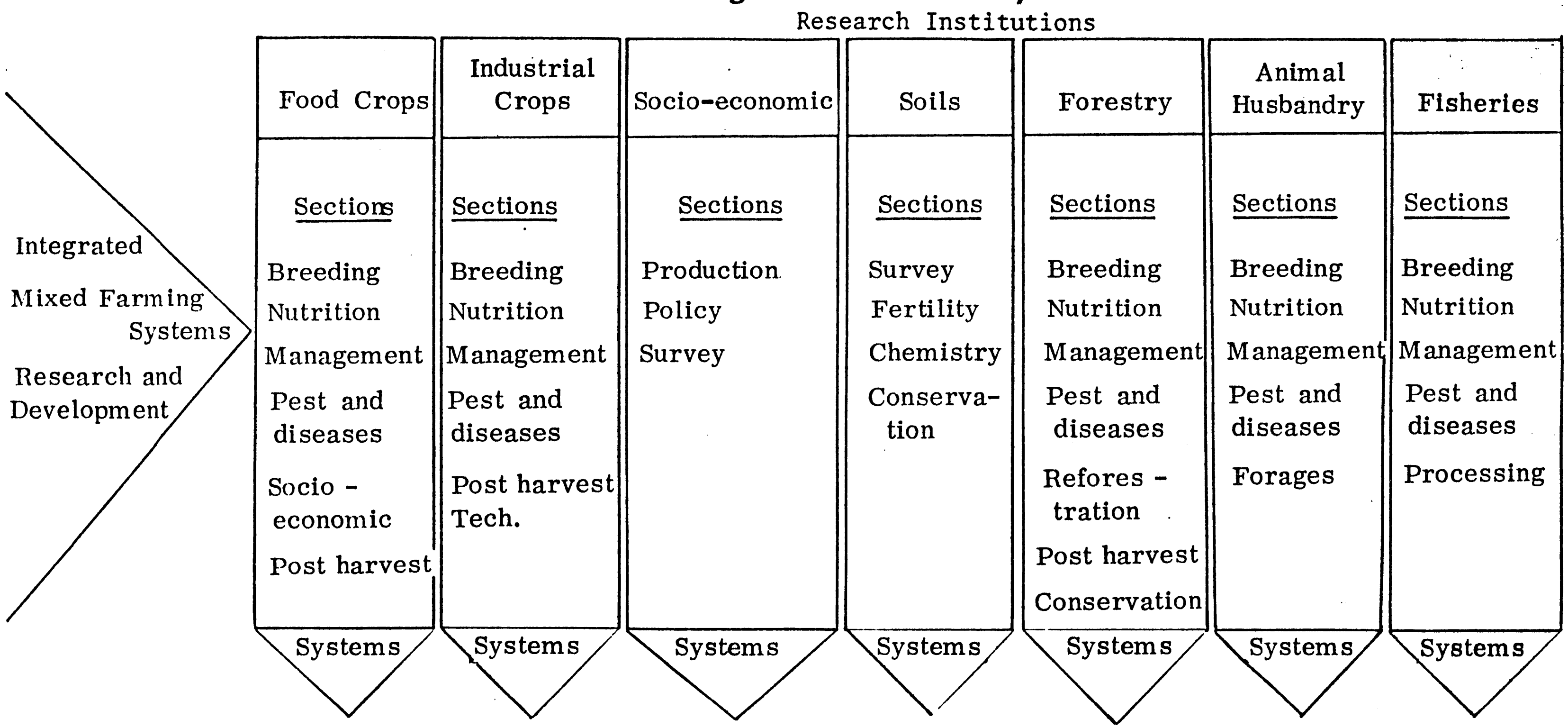


Figure 3. Organizational structure of AARD.

Research Organizations and Systems Research[1]



[1] this diagram illustrates how research in a farming systems program (FSP) interacts with other systems, programs and traditional commodity and discipline-oriented research activities.

Figure 4.
Framework for integrated mixed farming systems research for small farms.

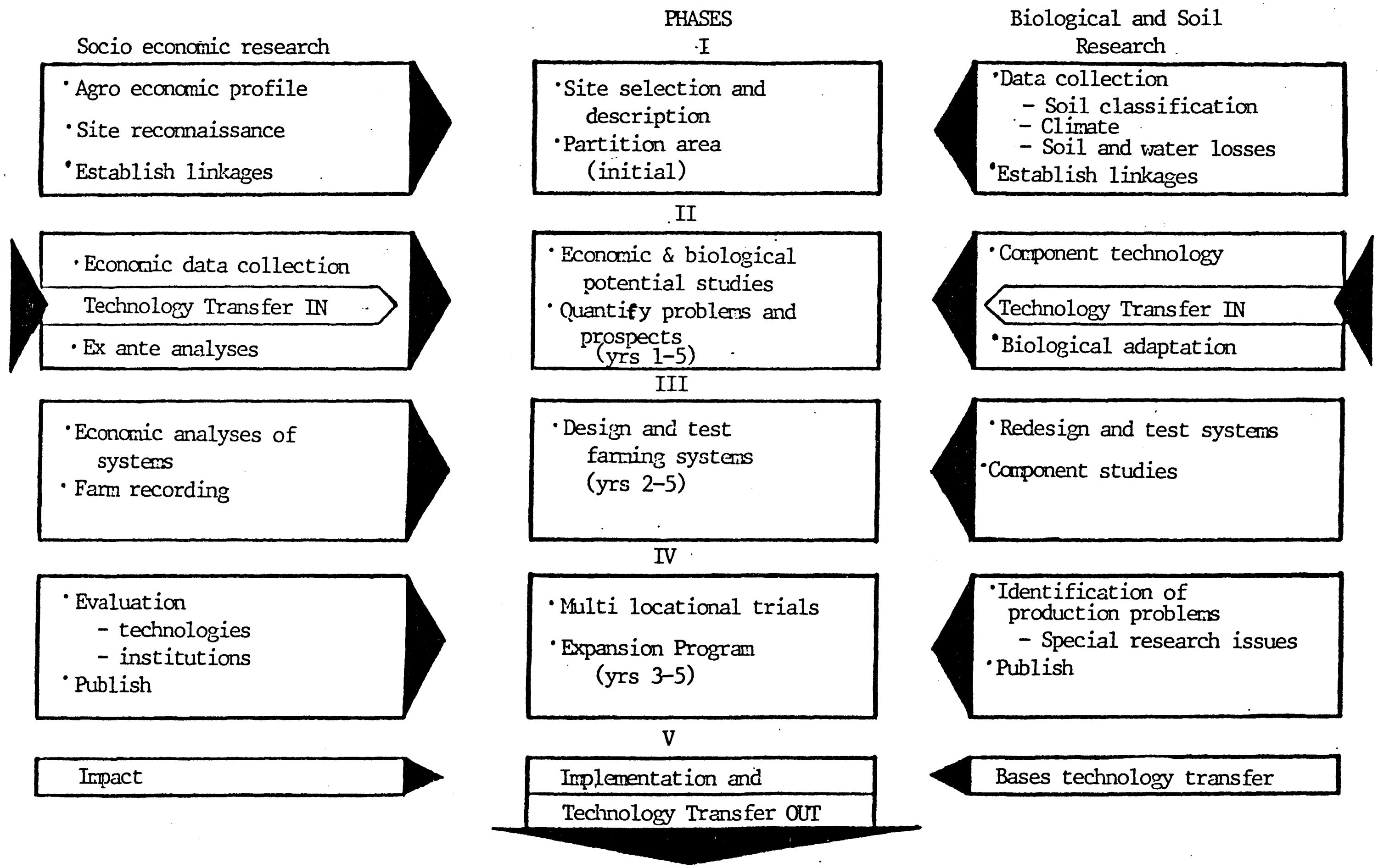


Figure 5. Parallel biological and socio-economic activities required for the five distinct research and implementation phases of a Farming Systems program with little inflow of technology.

Research-Extension interface over different phases of a farming systems program.

	RESEARCH & IMPLEMENTATION PHASES					
Target Area Selection	I Site Description	II Econ & Biol.Pot'l	III Design & Test	IV Pilot Prod.Prog	V Implementation	Technology Transfer
FSWG[1]	FSWG	FSWG	FSWG	FSWG	FSWG	FSWG
Extension Local Gov't. Nat'l Gov't	Extension Local Gov't	Extension Farmer Local Gov't Bureau Stat.	Extension Farmer Local Gov't.	Extension Farmer Dir. Prod. Local Gov't.	Extension Farmer Nat'l Prod.Prog. Local Gov't.	Extension Other Nat'l Gov't. Agen.

[1]FSWG - abbreviation for farming systems working group which is the multi-disciplinary research group that coordinates and carries out the research plans of farming systems programs in a target area.

Fig. 6. This is a schematic representation of the research-extension workload distribution and interaction with farmers and other government agencies in different phases of farming systems research and implementation.

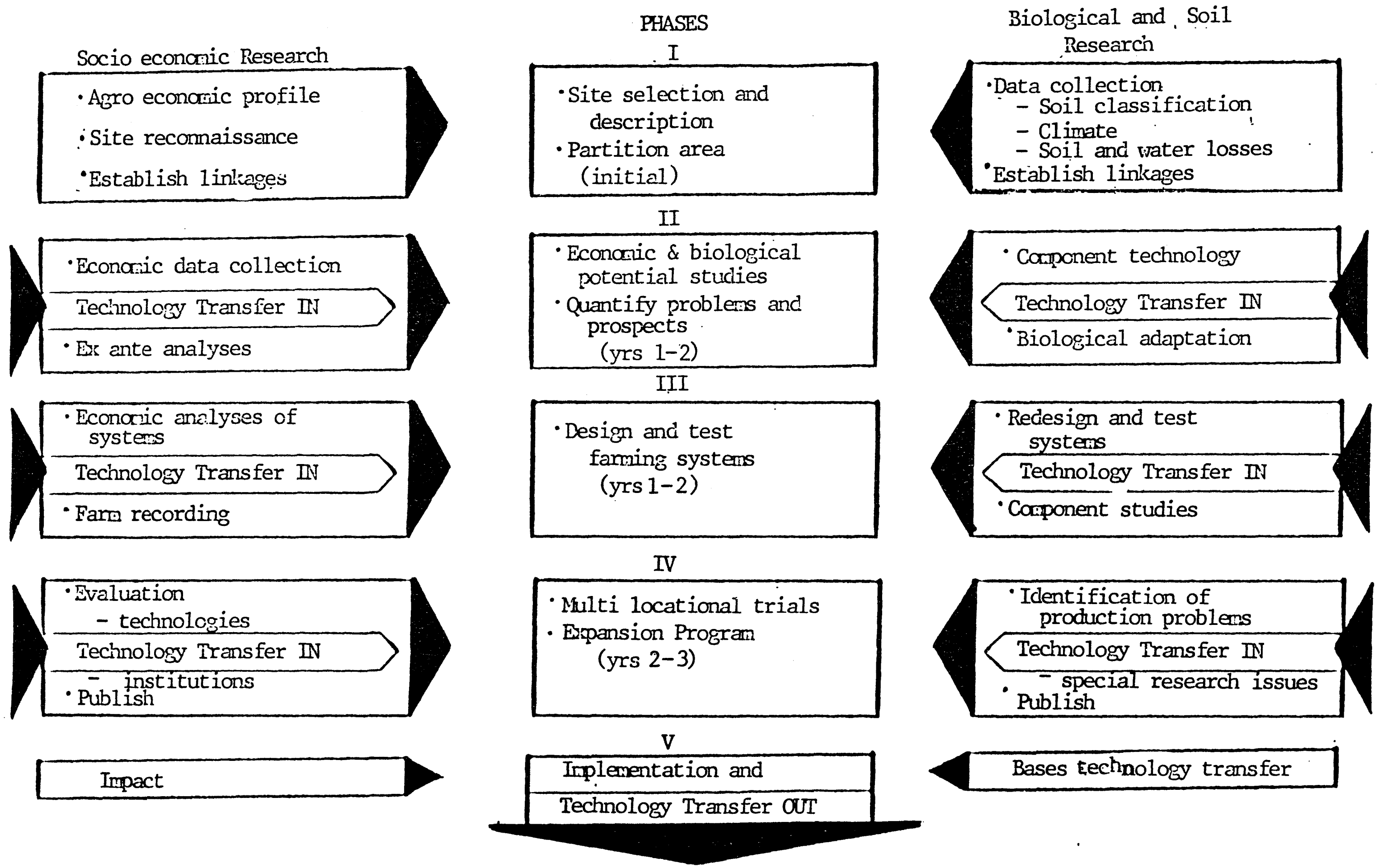


Figure 7. Time frame for research and implementation phases of a Farming Systems program with significant inflow of technology from research in areas with similar site descriptions. This technology transfer may reduce the research time in a target area by two or more years.

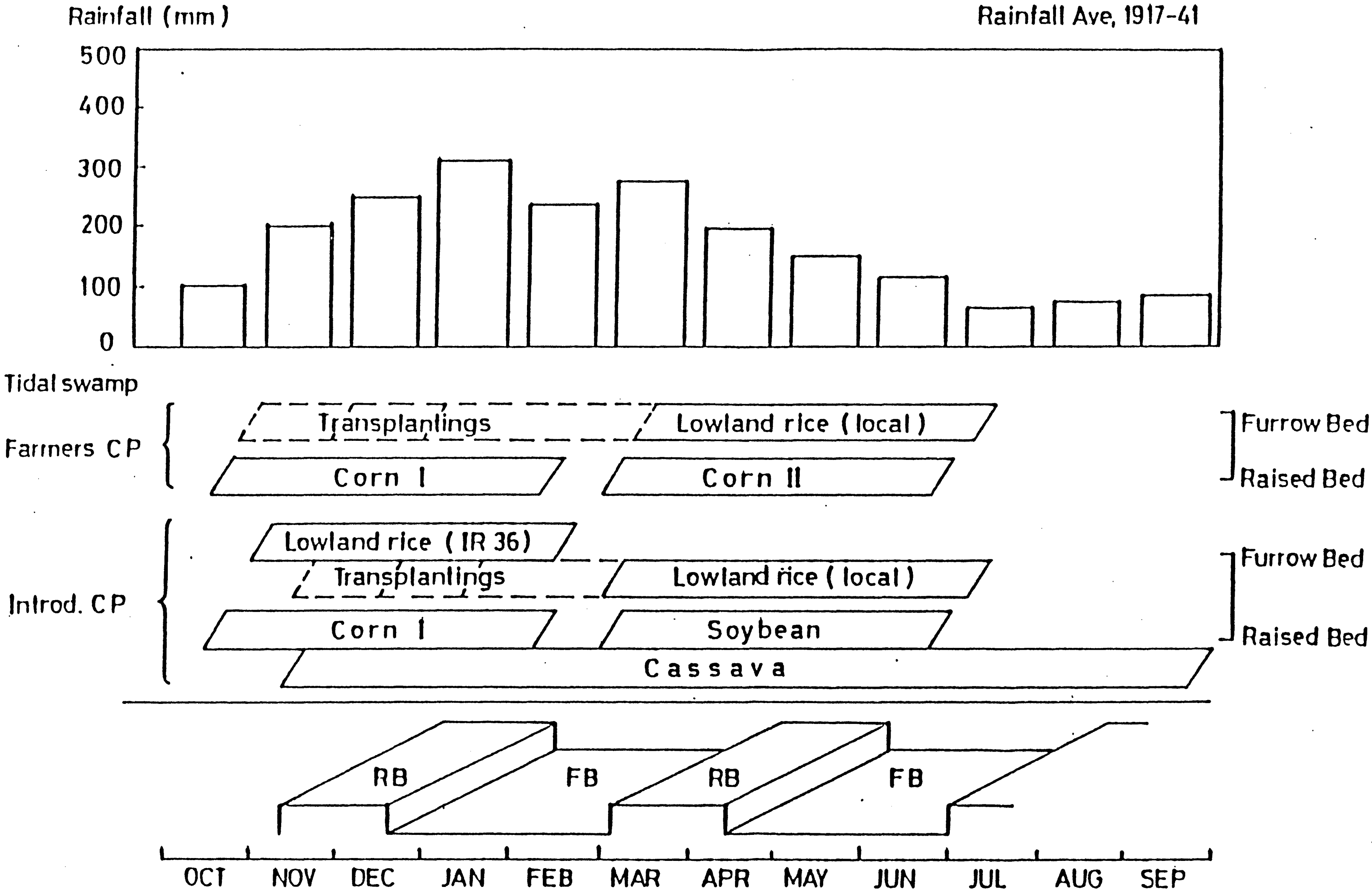


Figure 8. Rainfall distribution, cropping patterns tested and bedding arrangements for cropping system research in drained tidal swamp. Barambai, South Kalimantan. 1979-81.

Source: Annual Report, Banjarmasin Research Institute for Food Crops, 1982.

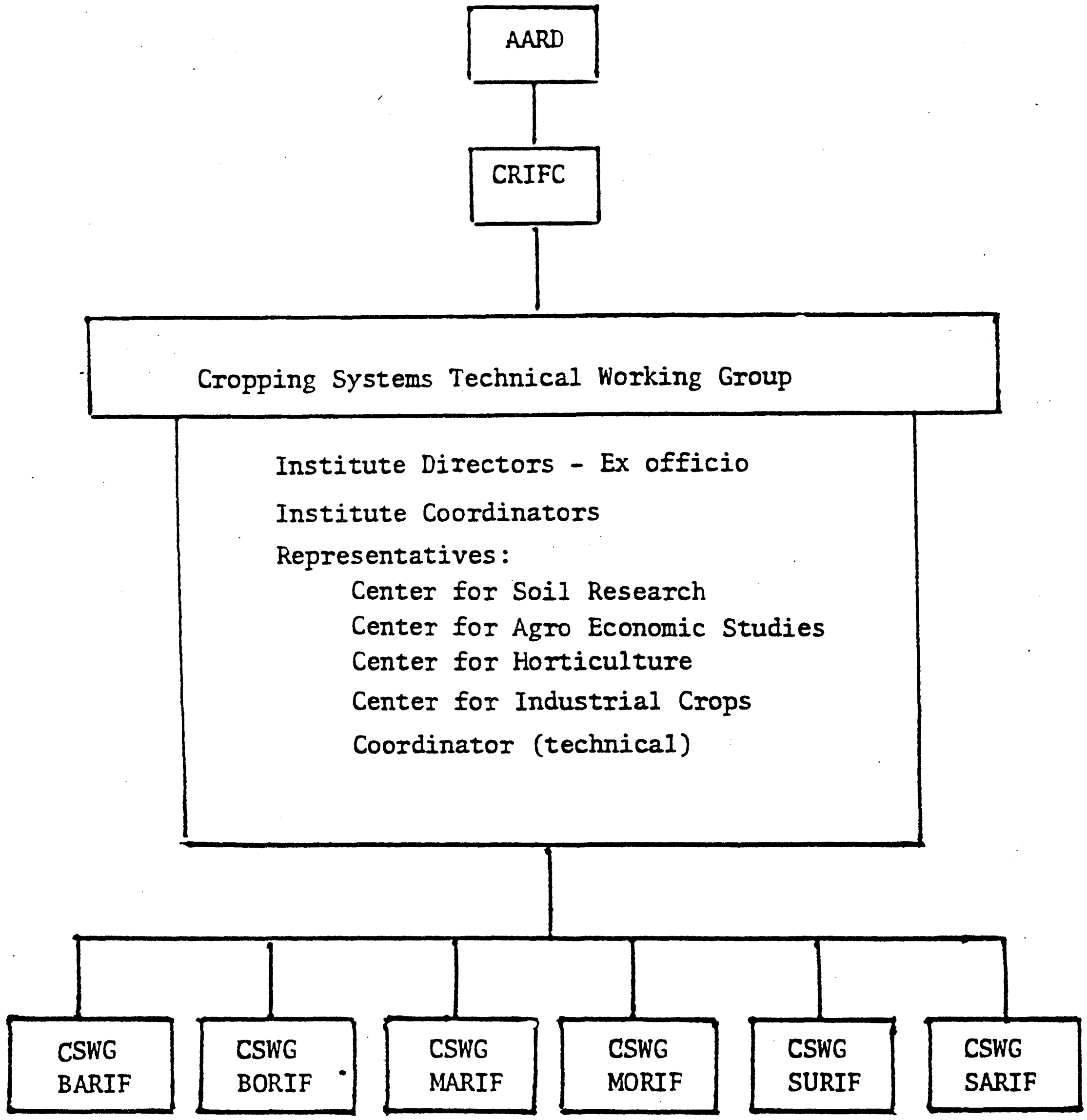


Figure 9. A possible administrative structure for technical coordination of cropping systems research.

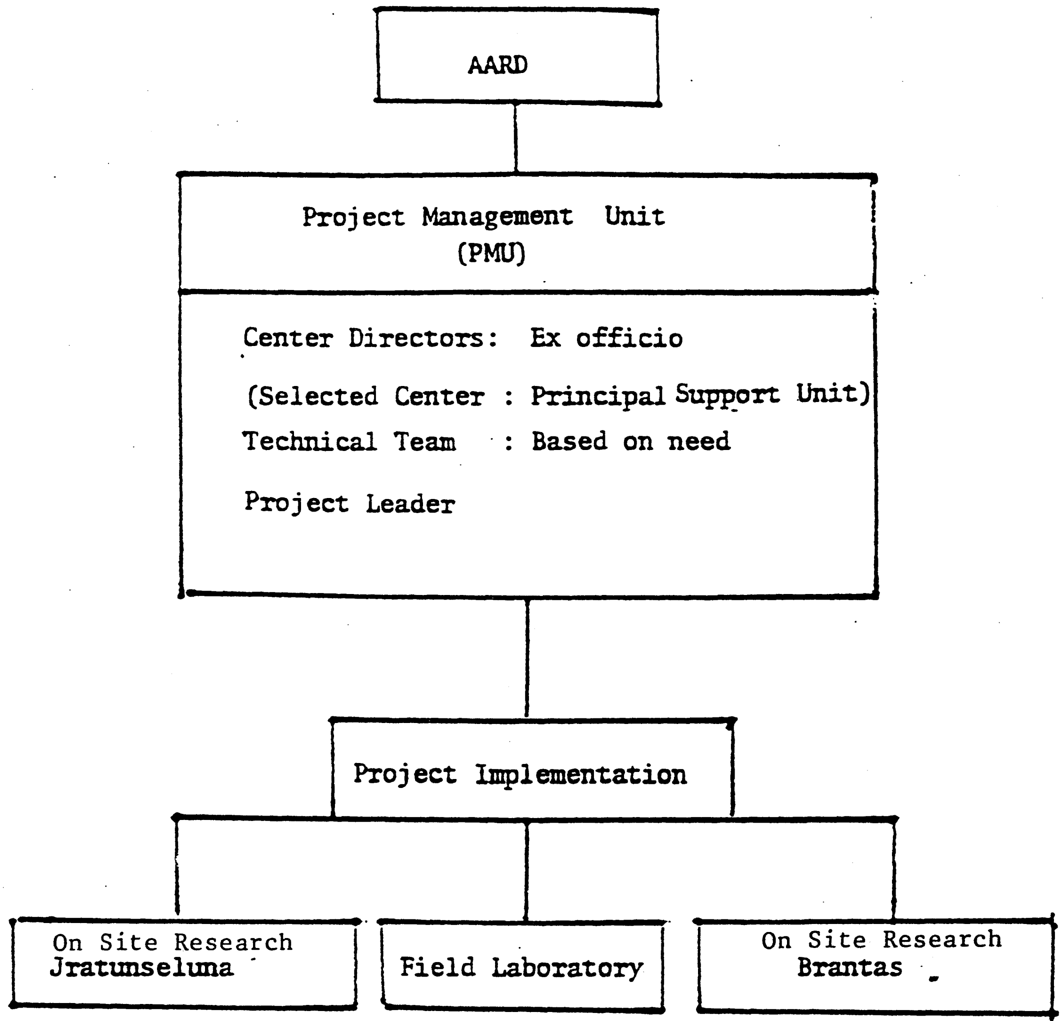


Figure 10. Organizational framework for Farming Systems Research in the Upland Agriculture and Conservation Project.

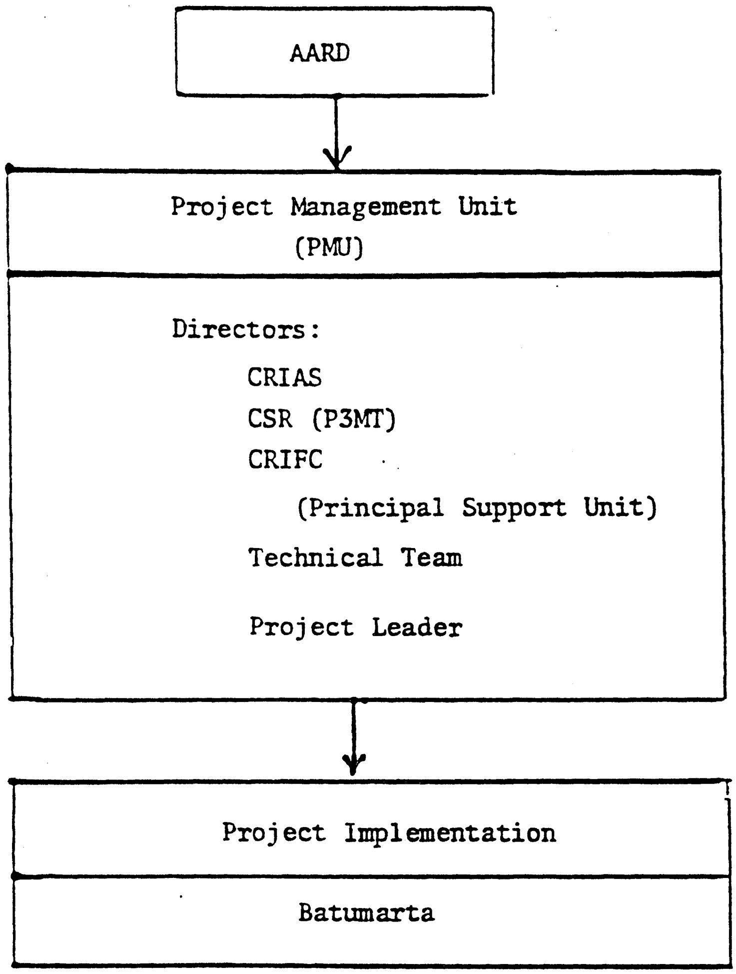


Figure 11. Organizational framework for the crop/livestock project in Batumarta, South Sumatra.

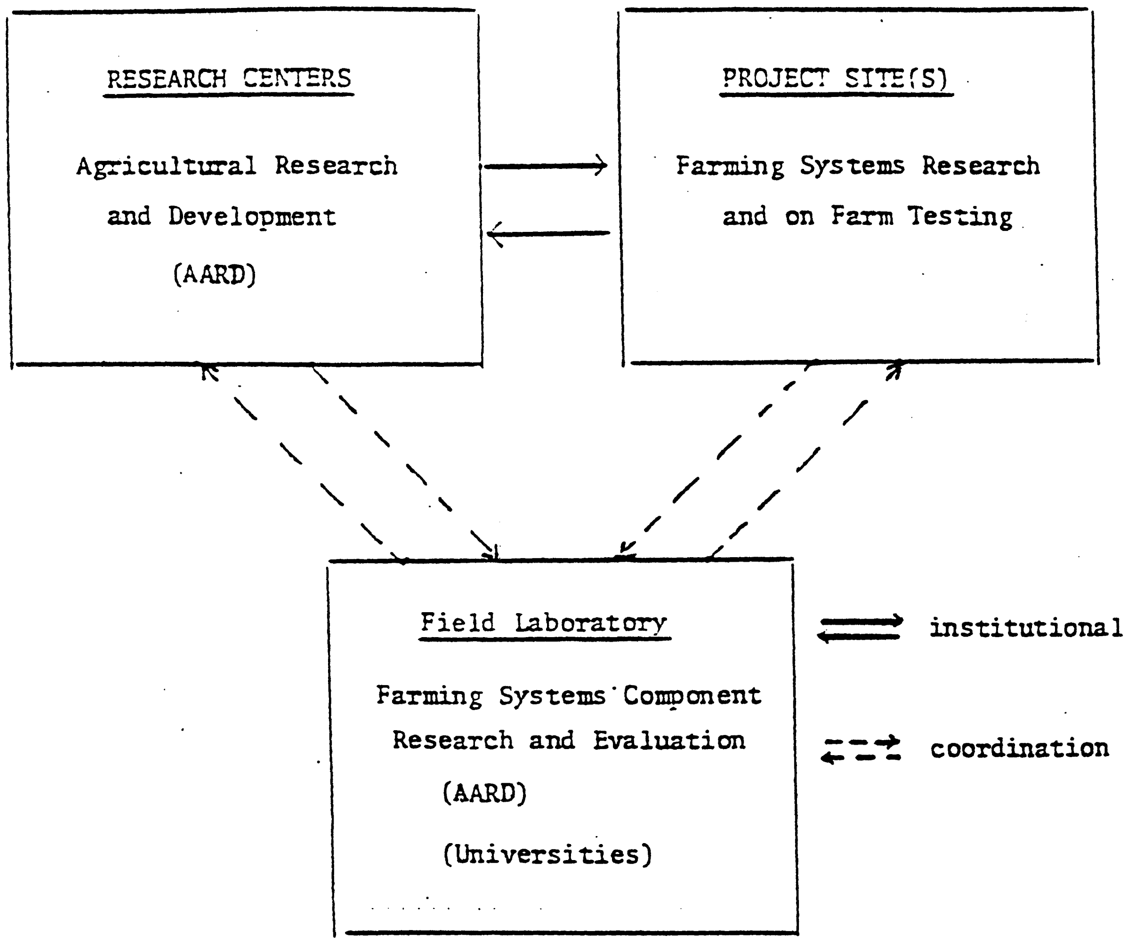


Figure 12. Development, evaluation, testing and flow of technology for Farming Systems Research and Development.

Table 1. Research Institutes and their mandates, within the Central Research Institute for Food Crops.

Banjarmasin BARIF	- Tidal Swamp Areas
Bogor BORIF	- Pioneer Research
Malang MARIF	- Palawija Crops Areas
Maros MORIF	- Upland Rainfed, Drought Prone Areas
Sukarami SARIF	- Upland Rainfed, Humid Areas
Sukamandi SURIF	- Lowland Rice Areas

Table 2. Status of Cropping Systems Research in terms of land areas, research and implementation phases, present impact and potential for cropping systems development in Indonesia.

Land areas	Research: Sites	Research: Phase	Research: Cropping pattern	Implementation: Location	Implementation: Status	Implementation: Target 1982-83 ha	Implementation: Potential Area ha
I. Lowland							
Irrigated	Indramayu	Implementation	LLR-LLR-Leg[1]	Rentang & Jati-luhur irrigation system	Prod.program	150,000	1,070,779
Partially irrigated & Rainfed	Indramayu	"	GRR-LLR-Leg[2]	Lampung	Prod.program	72,000	
	Serang	"	or	Serang	Pilot prod.	5,000	2,900,000
	Cibarusa	"	GRR-Leg	Madura	Pilot prod.	5,000	(partially irrigated)
	Madura	"	"				
	Bontoa	"	"	S. Sulawesi	Prod. program	75,000	1,800,000
				NTB (S. Lombok)	Prod. program	26,000	(rainfed)
II. Rainfed upland							
Humid areas	Sumatra						
	Sitiung	Testing	C+ULR/CV/PNT-CP[3] (main)	Lampung	Opsus	-	6,000,000
	Pasir Pangaraian	"	and	S. Sumatra	Pilot prod.	-	(1/3 x total)
	Pematang Panggang	Pre-prod.	C+SB-MB-CP (aux)	Riau	Pilot prod.	-	
	Baturaja	Pre-prod	"	S. Kalimantan	Pilot prod.	-	
	Tulangbawang	Pre-prod	"	Yogyakarta	Opsus	30,000	
	Way Abung	Pre-prod	"	Lampung		-	
	Bandarjaya	Implementation	"	Lampung	Pilot prod.	-	
	Kalimantan						
	Tajau Pecah	Implementation	"	S.Kalimantan	Pilot prod.	-	
	Sulawesi						
	Luwu	Implementation	"	S. Sulawesi	Pilot prod.	-	
	Puriala	Testing	"	S.E. Sulawesi	-	-	
	Java						
	Madura	Implementation	C+ULR/CV-PNT		Pilot prod.	-	

[1] Indicates the pattern: Lowland Rice followed by Lowland Rice followed by Legume.

[2] GGR indicates gogo rancah rice — rice that is direct seeded on aerobic soil and later flooded.

[3] Indicates the pattern: Cassava interplanted into an intercrop combination of Corn plus Upland Rice (the latter two crops planted about the same time). After harvest of Corn plus Rice, Peanut is interplanted in the Cassava and followed by Cowpea.

Table 2. (cont.)

Land areas	Research			Implementation			
	Sites	Phase	Cropping pattern	Location	Status	Target 1982-83	Potential Area
						ha	ha
Drought prone	Atambua	Testing	C+ULR/CV-CP or C+PNT/CV-CP	NTT			
Upper river watersheds	Panawangan	Preproduction	C+ULR/CV-PNT-CP	West Java	Pilot prod.		
	Solo	Preproduction		C. Java	Pilot prod.		
III. Deep water	Kayu Agung	Site selection		S. Sumatra			
IV. Tidal swamp	Barambai	Implementation	Surjan system	S. Kalimantan	Pilot prod.	1,000	2,000,000
	Karang Agung	Design	Raised bed: C+PNT or SB/CV-CP Lower part: LLR-LLR	S. Sumatra			

Table 3.. Comparisons of yields and economic returns from Farmers' and Introduced Cropping Patterns. CRIA- C.S. Project, Indramayu, West Java. 1975-78.

Cropping Patterns	Irrigation category 10 months	7-9 months	5-8 months
	Ave. yield - kg/ha[3]		
Farmers' C.P.[1] (1975-77)			
Lowland Rice -	5,560	5,334	3,628
Lowland Rice -	5.820	2.758	2,250
Net Returns	Rp.381,317	Rp.250,599	Rp.131,178
Introd. C.P.[2] (1975-77)			
Lowland Rice -	5,314	5,647	4,781 (GRR)
Walik Jerami Rice -	5,032	4,578	4,630
Legume -	768	944	541
Net Returns	Rp.379,591	Rp.422,237	Rp.222,872
Introd. C.P.[4] (1977-78)			
Lowland Rice -	6,915	7,195	3,451 (GRR)
Walik Jerami Rice -	4,910	4,550	2,901
Soybean -	462	610	---
Cash Surplus[5] to rice	Rp.527,923	Rp.523,099	Rp.205,539

[1] Farmers' cropping pattern.

[2] Introduced cropping pattern. Walik jerami rice is rice directly planted after preceding rice crop w/o plowing the land and Gogo Rancah Rice (GRR) is rice directly seeded on aerobic soil at beginning of rainy season. It is flooded later.

[3] Yields were measured by sampling from 1000 M^2 plots. There were 3 replications/treatment/year for the 2 years, 1975-77.

[4] Yields were measured by sampling from contiguous areas of approximately 3 hectares for each irrigation category for pre-production test trials, 1977-78.

[5] Cash surplus is gross returns minus cash costs for materials and labor, while net returns is gross returns minus costs for all materials and labor, including farmers' labor. One US dollar equal to 425 rupiah at time of research.

Source: Annual Reports, Cropping Systems Research in Indonesia.

Table 4. Adoption of gogo rancah in Lampung. 1976-83.

Year	Nambahdadi	Way Seputih	Lampung
	------------------ hectares ---------------		
1976-77	0.1	-	-
1977-78	4.0	-	-
1978-79	30.0	-	-
1979-80	212.5	-	-
1980-81	262.0	-	-
1981-82*	640-0	5,517	7,000
1982-83**		8,000	72,000

*PROGRAM Insus

**Target

Source: Tim Studi Dampak.

Table 5. Yield performance of crops in the introduced cropping pattern tested in ten different rainfed upland areas.

Location	No. years of testing	Yield of crops (t/ha)*				
		Corn	+ upland rice $\not+$	cassava $\not+$	peanut –	ricebean
1. Bandarjaya	5	2.1	2.4	25.6	0.6	0.5
2. Way Abung	5	1.4	2.3	14.7	0.5	0.3
3. Batumarta	5	1.6	1.8	14.8	0.7	0.5
4. Tulang Bawang	2	1.1	2.4	17.7	0.9	0.5 (cowpea)
5. Pematang Panggang	2	0.9	1.3	6.1	0.9	0.4 (")
6. Kotanegara	2	1.2	0.7	9.8	0.5	0.3 (")
7. Tajau Pecah	2	0.7	0.7	9.7	0.6	0.3 (")
8. Pasir Pangaraian	2	1.5	1.2	8.0	1.0	0.4 (mungbean)
9. Puriala	2	1.0	2.1	11.2	0.4	0.3
10. Lahat - Tebingtinggi	1	2.4	2.8	14.9	0.6	0.3

*Dry grain for corn, rice and legume and wet root for cassava when grown in the crop combinations indicated (+ means planted together, $\not+$ means intercropped with and - means followed by).

Table 6. Production and economic comparison of the farmers' existing cropping pattern with the introduced cropping pattern in two different rainfed upland areas. Southern Sumatra, 1976-82.

	Way Abung		Batumarta	
	FCP	ICP	FCP	ICP
Yield of crops (t/ha)				
Corn	0.6	1.4	0.6	1.6
Upland rice /	1.5	2.3	1.2	1.8
Cassava /	7.8	14.7	4.2	14.8
Peanut -		0.5		
Rice bean or Cowpea		0.3		
Total calories (KCal/ha/year)	15,081	31,732	9,972	32,326
Rice (gabah) equivalent (t/ha/year)	6.3	13.2	4.1	13.5
Total labor (man-days/ha/year)	285	605	245	517
Total cost of production (Rp/ha/year)	164,300	444,920	193,250	504,045
Gross return (Rp/ha/year)	348,000	1,004,500	297,750	1,097,523
Net return (Rp/ha/year)	183,700	559,580	104,500	593,478

Note:

FCP = Farmers' cropping pattern
ICP = Introduced cropping pattern
1 US$ = Rp.970.

Table 7. Research goals for farming systems research and the degree to which these goals have been attained in upland Transmigration Areas.

Goals for Systems Research	Status
I. Initial subsistence (cropping systems)	
• Appropriate food crops systems	- OK
• Productivity (subsistence)	- OK
• Economical (break even)	- OK
• Acceptable level of risk	- Still too high
• Stability (Short term)	- Need economic stability
• Family labor use	- Not adequately used on farm (off farm labor sought)
• Land resource use	- Still land not used
II Long term (farming systems research)	
• Subsistence + Cash income	- Need more cash income
• Full use of family labor	- Opportunity for more on farm labor needed
• Full use of land resource	- Options for use fallow land
• Low risk	- Need for technology for alternative agricultural interprises
• Stability	
Production	a. Subsistence needs met with food crops
Economic	b. Alternative interprises, for example, animal and perennial crops needed.
• Sustainability	
Production	Perennial crops needed to make better use of land and provide production and economic stability and sustainability.
Economic	

Cropping/farming systems research sites that have been completed and those that are on-going, AARD.

Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
1. Bandarjaya, Lampung, Sumatra	Rainfed upland	5	2	Orthoxic Tropudult, loamy, mixed, isohyperthermic	40^{o} 40'S

Descriptive phrases: Cropping systems, interdisciplinary, integrated and on farm research; food crops and economic component studies.

This research was designed to determine the potential for food crops production on red-yellow podzolic soils through improved soil fertility and crop management practices. The research was carried out under researchers' management but in farmers' field. The research showed that these soils were very responsive to phosphorus and that year round cropping patterns under good management were able to produce food calories and protein equivalent to that from at least 15 tons of rough rice. Through improved crop management and returning of all crop residues the crop production remained stable and soil phosphorus and organic matter increased over the seven years the project was in effect. This research showed the potential for crop production on these soils and provided the bases for expanded research and transmigration activities in areas where similar conditions exist.

Years: 1973-80 Institution: CRIFC

Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
2. Indramayu, West Java	Lowland rice: Full Irrig. Partial Irrig. 7-9 months 5-7 months Rainfed	3	4	Vertic Tropaquept, clayey montmorillonitic, isohyperthermic	6° 20'S ± 5 M

Descriptive phrases: Cropping systems, interdisciplinary, integrated and on farm research; food crops and economic component studies.

Strategies were developed to intensify cropping intensity by at least one extra crop per year for each of the edaphic conditions listed through use of earlier maturing varieties of rice and palawija crops, earlier planting of rice (gogorancah where appropriate) and reduced turn around time (walik jerami where appropriate). In partially irrigated areas two extra crops were grown per year (gogorancah plus soybean). This technology was rapidly adapted after farmers were obliged to use the brown planthopper resistant variety IR-36 which matures in about 110 days. Previously even where two crops of rice had been grown the second crop many times suffered from drought and produced low yields. Consequently, new technology brought about increased production per unit area of land by increasing cropping intensity and increased yield from dry season crops. Component studies showed the problems with weeds for gogorancah rice and with gall midge for rice planted in January and February. Constraints to palawija crop production in dry season are mostly related to surface water drainage at time of planting and drought stress later in season. Shallow surface drains spaced according to severity of the situation are practical solutions to these problems.

Years: 1973-78   Institution: CRIFC.

Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
5. Nambah Dadi, C. Lampung, Sumatra	Partial Irrig. ± 5 months	5	2	Typic Paludult (presently has an aquic moisture regime)	4° 40'S ± 35 M

Descriptive phrases: Cropping systems, interdisciplinary, integrated and on farm research; food crops and economic component studies.

While research on cropping systems was being condicted in Bandarjaya it was observed that cropping intensity was higher in the upland than in the adjacent lowland areas where some irrigation water was available. This anomaly caused us to open a research site in the Way Seputih Irrigation Area to see if the rain and irrigation water could be used more efficiently. We were able to grow two rice crops and a palawija crop by using earlier maturing varieties, direct seeding (gogorancah) and reduction in turn around time. The farmers had become dependent on irrigation water which permitted them to grow one crop of lowland rice. But they had not effectively made use of rainfall. Crop yields per year in cropping systems studies showed that total production could be increased from 3.7 tons (lowland rice) to 5.6 tons (gogorancah) rice plus 2.9 tons (walik jerami) rice plus 0.7 ton of cowpea per year. This technology spreads spontaneously throughout the Way Seputih Irrigation project and has since been adopted as a production practice for similar areas in Lampung.

Years: 1975-78 Institution: CRIFC.

Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
24. Mijen and Demak, Central Java	Rainfed lowland	5	6	Vertic Tropoquept	6^{o} 50'S 1-5 M

Descriptive phrases: Animal systems, interdisciplinary, integrated and on farm research; animal feeds and nutrition and economic component studies.

This research was designed to maximize the utilization of crop by-products for ruminants among smallholders in rainfed lowland areas that tend to flood. Understanding the interaction among ruminants, food and industrial crops, and environment is the prime objective. The research is carried out under farmers' (and key farmers) management and with close collaboration among researchers from Balai Penelitian Ternak (BPT), Livestock extension officers and Universities. Breeding, feed technologies, animal health and management, and to some extent marketing, are all part of the research.

Years: 1983 Institution: CRIFC.

Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
35. Batumarta	Upland rainfed	7-9	2	Typic paleudult, fine loamy, kaolinitic, isohyperthermic	± 4° S 90-120 M

Descriptive phrases: Farming systems, integrated, interdisciplinary, on farm research; crop/livestock and economic component research.

This research is designed to develop methodology for interdisciplinary research involving crops and livestock. It will be carried out in older parts of the Batumarta Transmigration Area where original research was conducted on cropping systems from 1976-1980 and where more recently component studies on terracing and fertilizer efficiency have been conducted. Specific research objectives will be to (1) identify and remove constraints to improved crop and livestock production systems in upland rainfed transmigration areas, (2) further develop relevant component technologies for both crop and animal systems and (3) develop methodologies for effective and interdisciplinary farming systems research.

Year : 1984 Institution: AARD and BORIF

	Site location	Edaphic condition	No. Months with Rainfall >200 mm	and <100 mm	Most probable Soil Classification or Type	Latitude: Elevation:
36.	Jratunseluna	Upper river watershed	6	2	Andepts to Vertisols	$\pm 7^{\circ}$ S 200-1000 M
37.	Brantas		5	5		$\pm 8^{\circ}$ S 200-1000 M

Descriptive phrases: Farming systems, interdisciplinary, integrated and on farm research; food crops, perennial crops, animal, soil conservation and socio-economic component studies; terracing and post terracing management.

This farming systems research is a component of a comprehensive research and development project in upper river watershed areas of the Brantas and Jratunseluna rivers systems. The purpose of the research is to refine existing and develop alternative farming systems technologies adapted to the specific agro-climatic conditions found in these watersheds and to evaluate fully the economic and financial returns of these alternative systems. Together with the results stemming from the Citanduy project, which would also be monitored in this project, the information developed will provide a technological base for production and soil conservation programs for these and other similar watersheds with the ultimate objectives of increasing incomes and agricultural productivity of rainfed upland farmers and conserve soil and water natural resources. Specific emphasis will be placed upon component research for food subsistence, animal and perennial crops production for cash and soil conservation practices. These will be preceded, accompanied and followed by socio-economic studies.

Years: 1984-1991 Institution: AARD.

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FARMING SYSTEMS CASE STUDIES

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A CASE STUDY OF ON-FARM ADAPTIVE RESEARCH AT BIDA AGRICULTURAL DEVELOPMENT PROJECT, NIGERIA

MALIK ASHRAF

INTRODUCTION

The Bida Agricultural Development Project (BADP) operates from 1980 until 1985. It is jointly funded by the Federal Government of Nigeria (25%), Niger State Government (39%) and a World Bank Loan (36%). The objectives during the Project life, are to raise agricultural production by 25% and to increase farm income by providing farm inputs such as fertilizers, credit, tractor hiring service, extension information, developing low cost irrigation schemes, and by constructing feeder roads for the evacuation of surplus farm products.

In late 1981 Bida Agricultural Development Project in collaboration with the International Institute of Tropical Agriculture (IITA), initiated an agronomic research program designed to identify major production constraints in the local farming systems. The aim was to identify intervention points and develop technologies and recommendations adapted to the needs of the local farmers, for use by the Project's extension staff. This case study is a preliminary description of the resulting On-farm Adaptive Research (OFAR) program.

DESCRIPTION OF THE PROJECT AREA

The Project area covers some 17,000 km^2 of land in the southern part of Niger State and lies in the Southern Guinea Savannah zone. The topography is characterized by gently undulating country, underlain by sandstone. One of the major determinants of the cropping system is the network of rivers, especially the Niger River and its tributary and the Kaduna River. These rivers are characterized by their large, swampy flood-plains, which flood during the rainy season and then gradually dry out during the dry season. The flood-plains and the complex of smaller river valleys and inland swamps (fadamas) are usually referred to as lowlands and are used to grow rice. The major part of the project area, which does not flood, is referred to as, upland and is used for rain fed farming. Soils in the uplands are generally sandy and acidic with low levels of organic matter and low cation exchange capacity. They are also highly permeable and liable to erosion, especially on steeper slopes. Soils in the lowlands are loamy and of higher quality, allowing longer periods of cropping without need of a fallow period. Temperatures rarely fall below 20˜C, except during the dry season and are not a major constraint to crop growth in the area. Rainfall is the major constraint and is characterized by its seasonal nature, monomodal distribution and variability from year to year. Seed-bed preparation, germination and the early stages of crop growth are entirely dependent on the amount and frequency of precipitation, since the soil profile and particularly the soil surface carry a large soil moisture deficit at the beginning of the rainy season. Reference to Figure 1 shows the high variability in the amount of rainfall during this period. Mean rainfall (1182mm/annum, 23 years data, Bida Airport) is in excess of evapotranspiration from 11th May until 10th October (152 days). However, rainfall can only be relied on to exceed evapotranspiration from 1st July until 30th September (91 days). The period between early May and early July presents considerable risk to farmers. The amount of moisture available may not be sufficient for sustained crop growth.

An estimated 9% of the total Project area is under cultivation (BADP, 1982), with concentrations of farm land around the lowlands and Bida, the major urban center. Cultivation in the lowlands is semi-permanent to permanent in nature (following Ruthenberg's classification, 1980). Upland farming is practiced under bush fallow or shifting cultivation. Little of the lowland area is cultivated in the dry season except for plantings of cassava, grown as a gap filling crop for consumption during the 'hungry period' prior to the main harvest, sugar-cane (for chewing) and vegetables. Nomadic Fulani herdsmen migrate into the area during the dry season with their cattle (estimated 400,000 head/year) to find dry season grazing and drinking water.

The Project area contained an estimated 65,000 farming families with an average size of 6.5 persons. Population is denser to the east of Kaduna, especially around Bida, the main urban center. Farming is the main occupation of the rural population and is the primary source of income. Supplemental income activities are fuel wood, fishing, trading and employment in government.

Rice, sorghum,[1] and dried fish are the major surplus commodities in the area and a local marketing system has arisen for these items. Most villages hold a market every 5 days for sale of goods for local consumption. Project area level surpluses are sold through two marketing systems; through the major markets which are usually found on the main roads and to traders who visit the villages during the harvest period to buy directly. Bida market is the dominant market and is held daily. Bida and other large markets serve as the wholesale markets for sorghum and rice. Traders from urban centers outside the project area also come to villages each year to buy par-boiled rice. It is estimated (BADP, 1982) that 16,000 tons of rice and 15,000 tons of sorghum leave the project area every year. The on-farm storage and marketing of surplus farm products is not considered to be a major constraint at the present time.

ORGANIZATION OF THE OFAR PROGRAM

The function of the OFAR program was to provide recommendations for use by the Extension Service which would be adapted to the farmers within the project area and would utilize the potential benefits of inputs and services provided by the project. The OFAR program of BADP can be split into 5 activities:

a) Exploratory and diagnostic phase to make a preliminary

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[1] Sorghum is the common vernacular name for guinea corn.

definition of target areas and identify opportunities for experimentation within these areas;

b) Screening trials of on-station technology for use in the on-farm trials;

c) On-farm testing and evaluation of selected technology;

d) Verification of target domains and use of knowledge gained from farmer interviews and reactions to trials for design of the subsequent years' program;

e) Recommendations to the Project extension service.

The Exploratory and Diagnostic Phase

The wide range of agroeconomic circumstances faced by farmers within the Project area made it impossible to run a series of on-farm trials relevant to all farmers within the area. Therefore it was necessary to first group farmers with similar agroeconomic circumstances and then design a program to produce recommendations relevant to the separate groups (target domains).

The Project was visited by an IITA agricultural economist and an agronomist shortly before the start of the planting season in 1981. After an aerial reconnaisance to familiarize themselves with the general features of the area, the team collected secondary data concerning population, general agronomic practices and farm labor use pattern.

The obvious difference between farmers whose cropping system was based around the lowland cultivation of rice and farmers whose cropping system was based on upland crops led to an initial hypothesis of two target domains i.e. farmers with a lowland based cropping system (Domain 1) and those with an upland based cropping system (Domain 2).

The short period of time available before establishment of the first year trials did not allow time for extensive verification of the target domains. Verification and refinement of the target domains was carried out concurrently with the first year trials. Analysis of a yearly agronomic survey, referred to as FRADYS (Field Records for Agronomic Details, Yields and Stands) and a series of informal interviews, formed the basis for verification. Data from the 1982/83 survey of 225 farmers in 15 villages was used. Farmers were grouped by land area allocated to specific crops/crop mixtures, on the assumption that aggregate area reflects the interaction between the bio-physical and socio-economic circumstances of the farmers and their priorities.

Analysis revealed 4 cropping systems based target domains, 1 in the lowlands and 3 in the uplands:

(i) Lowland rice based;
(ii) Upland yam based;
(iii) Upland cassava based;
(iv) Upland cereals based.

The major determinants of the four cropping systems were soil types (including the varying level of soil fertility) and the availability of moisture during the wet and dry seasons. In the lowland, surface soils are deep and loamy. They are subjected to flooding caused by surface runoffs and there is seepage water supply during the dry season. The upland soils can be divided into three types. The first type contains the lower edges of the sloping fields having deep rich surface soil, heavier soil texture and experience little erosion. Farmers use these soils for growing yams and maize. The availability of such soils is limited in the project area. The second type has slightly loose soil texture, lower fertility and lies on the mid slopes. These fields are planted to cassava. The third type refers to the top section of the catena; they are either sandy or gravelly, highly eroded, leached and very low in fertility. Majority of the project land falls in this category. These fields are planted to sorghum, millets, egusi melon, bambaranut, groundnut, etc; the crops best adapted to low fertility soils.

Although Nupe population settlement is related to the location of inland valleys and access to the drinking water supply during the dry season, they farm all types of land. Some farmers have access to both lowlands and one or the other type of upland, while many farmers have access to only different types of upland. Thus, those farmers having both lowland and upland, are referred to as practicing the rice based cropping system. Those having upland, some of which is suitable for yam cultivation, are referred to as practicing a yam based system. Similarly, those farmers who grow both cassava and upland cereals are referred to as practicing a cassava based system. Lastly, those farmers who have access to only poor quality land which is planted to rough cereals and legumes are referred to as practicing a cereals based cropping system.

The definition of target domains in this paper is therefore very much related to the bio-physical factors which, in our view, have major influence over farmer's cropping plans and management decisions.

DESCRIPTION OF TARGET DOMAINS

The dominant crop by area in all four target domains was sorghum (Appendix 1) but within their respective domains rice, yam, and cassava were the major cash crops. These crops also produced higher yields (Appendix 2) and failed least often (Appendix 3) in their respective domains. Crop failure rates were highest in the upland cereals based system. As mentioned above, this system is confined to the less fertile soils in the uplands, with soils which are both highly erodable and shallow and which quickly show the effects of drought.

Rice Based System

Twenty seven percent of the sampled farmers fall into this system i.e. growing both lowland and upland crops. In late April or May, upland fields are planted with sorghum (Figure 2), usually in a mixture with millet, maize or egusi melon. Sorghum is the major food grown for home consumption and so priority is attached to ensuring good establishment of this crop. Although, once established, the crop can compete well with weeds, it is important that fields be kept clean during the early stages of growth. Therefore, land preparation for the rice crop in the lowlands occurs only after the first weeding of the upland crops, in late July and

August. Since the majority of the rice area is classified as rainfed lowlands with little water control, the crop is exposed to the risk of moisture stress at the end of the rainy season. Delay in planting of rice is exacerbated by the high labor input necessary to ridge the land.

Within the project, rice is grown mainly in two ecological environments: on the flood plains; and in inland valleys where seepage water from the surrounding uplands accounts for much of the water. In both environments ridging is the major method of seedbed preparation and is a function of water status and position in the topographic sequence. Close to the bottom of the sequence, where the water level is deep, rice is seeded directly onto the ridges; while in the upper part of the toposequence, ridges are made to conserve water and facilitate weeding.

Land preparation for rice usually occurs 3 months after the start of the rainy season and so farmers are faced with substantial weed growth. Simply turning over the soil will not prevent quick re-growth unless water is present in sufficient quantity to suppress them. Therefore, farmers use ridging as a weed control measure at the establishment stage and also during the first weeding, when weeds are pulled into the furrow with the hoe and then buried. Herbicides are only rarely used and are unknown to most farmers.

Harvesting of short-season upland crops such as millet and egusi melon and weeding of the rice crop are the major activities until the dry season in November and December, when the sorghum and rice are harvested.

The dry season is a period of slack labor demand for most farmers in the rice based system, since only a small part of the lowlands are utilized for production of dry season crops on residual moisture and few opportunities exist for off-farm employment.

Upland Based Systems

Within the survey sample, 27% of farmers fall into the yam based system, 7% into the cassava based and 39% into the upland cereals based system. Farm size was largest for farmers in the yam based system, smallest for those in the upland cereals based. For the yam and cassava based systems, farm labor input was high at 365 and 239 man-days respectively, with peak labor demand at the start of the rains during the planting of sorghum and after the rains when harvesting occurs. Potential conflicts in the allocation of scarce labor for establishment of yam and sorghum are avoided by planting most the yam area during the dry season (Figure 3), thus spreading out the demand for labor over time. Within the cassava based system, the planting of cassava occurs after the establishment of the sorghum crop. Since cassava is a relatively drought resistant crop with a growth cycle of over 12 months, timeliness of planting is not as important as it is for the rice crop allowing establishment over several months (Figure 4).

The upland cereals based system was the poorest domain; crop yields were lower than in the other domains and farm size was smaller. The first half of the rainy season is usually busy in the activities of planting and weeding, (Figure 5) during the second half many of these farmers sell their labor to richer farmers who practice rice and yam based systems. Families in this domain hunt, fish or sell their surplus labor to supplement farm incomes.

Farm Productivity

Farm productivity measured in terms of farm income and returns to farm inputs varies considerably among the four target domain cropping systems. The root crops based systems of yam and cassava yield greater quantities of food, when converted to value terms these systems produce higher farm incomes. The rice based system which has access to good land and water resources is comparatively less productive, mainly due to lower cropping intensity practiced in the lowland fields. Farmers' capital costs are mostly in the form of seed, small quantities of fertilizer and primitive hand tools. Farmers do not have access to animal and mechanical farm power. Thus, the return to capital is negligible. Nearly 85% of the farm costs are labor inputs (mostly family sources) and returns to labor input is close to the rural wage rate. After accounting for costs of labor and capital, the return to land is negative for the rice and cereals based systems and positive for the yam and cassava based systems (Appendix 4).

SYSTEM CONSTRAINTS AND EXPERIMENTAL OPPORTUNITIES

Rice Based System

Planting of rice is usually delayed by the farmers' practice of weeding their upland crops before commencing land preparation for rice and by the large labor input necessary for ridging by hand. Easing this labor constraint in July and August would allow for an increase in the area of rice planted, increase yields by more timely planting and lessen the risk of crop failure due to moisture stress later in the season. Changing from ridged to flat seedbeds would save labor and also fit in with the newly expanded tractor hire services and chemical weed control methods provided by the Project. The change would also tie in with the Project work on informal irrigation schemes in the lowlands and their advocacy of contour bunding.

Other factors limiting rice yields in the area were the low stand density and iron toxicity. Stand density is closely related to the ridging of seedbeds; wider spacing between ridges results in lower stand densities. Stand density could be increased either by reducing the gap between ridges or by planting on the flat.

Iron toxicity is a more complex problem. Improved varieties tolerant to this problem is one possible solution which the farmers might easily adopt. Other expensive solutions are use of lime (1-2 tons/ha), drainage of seepage water and planting on raised beds. Other problems, such as irregular water supply and bird damage were noted, but as these problems were outside the control of the farmer, they were not included in the short term research program.

The presence of seepage water from the surrounding uplands in the fadamas during the dry season offered the possibility of increasing system productivity by growing a 'catch crop' using this residual moisture. Since labor was not a constraint within this system during the dry season, this opportunity offered chances of introducing change into the system without major problems of resource allocation.

The Upland Based Systems

For the three systems, improvement possibilities lie in the mid-season, between July and November, when surplus labor is available. Project records and informal interviews have shown that the area planted to cowpea had declined rapidly within the last few years due to insect problems principally at flowering. Cowpeas are still a major component of the diet and are imported from Northern Nigeria. Local cowpea varieties are indeterminate, making the use of insecticides inefficient, since the crop flowers over several weeks. The surplus labor in mid-season and new determinate varieties requiring a minimum spray regime for insect control, offer the opportunity to re-establish the crop(Fig.6).

The local cassava varieties were observed to be heavily infested with green spider mite and cassava mosaic virus, both depressing their yields. As solution to this problem, improved varieties could be screened for tolerance to these problems.

Although the Project area is well suited to maize production, maize was a relatively minor crop grown mainly for home-consumption. The Project extension unit was attempting to increase maize production, but a major constraint observed was the parasitic weed, Striga homotheca. As an initial step, screening of improved varieties with some resistance to striga and finding cultural control are necessary.

ON-FARM TRIALS AND RESULTS

The aim of on-farm trials was to maximize information about the constraints identified in the diagnostic phase and evaluate selected crop varieties and management alternatives to overcome crop specific constraints. Results were used to assess the agro-economic feasibility of the selected interventions compared to the farmers current practices and to improve the level of socio-economic information which was found lacking during the diagnostic phase. After discussions with scientists and project staff, priority was placed on research in the lowland rice based domain. The rice based cropping system was identified as having the most potential for improvement using technologies available on-station. In addition, the first year trials were used to:

a) develop the capability of Project staff to run OFAR trails and to reveal areas in which further training would be necessary;
b) assess the logistical demands of the program;
c) develop knowledge of the level of farmers willingness to participate in OFAR and their level of technical sophistication.

Rice Based System

As stated before, farmers grouped under the rice-based cropping system grow rice in the lowland and a mixture of cereal and legume crops in the uplands. The productivity of the lowlands is very low mainly because of low paddy yields caused by a late planting and less intensive use of lowland fields. Since farmers attached greater importance to the cash crop of paddy, system improvement was therefore sought through changes in the crop management practices of lowlands.

There are two feasible approaches to the moving forward of rice planting dates by; (a) changing the existing laborious ridge seedbed preparation method to the flat cultivation techniques and (b) replacing a portion of the area planted in photoperiod sensitive sorghum varieties to a short season modern variety which can be planted later in the season, thus allowing the paddy to be planted a few weeks earlier. The third alternative of saving weeding labor from the upland fields was not considered since there was no known mechanical or chemical technology for the crop mixtures practiced by the farmers.

Relating to the first approach, rice trials were conducted to evaluate the effects of flat seedbed preparation, rice hill density of 50%, and modern rice varieties, on the paddy yield and the labor use pattern. Experimentation was conducted on the second approach to identify and evaluate the short season improved sorghum varieties by planting later i.e. in the month of August.

A factorial agronomic experimental design was used for the rice trials with two treatment levels, the farmer level and the level recommended by the scientists. The variety factor included four varieties, one of which was the farmer's. The three experimental factors were: (a) seedbed preparation method; (b) stand density; and (c) variety. These were combined in an experimental design which required different levels of management. The first design consisted of representing 5 different rice fadamas under direct management of the Project research staff. The second design included two varieties rather than four and utilized farmers' participation, especially for the management of non-treatment factors. In the third design, stand density was eliminated, leaving 2 varieties and two seedbed preparation methods. These trials were fully managed by the farmer and supervised by the Project Extension Staff. These trials were conducted consecutively for two years and produced valuable feedback.

<u>Variety</u>

A total of 6 varieties were planted at different sites. Varietal selection was based on performance in a seed multiplication plot, with new varieties being recommended by the extension service. Due to the late start of the rains, rice planting by farmers in the project area was delayed by two to three weeks. The planting of on-farm trials was, therefore, also delayed at all but one site. The farmer variety was photoperiod sensitive and experienced little water stress after cessation of the rains. Among the improved varieties, only one had a comparable season length and did not experience moisture stress at panicle filling. The local short season varieties, which yield 2.25 tons per hectare were better adapted to local physical and biological conditions of little or no water control than the selected improved varieties.

At one site where water management was good and irrigation continued after the rains ceased, yields of the improved varieties were 32% - 40% higher than those of the local control.

Seedbed Preparation

The hypothesis was that yield could be maintained or even increased by planting rice on a flat seedbed rather than on ridges, thus saving labor. Results from the trials produced two opposing agronomic yield responses. Half the sites showed a positive yield response to changing from a ridged to flat seedbed, the other sites a negative yield response. Based on the preliminary observations made during the crop season and subsequent visits by a soil scientist it was concluded that the differing yield responses were due to differing levels of flooding and degree of water control. On sites where flooding through seepage water was less severe, flat planting of rice (direct seeding) produced higher yields. However, for sites where seepage water brings excessive amounts of ferrous iron, the farmers' practice of ridge planting to raise plant beds minimized toxicity problems and thus produced better results.

For sites with a positive yield response to flat seedbeds, yield gap analysis showed that the switch from ridged to flat seed beds contributed on average, an extra 514 kg/ha of paddy yield or about 23% above the farmer practice yield rate of 2.2 tons/ha. Appendix 5 shows that the management change was highly beneficial, with return to labor expressed as paddy yield and gross return per man-day being increased with little or no increase in total labor use.

Stand Density

The farmer stand density of less than 100,000 plants/ha was considered low to make full use of land and water resources. As with the tillage method, some increase in stand density from 100,000 plants/ha to 150,000 plants/ha was observed. At sites identified as not having a flooding problem, increased stand density produced an extra 300 kg/ha of paddy rice. At sites identified as having excessive seepage of water, yield increments for increased stand density were not significant. The contribution of increased stand density is, however, expected to be much greater with a modest dose of fertilizer use.

Farmer Opinion to Interventions

The informal surveys of rice growers revealed the possibility of recommending closer spacing and flat seedbed preparation to farmers in those areas with better water control. When asked about using flat seedbeds instead of ridges, farmers stated that they want to try it on their own plots and agreed that it might give as good or better yields and/or be less work than ridging. However, some farmers believed that planting rice on flat seedbeds was either not feasible due to the variation in water conditions during the season, or would take more work to achieve good weed control. Based on these reactions BADP has undertaken work to classify different types of fadamas and layout plots to demonstrate the value of planting a denser crop on flat seedbeds.

Farmers reactions to increasing stand density were mixed. This was due to fears that increased stand density would reduce tillering and make it more difficult to hoe weeds as closer spacing would not leave room for their hoe between stands and weeding would be more time consuming. Adaptation to closer spacing was observed in one village where a smaller hoe was used. A survey of farmers' hoes indicated that smaller hoes were not easily available in the project area and it required a special effort to have the blacksmiths make small hoes. Thus a wider spacing between hills was considered necessary for weeding with large hoes.

Regarding experimentation on later planting of short-season sorghum varieties, two years exploratory work has shown that under research management, International Crops Research Institute for the Semi-Arid Tropics(ICRISAT) varieties are highly suitable and have produced economic yields. This experimental work has now been shifted to the on-farm testing phase along with the study of labor use pattern and farmer assessments of the new sorghum varieties.

Exploratory Cowpea Trials

An informal survey of project farmers was conducted investigating the possibility of intensifying the use of lowland fields. It indicated that their lowland fields after paddy crop remained wet for some weeks during the dry season. Farmers have surplus family labor during the dry season and said that they would welcome any innovation which would increase their food supply by using slack period resources. Survey investigations further revealed that the average Nupe family consumed 2-3 meals each week prepared from cowpeas and spent about $250 per annum in buying them. A variety popularly known as 60-day cowpeas was considered a good "catch crop" on residual moisture during the dry season.

The exploratory trials were designed to test the viability of growing cowpeas after rice. Since farmers had the best understanding of local conditions, they were asked to bear responsibility for trial management. Trial design was kept simple with only two experimental factors, variety and insect control. Four short season varieties were selected and the plot was split into 2 sections, one section was sprayed to control insects, the other section was not.

Results from the two sites established in the first year were encouraging. At the first, site established yields were reasonable, especially for the variety IT82 E-60, which had the shortest season length. Yield rates from the second site whose establishment was delayed by two weeks were considerably depressed due to moisture stress and the reported destruction by goats. Economic returns (Appendix 7) at the first site compared favorably with cash costs, especially for a slack labor period. Total cash costs for seed and fertilizer at the local market price and for spraying were figured at $125/ha while net return to labor and land inputs was $1470/ha. The cooperating farmers also stated that demand for seed from other farmers was high. Encouraged by the results of the first year dry season cowpea trials, the subsequent dry season research program was expanded to gain information on factors affecting crop establishment, suitable methods of seedbed preparation, and the effect of planting date and location of the crop in the toposequence for the dry season crop.

The three methods of tillage: zero, strip, and conventional hand hoe were all successful for seed germination and crop establishment in the paddy fields, thus offering the possibility of reducing labor input and expanding the area under cowpeas through timely planting. Crop performance along the slope/gradient was affected by the availability of moisture. On the top sections of fadamas with 5% or steeper slopes, moisture depletion was fast and therefore, yield level was uneconomic. Crops on the middle and bottom sections of the fadamas matured successfully by giving economic yields both on experimental and extension verification plots (Appendix 6). The dry season cowpea yields of 600-700 kg/ha with two sprayings have been quite attractive to farmers who have become so enthused with this new crop enterprise that they refused to sell their produce to the Project and have begun to invest in the spraying equipment.

Farmers' experience with the dry season cowpeas revealed a number of adaptive innovations. Once told about the moisture requirement of the crop, they were fairly accurate in locating fields on the toposequence and using the appropriate method of seed-bed preparation.

In the wetter fields they preferred planting on raised beds and in drier fields on flat beds. To protect their cowpea fields against rodents and monkeys, farmers used five alternative devices: (a) fencing with tree branches; (b) fencing with fish nets; (c) tieing a dog inside the plot; (d) erecting scare-crows; and, lastly, (e) by having their young children watch the crop at the podding stage. Similarly, to protect the crop from the Fulani cattle, village chiefs were influencial in alerting the herdsmen. Farmers erected small signboards in their cowpea fields that the herdsmen were eager to avoid (signboards are traditionally used to label government property).

We had previously estimated an increase in paddy yield of 800 kg/ha, with changes in hill density and tillage method while requiring little extra labor input. Similarly, dry season cowpea crop (E-60) produced 777 kg/ha yield with 60 days labor and about $125 capital cost/ha in insecticide spraying. Using these extra costs and returns we have measured their consequences on overall farm productivity (Appendix 8). Column one represents the benchmark situation while columns 2, 3 and 4 show the level of costs and returns with an incremental change of rice management practices, dry season cowpea and when respectively both of these improvements are incorporated into the system. With the selected crop component improvements there has been substantial improvement in net farm returns to labor and capital inputs. Farm returns of all costs have become positive from its benchmark state of negative income. Because of the low costs and high financial gains associated with these innovations many of the farmers have started increasing the plant density of their paddy crop and growing dry season cowpeas.

Rice Sickle

During the course of second year OFAR trials it was observed that farmers preferred to harvest paddies when the crop was over ripened and fully lodged which not only caused loss of paddy through shattering, but also delayed the planting of dry season cowpeas. Farmers alleged that lodged paddy was easier to harvest and it saves their labor time. A paddy reaping experiment conducted with the farmers' unserrated sickle and the improved serrated sickle confirmed the farmers' opinion (Appendix 9). This experiment also revealed that before modern rice varieties (comparatively short and unlodging) are accepted for mass adoption, farmer sickles must also be improved. Although farmers preferred the serrated sickle (and a few rich farmers have acquired them from abroad), the village and town blacksmith lacked equipment to put on the serration.

Upland Based Systems

Only limited on-farm research was carried out in the upland based systems. It was conducted to generate more information on improved crop varieties for their ability to withstand attack by common insect pests and diseases and to test the suitability of introducing short season cowpea crop towards the end of the rainy season.

With the success of dry season cowpea, farmers' interest for main season cowpeas on upland fields has considerably been increased for a number of reasons. These were related to cost economies in the fixed operational cost of spraying equipment; reductions in the on-farm storage period and consequently less losses; and to improvement in the farmer cash flows. As stated before, the months of August/September for the upland based cropping systems were a period requiring relatively less labor input. Any crop enterprise which will successfully mature within the last two months of the rainy season was of interest to the farmers, particularly to those who practiced a cereals based system. Land is not a limiting factor of production. Short season cowpea varieties were tested under farmer conditions for the upland systems and found to produce a yield level between 700 - 1000kg/ha with a minimum spraying regime. Thus, for the main season, the cowpea enterprise has a benefit: cost ratio of at least 8:1 for the pest management coverage.

The failure of the maize trials emphasized the need for a striga resistant variety and/or effective cultural practices. Although the cassava trial was not harvested until the second year, observations suggested that several of the improved varieties were tolerant to cassava mosaic virus and cassava mealy bug. Since these improved varieties had been successful elsewhere in Nigeria, it was decided to set up cassava extension trials to assess the agronomic performance of the new variety under the care of the extension staff.

The success of the improved varieties of cowpea when sprayed in the on-farm trials proved that the crop was agronomically viable. Further work is needed to investigate the economic returns to this crop, especially considering the necessity for the farmer to buy an insecticide sprayer to control pests. In addition, cowpeas are traditionally grown in mixture with other crops, such as sorghum, whereas the cowpea screening trials were carried out with a sole crop. Therefore, further trials are planned to assess the agro-economic performance of cowpeas when intercropped with sorghum.

CONCLUSION

The experience of 2 years OFAR trials at BADP has shown that it is possible to quickly identify areas of improvement in the local farming systems and to successfully exploit them. The intervention of short season cowpeas as a dry season crop has proven so successful that demand for seed by farmers was far in excess of the Project's ability to supply it. In addition, many farmers now wish to re-introduce the crop into the main season as an upland crop. Farmers in the upland based systems are also showing interest in the crop, even though the 2 years of main season trials created little interest. This lack of interest was due to the unavailability of good quality seed and cost economies of spraying equipment over two crops a year.

Unless they stand to gain something, farmers are reluctant to offer their fields for trials that require significant changes in crop management. Their reluctance stems from the high cost of land and seedbed preparation and from the risk involved in making changes. However, farmer participation proved to be essential to the establishment and maintenance of research plots and for assessment of farmers' reactions to the proposed changes in crop management.

The OFAR program at BADP has shown the potential benefits of the farm level agro-economic data collected by the Project's Monitoring and Evaluation Unit. Without any extra efforts, the data was sufficient for delineating the important cropping systems and farmers' production practices. The data facilitated the diagnostic part of the OFAR program and provided insights for identifying opportunities for the agronomic experimentation. The Project's interest in OFAR approach enabled the research institutes to test their component technologies and helped the BADP by identifying those components which are suitable for farmer adoption. For example, the Project was able to offer the potential for improving the local farming systems through the introduction of short season cowpeas and serrated sickle. It was also able to exhibit to farmers located in good fadamas the value of increasing rice hill density. The Project identified the need for undertaking land development engineering work for the control of surface runoff and seepage water to enable a better utilization of stream flow on valley land.

The on-farm adaptive research program has been instrumental to the development of close contact and cooperation between the BADP's commercial, extension and research divisions. The contact point was the farmer, whose progress is the best measure of success for all these divisions.

The major impediment to success in the OFAR program has been staffing. Despite a training program run by the Project for its field staff, the level of technical knowledge and ability of staff remained low. Since many of the junior staff were from an urban back-ground, there was little understanding or appreciation of the traditional farming systems or why farmers carried out certain operations. An OFAR program such as that run at BADP is dependent on field research staff carrying out their work accurately and conscientiously. For the West African region as a whole, the lack of trained research staff capable of carrying out diagnostic farm survey and agronomic experimental work will be the major impediment to the expansion of an OFAR program.

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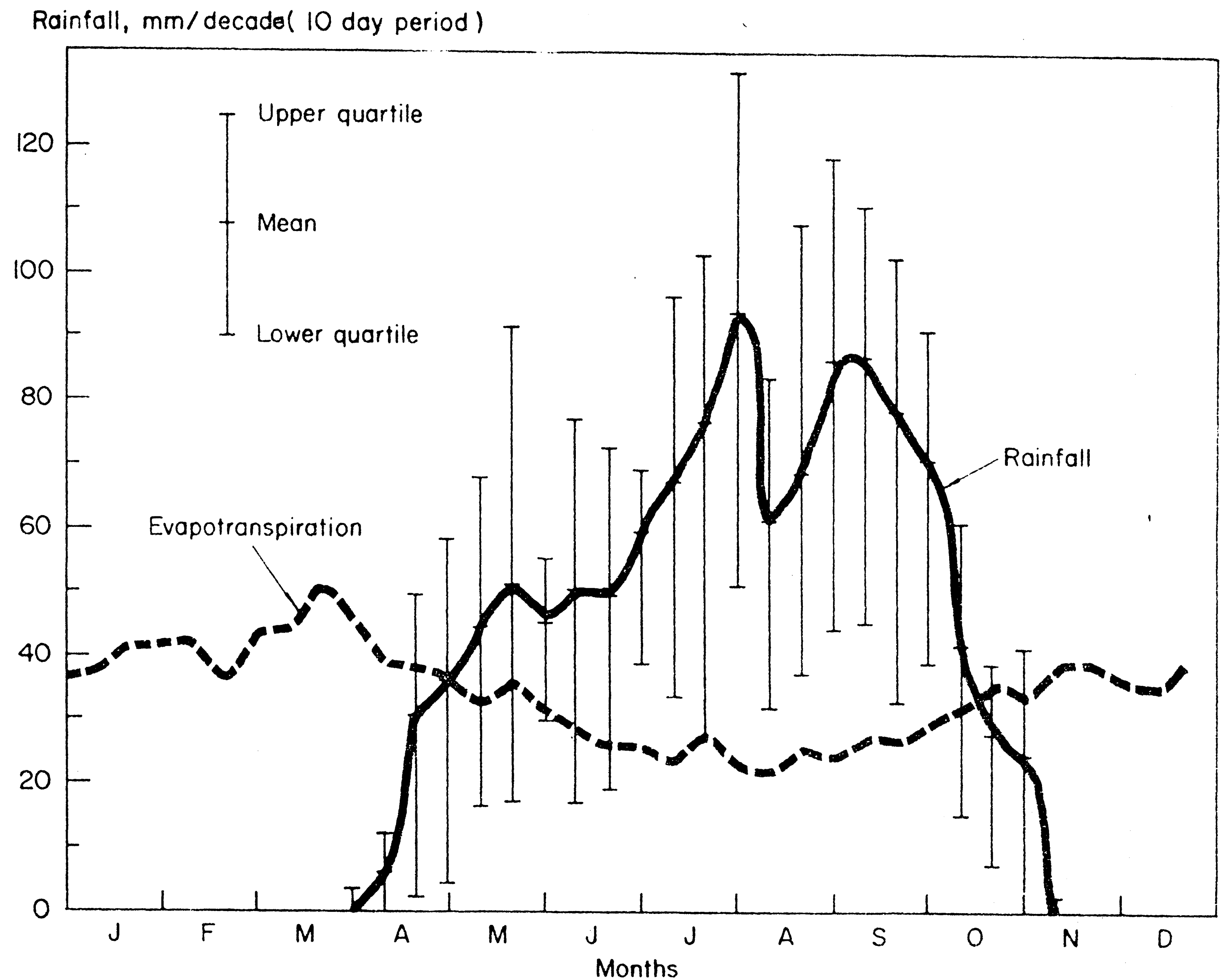

Fig. 1 Rainfall for 10-day periods (decade) at Bida, Nigeria (1961-83).

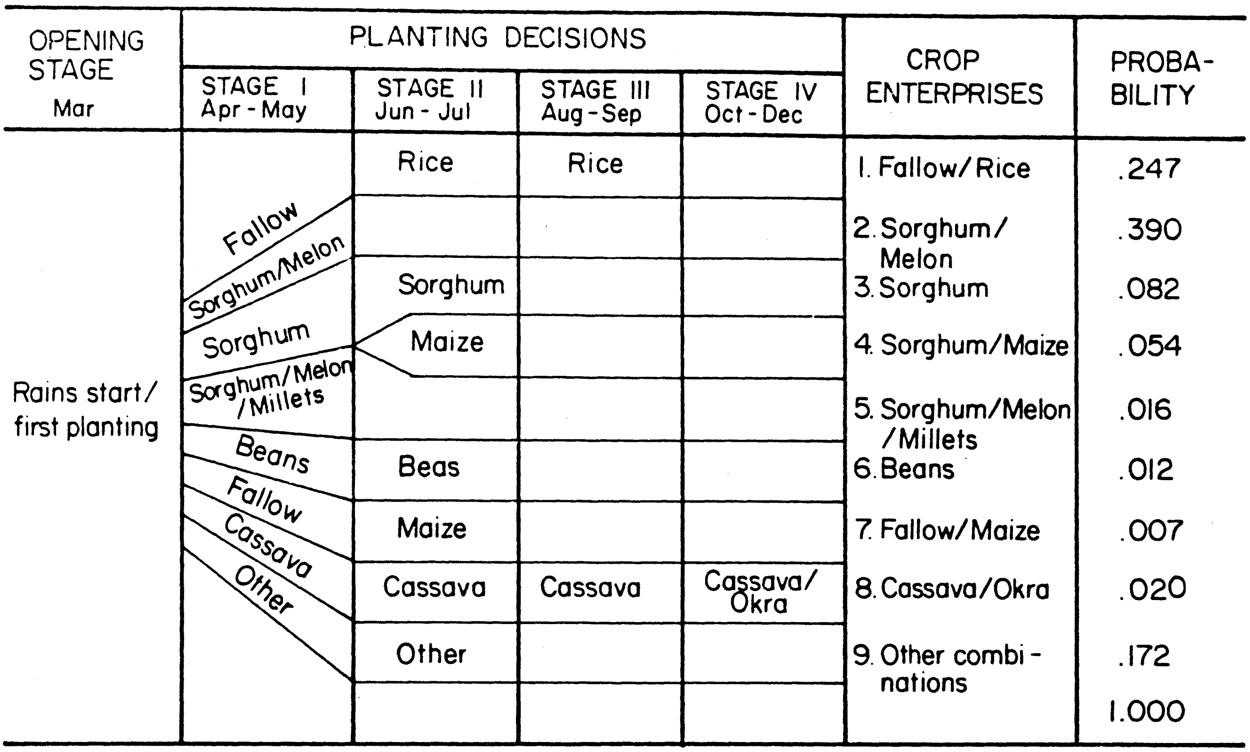

Fig. 2. Crop enterprise decision tree for the rice-based cropping system, Bida ADP (Avg. for 1982-83).

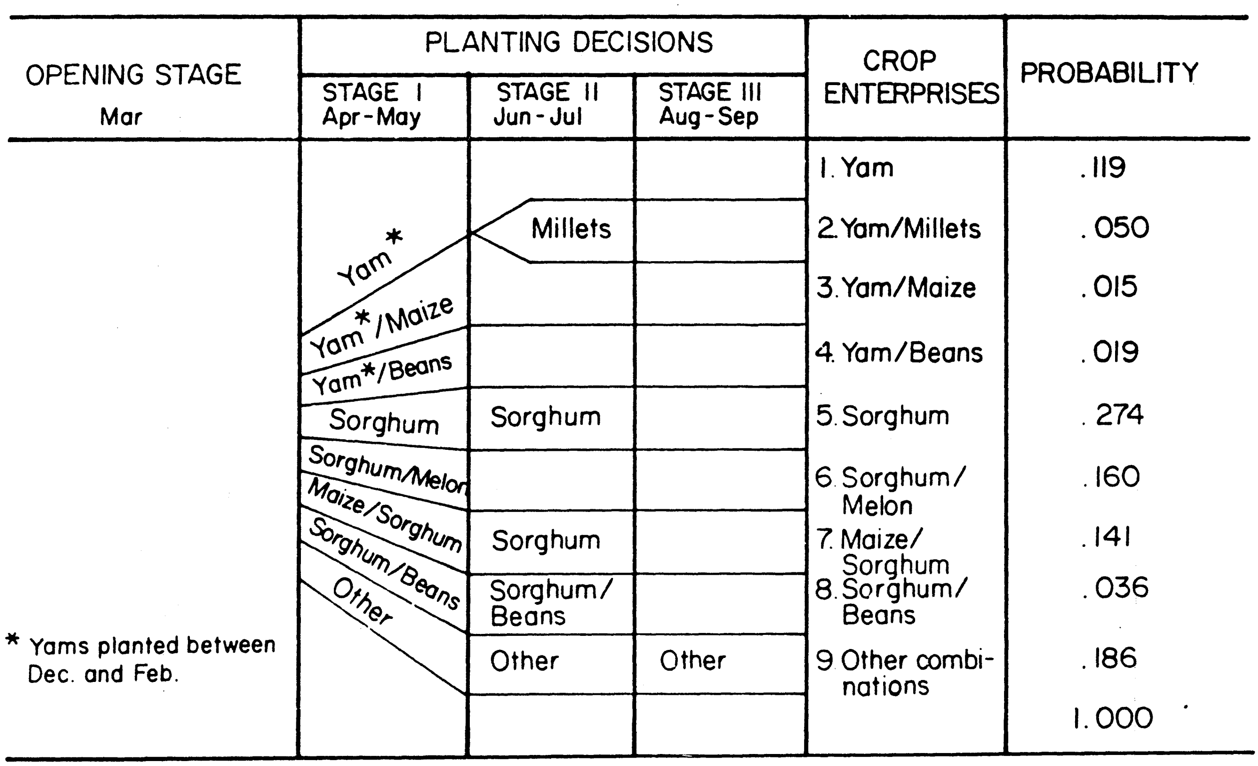

Fig. 3. Crop enterprise decision tree for the yam-based cropping system, Bida ADP (Avg. for 1982-83).

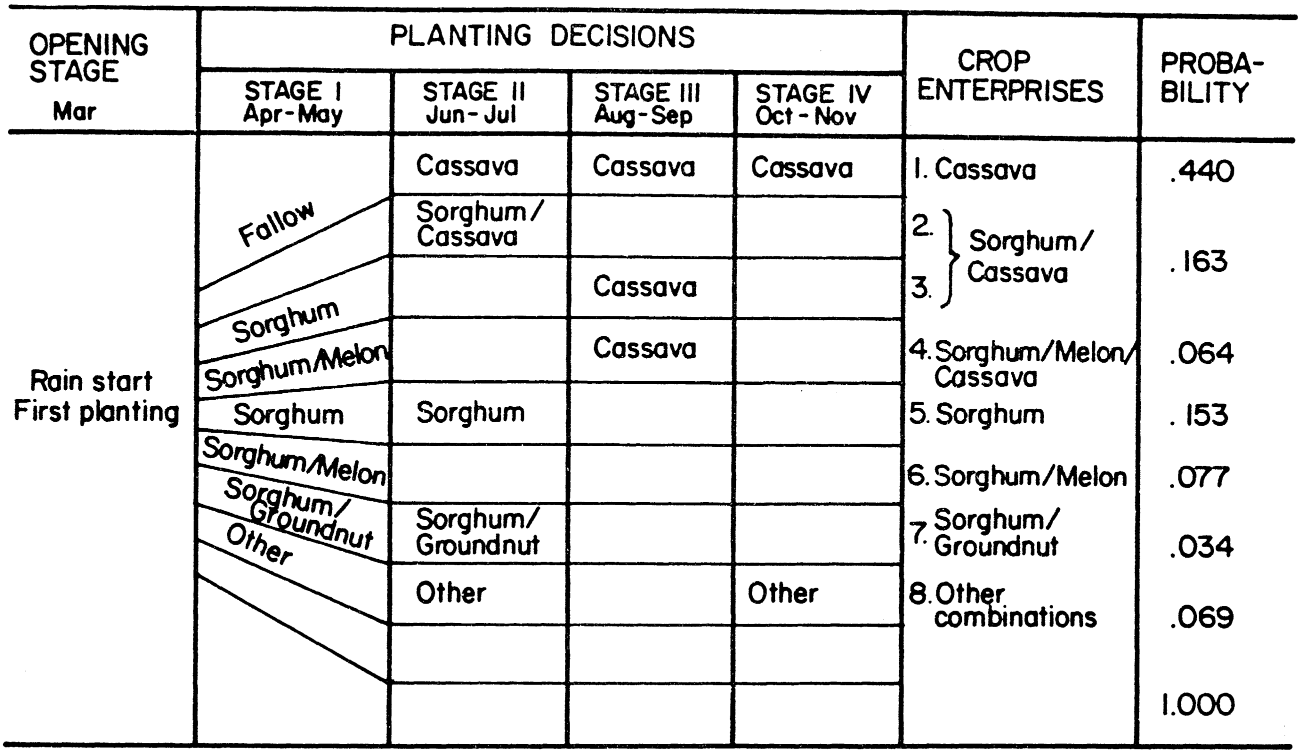

Fig. 4. Crop enterprise decision tree for the cassava-based cropping system, Bida ADP(Avg. for 1982-83).

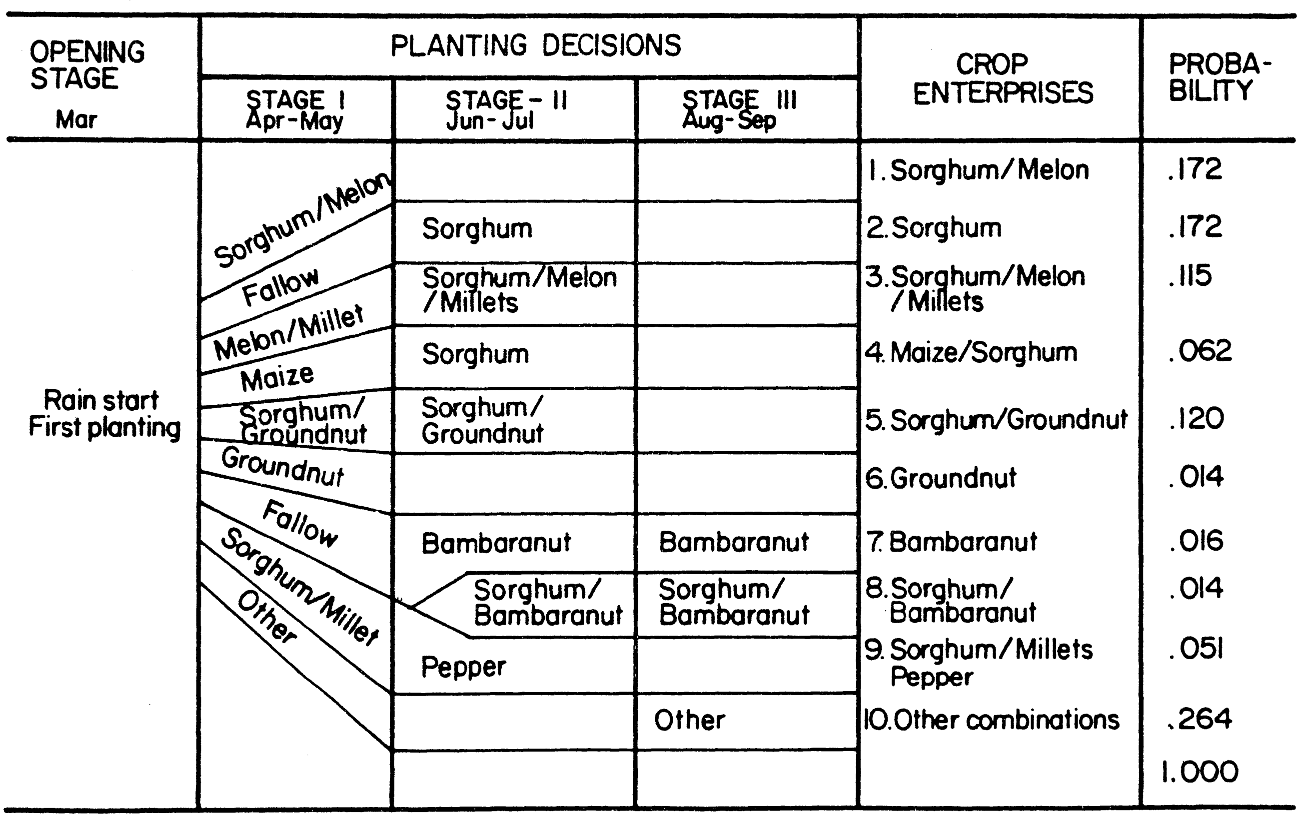

Fig. 5. Crop enterprise decision tree for the cereals-based cropping system, Bida ADP (Avg. for 1982-83.

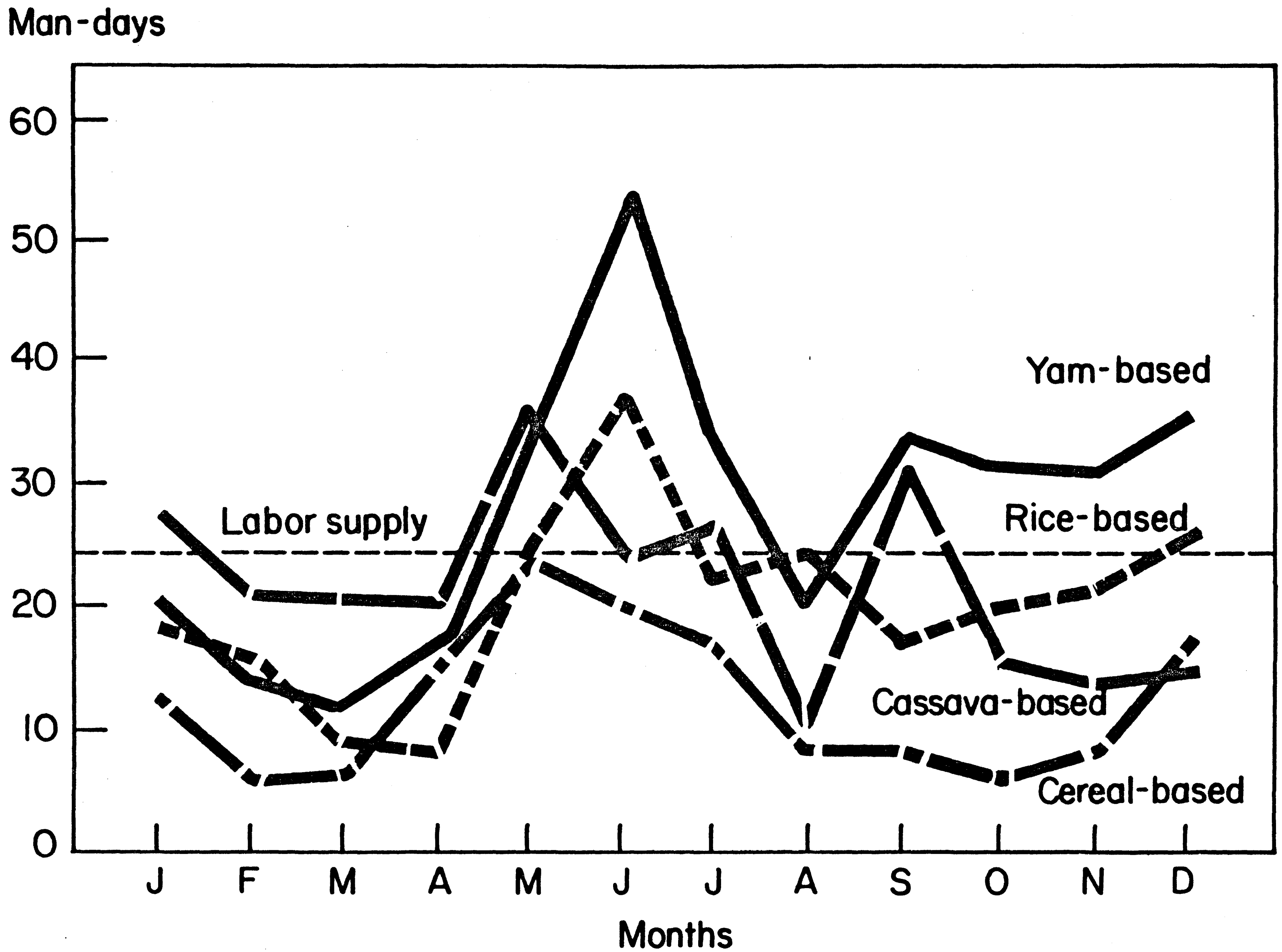

Fig. 6. Average household labor input (man-days) for agricultural activities in various cropping systems, Bida ADP, Nigeria 1983.

Appendix 1

PERCENT AREA GROWN TO DIFFERENT CROPS AND MIXTURES BY TARGET DOMAIN IN BIDA ADP, NIGERIA, 1982

Crop Enterprise	Cropping System Domain				
	Rice based	Yam based	Cassava based	Cereals based	Overall
Rice	25	*	-	3	7
Yam	9	12	-	4	8
Yam + Millets	-	5	-	-	2
Cassava	1	1	44	2	4
Sorghum	8	27	15	18	19
Egusi Melon	3	1	-	3	2
Sorghum + Melon	40	16	8	17	22
Sorghum + Maize	5	14	3	6	9
Sorghum + Millet	*	3	-	4	2
Sorghum + Cowpea	*	4	-	-	2
Sorghum + Groundnut	1	1	3	12	4
Sorghum + Millet + Melon	2	1	-	12	4
Cereals ± Others	1	8	-	3	5
Tubers ± Others	1	3	24	5	4
Others	4	4	3	11	6
Percent	100	100	100	100	100

* Denotes value less than 0.5 percent

Appendix 2

CROP YIELD RATES(Ton/Ha) BY TARGET DOMAIN IN BIDA ADP, NIGERIA 1982*

Crop	Target Domain				Overall
	Rice based	Yam based	Cassava based	Cereals based	
Rice	2.2	1.2	-	1.3	2.1
Yam	5.5	9.1	2.7	6.9	7.9
Cassava	2.2	3.9	6.6	1.6	5.4
Sorghum	1.3	1.2	1.1	0.9	1.1
Millets	0.5	0.8	-	0.9	0.8
Maize	1.4	1.1	1.2	0.5	1.0
Cowpeas	0.3	0.5	-	**	0.5
Groundnut	0.3	1.0	1.3	0.8	0.8
Bambaranut	-	0.6	-	0.5	0.5
Melon Seed	0.1	0.3	**	0.2	0.2

* Yield rates are average under various inter or mix cropping situation.

** Denotes value less than 0.1 ton/ha.

Appendix 3

PERCENT CROPPED AREA FAILED IN BIDA ADP, 1982

Crop	Target Domain: Rice based	Yam based	Cassava based	Cereals based	Overall
Yam	0	3	0	2	2
Cassava	43	0	2	15	8
Sorghum	4	1	3	5	3
Millets	0	*	-	2	2
Maize	0	6	0	20	10
Cowpeas	0	0	-	19	2
Groundnut	0	0	0	1	1
Egusi melon	6	3	0	2	4
Total	4	2	2	6	4

* Denotes value less than 0.5 percent.

Appendix 4

AVERAGE FARM COST AND INCOME BUDGETS FOR TARGET DOMAINS
IN BIDA ADP, NIGERIA, 1982

Item	Target Domains				
	Rice based	Yam based	Cassava based	Cereals based	Overall
1. Average Farm size (ha)	2.02	3.21	2.1	1.32	2.07
2. Total Labor input:					
Mandays	248	365	239	147	250
Cost 1/	1674	2464	1613	992	1686
3. Seed Cost ($)	153	285	66	86	147
4. Fertilizer input cost ($)2/	16	3	18	9	12
5. Farm tools annual cost ($)3/	92	79	79	77	82
6. Land rent ($)4/	27	43	28	18	29
7. Total farm cost ($)	1962	2874	1804	1182	1956
8. Total Farm Income ($)	1802	3842	2427	1053	2281
9. Net Farm Income ($)	-160	968	623	-129	326
MEASURES OF EFFICIENCY					
Return to Land ($/ha)	-66	315	310	-84	171
Return to Capital ($)	0.4	3.6	4.8	0.3	2.3
Return to Labor and Management $/man-day	6.1	9.4	9.4	5.9	8.0

1/ Labor valued at the current wage rate of ₦5 (or $6.75)/man-day.

2/ Fertilizer cost is calculated at the subsidized price of ₦2 (or $2.70)/50kg bag of fertilizer.

3/ Cost based on a hand tool set of 2 large and 3 small hoes, 2 cutlasses, one axe, 3 sickles (rice system only), 3 baskets and 2-5 sacks. Annual cost of cash capital is charged at 25% interest rate.

4/ Land rent is assumed at ₦10 or $13.5)/ha.

Appendix 5

EFFECT OF CHANGING TILLAGE METHOD AND INCREASING RICE HILL DENSITY ON LABOR PRODUCTIVITY ON LOWLAND RICE PRODUCTION BIDA ADP, NIGERIA, 1982

Management Practices	Average yield kg/ha	Total Labor input man-day/ha	Total Revenue $/ha	Labor productivity	
				kg/man day	$/man day
1. Farmer	2203	118	1190	19	10
2. High hill density (HD)	2552	129	1378	20	11
3. Flat cultivation (FC)	2683	112	1449	24	13
4. HD + FC	3003	122	1622	25	13

Appendix 6

AVERAGE YIELD/HA OF E-60 AND TVX3236 COWPEAS BY LOWLAND TYPE/TOPOGRAPHIC POSITION WITH 2 INSECTICIDE SPRAYINGS, BIDA, 1983/84

	E-60			TVX3236		
Lowland Type	Middle	Bottom	Average	Middle	Bottom	Average
a) Fadamas	571	620	578	707	536	669
b) River overflow	750	672	711	750	-	750
c) Floodplain	-	-	-	-	830	830
Overall	597	646	608	712	634	691

Appendix 7

ECONOMIC RETURNS FROM EXPLORATORY SHORT SEASON COWPEA TRIALS, BIDA

Cowpea Variety	Yield (kg/ha)	kg/ manday*	Total Crop Value ($/ha**)	Net benefits ($/ha+)	Benefit/cost Ratio
A. 1982/83					
E-60	945	14.5	1595	1470	12.8
E-77	545	8.4	920	795	7.4
B. 1983/84					
E-60	608	9.4	1026	901	8.2
TVX3236	691	10.6	1166	1041	9.3

* Based on 65 man-days/ha

** Based on net field price of N1.25/kg (N1.00 = US $1.35)

\+ Assuming total cash costs of $125/ha, cost of family labor not included.

Appendix 8

ESTIMATED GAINS OF FARM PRODUCTIVITY FOR THE RICE BASED CROPPING SYSTEM*

Item	Benchmark (1)	Traditional with: Improved rice management (2)	Dry Season Cowpeas** (3)	Both (4)
A. FARM COSTS - ($/HA)				
1. Labor	1674	1701	1775	1802
2. Capital	261	261	314	314
3. Land Rent	27	27	27	27
4. Total	1962	1989	2116	2143
B. FARM RETURNS - ($/ha)				
1. Gross	1802	2018	2263	2479
2. Net after land & capital	1514	1730	1775	2138
3. Net after labor & land rent	101	290	461	650
4. Net after labor & capital costs	-133	56	174	363
5. Net of all costs	-160	29	147	336
C. RETURNS PER UNIT OF:				
1. Land ($/ha)	-66	28	86	180
2. Capital ($)	0.4	1.1	1.5	2.1
3. Labor & Mgt. ($/man-day)	6.1	6.9	6.9	7.6

* Measured for an average farm size of 2.02 ha cropped land.

** Dry season labor cost for the slack farm period valued at 50% of the normal wage rate (6.75/man-day).

Appendix 9

RELATIVE EFFICIENCY OF DIFFERENT SICKLES MEASURED BY AREA REAPED IN 20 MINUTES

Condition of Paddy	Local sickle	Improved sickle	% Efficiency increament
A. Field Condition			
Wet	53.4	65.3	22
Dry	83.1	92.4	11
B. Lodging Rate			
Fully Lodged	74.1	76.5	3
Semi-Lodged	67.5	78.2	16
Erect	57.7	80.8	40
C. Overall	67.5	78.2	16

* Tests carried out with 30 farmers on their fields.

THE RAINFED FARMING SYSTEMS RESEARCH IN NORTHEAST THAILAND: A TEN-YEAR EXPERIENCE[1]

Terd Charoenwatana

This paper describes the research works on rainfed agriculture at the Faculty of Agriculture, Khon Kaen University. The report covers research activities of two projects: (1) the Rainfed Cropping Systems Project started in 1975 with financial support from the Ford Foundation; and (2) the Integrated Rainfed Farming Systems Research Project initiated in 1984 with financial assistance from USAID. The latter is actually the continuation of cropping systems research, but an animal science component is integrated and it uses the farming systems research approach.

RAINFED CROPPING SYSTEMS PROJECT

Objectives

In 1975, the Faculty of Agriculture of Khon Kaen University initiated a cropping systems project, with financial support from the Ford Foundation and the Government of Thailand. The main objective of the project was to develop cropping systems for rainfed areas of the Northeast. The formal objectives of the project are:

(1) To develop cropping systems for rainfed cultivated areas of Northeast Thailand.
(2) To identify crop varieties and improve cultural practices suitable for the cropping systems under rainfed conditions.
(3) To provide a research framework in which staff members and students can participate in the problem solving efforts at the farmers' level.

Rationale

Northeast Thailand occupies an area of about 17 million hectares (ha) and has a population of 17 million; this is approximately one-third of the total area and population of Thailand. The northeast is the poorest region in the country. Over 80% of the population is engaged

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[1]The author wishes to express his gratitude to the Ford Foundation and Government of Thailand for their financial support to the Cropping Systems Project. Thanks are also extended to the USAID for the funding of the FSR project. Special thanks are due to A. Terry Rambo of East-West Environment and Policy Institute for his suggestions and comments. A note of thanks is also due to William H. Matthews, Director of EAPI, East-West Center for granting a fellowship to the author to work at EAPI during July-September 1984 which enabled him to finish this report.

in agriculture. Average farm size is 3.3 ha and supports a family of 7 persons.

Low income is due primarily to low agricultural productivity. Major environmental constraints limiting crop yield are the unproductivity of the soils and erratic rainfall. Soils are sandy with low moisture holding capacity and poor in fertility. Although the region has an average annual rainfall greater than 1,100 mm, about 80% of rainfall occurs during the rainy season (mid-April to mid-October) at irregular intervals and variable intensities. Drought is common during June-July. In the dry season, crop production is feasible only with irrigation. Irrigation is now available to about 5% of cultivated land. However, irrigation systems are very costly and limited to only a few areas. It was estimated that if proposed irrigation projects are complete, there will probably never be more than 15% of the cropped land under controlled irrigation. The majority of the agricultural population is therefore heavily dependent upon rainfed agriculture.

Under this poor natural resource, the farmers have developed cropping systems under rainfed conditions that are mainly monocropping of rice, kenaf, and cassava. Rice is the primary subsistence crop and occupies more than two-thirds of the cropped land. The rice fields not only occupy the lowland areas, but also spread up to the middle terrace or even the upland areas. These middle terraces are often left idle if the rainfall is not sufficient for rice production. Cassava and kenaf are the dominant crops in the upland areas. Farmers normally grow these two crops without fertilization, which results in progressive soil depletion. Corn and other field crops occupy only a small portion of upland areas.

<u>Approach for Crop Intensification and Proposed Cropping Systems</u>

Under present rainfed conditions, where monoculture is the rule, northeast farmers do not appear to utilize the full productive potential of their farm resources and environment. The most logical ways to boost farm productivity and thereby net income to small farmers is through crop intensification or diversification. The approach is to make use of the full growing season. The growing period may be extended beyond the rainy season from a few weeks to possibly a few months, depending upon the onset and withdrawal of the monsoon. Therefore, the period during which soil moisture is adequate for normal plant growth is approximately 270 days. Most of the annual crops grown in the region usually mature in 60-120 days (except cassava). By adjusting planting times and selecting crop varieties, it is possible to grow two or even three crops in one growing season. From available crop varieties and production technology, several potential cropping systems can be developed and tested for their suitability under the farm environmental conditions.

For the purpose of this study, land under cultivation can be classified into three types, namely upland areas where kenaf, cassava, and other field crops are grown, and upper and lowland paddy areas for rice production (Figure 1). Ways to develop potential cropping systems will be described as follows.

Upland Area

Cassava is generally planted in rows about one meter apart at anytime of the year. It takes about four months for the canopy to close the space between the rows. Suitable cropping patterns include intercropping of cassava with legume crops such as peanuts, mungbeans, soybeans, and cowpeas.

Kenaf is normally planted early in the season when the first rain occurs and very narrow spacing is needed to produce good quality fiber. Cropping can be intensified by intercropping or by growing second crops after kenaf. Certain field crops can be grown in alternate rows with kenaf at the beginning of the rainy season; these crops are then harvested before or after the kenaf, depending upon the type of intercrops. For double cropping, early maturing varieties of field crops are preferable. Proper land preparation is necessary to conserve soil moisture for plant growth throughout the growing period, which extends into the dry season.

Double cropping could also be practiced in areas where corn, sorghum, and other field crops are grown as the main crops in the rainy season. Corn and sorghum may be intercropped in alternate rows with other field crops like legumes.

Upper Paddy Area

There are at least three possibilities to increase the productivity of upper paddy field. First, the land may be completely changed to field crop production. Double cropping of field crops is possible, since precipitation received during the first half of the rainy season is usually enough for field crops.

Second, if farmers want to grow rice for their family consumption, they usually transplant rice in August when the field has enough water. The period of 3-4 months prior to paddy planting is long enough for one field crop. Therefore, a field crops-rice crop combinations is suggested. If proper soil management is practiced, it might also be possible to grow field crops after rice using residual soil moisture.

Third, the pattern of growing field crops before paddy may not be accepted by many farmers, since rainfall is not predictable and farmers may be afraid that field crops may interfere with their rice growing. These farmers may want to grow only a single rice crop. They will wait for water until very late in the season and then leave the land idle if the water is insufficient for rice production. Under this circumstance the farmers should grow field crops instead of leaving the land idle. Short duration variety field crops are preferable.

Lowland Paddy Area

In lowland paddy areas, there is always sufficient water and farmers can grow rice every year. Attempts can be made to grow field crops before and after the rice crop.

From the analysis described above it is obvious that the proposed cropping patterns are built around rice, cassava, and kenaf, the main crops grown in the region. The proposed cropping systems (Figure 2) can be listed as follows:

Upland area
1. Cassava-field crop intercropping
2. Kenaf-field crop double cropping
3. Double cropping of field crops

Upper paddy area
4. Double cropping of field crops
5. A field crop before and/or after rice
6. Late monocropping of field crops

Lowland paddy area
7. A field crop before and/or after rice

Methodology

The approach used in this project is different from the conventional one in which the experiments are done repeatedly within the research station and go through various stages of improvement before testing them in the farmers' fields. The approach shortens the time frame in screening the proposed cropping patterns by combining testing in the research stations as well as in the farmers' fields in the same phase. Field testing conducted by farmers is included very early in the program. It is hoped that this type of approach should enable us to identify some cropping systems or patterns which can be adopted by farmers in a short period of time. Such cropping systems are by no means perfect. However, the systems can be passed on to the farmers while the project works on improvements through component technology utilizing feedback information from the farmers.

Suitability tests were conducted both in the university farm and in the farmers' fields. Five villages different in socioeconomic background were chosen as the test sites. All villages are located in Khon Kaen province and can be reached by car within an hour from Khon Kaen University. Figure 3 illustrates the testing procedure.

Since the experimental farm on campus is in an upland area, cropping patterns being tested in the university farm were those that had upland crops as the main crops. Standard experimental design with several replications was used for testing. Experiments carried out in the villages were classified by the level of management into three types as follows:

1. The trials that were conducted by project staff in rented farmers' fields. Treatments were arranged in usual experimental design with replication.

2. Trials that were conducted by the farmers (called "Cooperator I") in their own fields. These tests were under close supervision of the project personnel. Production inputs like

seeds, fertilizer, and other necessary inputs are provided without charge.

3. Trials that were managed by another group of farmers (called "Cooperator II") in their own fields. They tested the most promising patterns on their own farms in demonstration type plots and received technical advice from the project. Production inputs credit was provided and had to be paid to the project after harvesting.

Results and Constraints

During the early phase of the project, emphasis was placed on screening cropping systems for the different types of land previously described, initially in the university farm and/or the rented farmers' fields and later by farmer cooperators in their own land for the most promising systems. Component technology research was kept at a minimum during the initial phase but was increased over time. Economic evaluation of the cropping systems was done as an integral part of the system evaluation. Other socioeconomic studies included a base line survey of the project villages and a study on marketing system of major crops of Northeast Thailand. In this paper, results of the cropping patterns tested during 1975-1983 are summarized.

Cassava-field crop intercropping. Several field crops were tested in intercropping with cassava. Crops tested included peanut, mungbean, soybean, cowpea, corn, sorghum, and upland rice. Some studies were also done on spatial arrangements of cassava-legume intercropping, planting dates, and responses to fertilizers. Results, although varied, showed that the legumes generally caused little or no reduction in cassava yield, and the best results were obtained from cassava-peanut, cassava-mungbean, and cassava-cowpea intercropping. Early planting generally gave poor performances of the interplanted crops, while later planting around May or June in the period of more assured rainfall resulted in better yields.

Problems found with this cropping systems included crop establishment of cassava and subsidiary field crops, with the exception of peanut, when planted right into the monsoon season. Strict insect pest control was also required for all legumes. Shortages of farm labour appears to be another main obstacle for adoption of the system, since the weeding period often coincided with rice seedbed preparation. Weeding by plowing between rows of cassava with water buffalo presents a complication for intercropping field crops with cassava. Farmers are reluctant to give up this practice in order to interplant field crops, since plowing requires less labor than weeding by hoe and gives higher yields due to better soil aeration and drainage.

Kenaf-field crop double cropping. Trials were conducted to examine the possibility of growing field crops after kenaf. Crops tested included peanut, mungbean, soybean, cowpea, corn, sorghum, pearl millet, yam bean, and water melon. Several dates of kenaf cutting from mid-August to October were also compared. In most cases, none of the field crops grown after kenaf produced yields high enough to be of practical value. Early cutting of kenaf resulted in a significant reduction in fiber yield, and the yield of the second crop could not compensate for the loss in kenaf yield in terms of net return. However, in one village (Ban Haad) where soil moisture appeared to remain longer after the end of rainfall period, satisfactory yields were obtained for some second crops, suggesting the possibility of the system in certain types of soils.

Even if the yields from these systems are profitable, early harvesting of kenaf will be of limited appeal to farmers with a large paddy land holding, because September is normally a rice transplanting time in the upper paddy fields. It is also difficult to sun dry kenaf in September.

Double cropping of field crops in upland area. Several combinations of crops were tested in the double cropping systems. Crops tested as the first crop were peanut, soybean, mungbean, cowpea, corn, and sorghum. The second crops evaluated were peanut, soybean, mungbean, cowpea, sorghum, pearl millet, yam bean, water melon, and sesame. Better success was obtained from peanut-mungbean, peanut-cowpea, mungbean-peanut, mungbean-cowpea, cowpea-peanut, and cowpea-mungbean combinations. Considering the limited market for cowpea, peanut-mungbean, and mungbean-peanut appeared to be the most promising combinations. The results, however, varied from field to field and from year to year, indicating that the system is unstable. More stable results were obtained from the village where moisture in the soil appears to last longer.

The main problems of this cropping pattern were crop establishment for the first and second crops, delayed land preparation for the second crop resulting from water logging during the rainy season, low yields of the second crop, and disease and insect management. More work on soil and crop management are required to improve the stability of the system.

Double cropping of field crops in upper paddy fields. Evaluation of various double cropping combinations was done in a similar manner as in the upland area, and similar results were obtained. The results, however, were generally better than in the upland area because of better soil moisture at the end of the growing season. Major problems included poor drainage, long turn over period, poor performance of the second crop in the year which the rain ended early, and insect damages.

Although satisfactory yields were obtained, it is unlikely farmers will adopt this system, because they believe rice should always take precedence over a cash crop. It is important to them to produce and store a surplus of rice for future home consumption in the event a drought or other natural disaster destroys the rice crop.

Field crop before rice in the upper paddy field. The patterns tested were mungbean-rice, peanut-rice, soybean-rice, cowpea-rice, sorghum-rice, and baby corn-rice. Promising combinations were mungbean-rice and cowpea-rice. Peanut-rice was also successful, if the peanut could be planted very early and harvested as "boiled peanut." The system worked nicely in years with early dry seasons, but gave poor yields for legumes in years with heavy rainfall during the early rainy season. Major problems were water logging for field crops if drainage management was not done properly, and limited time for water collection for rice growing.

As double cropping per se, the system appeared to be unstable. However, considering that upper paddy fields are generally left idle in most of the years due to insufficient rainfall for rice growing, the system has a great advantage over the present system in that the farmer is at least able to harvest a single crop every year, i.e. legume in the dry year, rice in the wet year, and in some years both the legume and rice can be harvested. Thus, as a flexible system of cropping, the system is stable and would increase the long-run average return for this type of land.

Late monocropping of field crops in upper paddy field. Several field crops were tested in this system. However, the results were generally unsatisfactory. The intended planting time in late September was generally too wet for good land preparation for field crops, and planting was possible only in October, when there is not enough moisture to last the field crop through the grain-filling stage.

Field crops before rice in lowland paddy fields. Several field crops were tested in this system. Early planting of short-duration field crops (70-75 days) was possible in lower paddy fields at the onset of rainfall before rice transplanting in July-August. Mungbean and cowpea are suitable crops. There was often flooding, however, that led to crop failure or poor yields. Efforts to develop a drainage system to eliminate flooding were not successful. Farmers felt the system was risky and field crops might interfere with planting their rice crop. Thus, it is unlikely to be accepted by most of the farmers.

Field crops after rice in upper paddy fields. Several field crops were grown after rice in both upper and lowland paddy fields, and several methods of crop establishment were attempted. The seeding methods included sowing with and without land preparation, direct seeding in rice stubble, and broadcasting before rice harvesting. None of the crops or seeding methods produced satisfactory seed yields. The crops germinated well and grew to a certain size, but later died or produced insignificant seed yields. The soils can hold moisture for plant consumption only for one or one and a half months, which is too short for most of the field crops. Rapid loss of soil moisture results in crop failure.

In 1981, the project started to look at traditional agriculture practiced by the farmers in certain areas throughout the region. Trips were made to places where some rainfed double cropping is normal practice. We found that peanut after rice are grown successfully in Surin province without irrigation. In these areas, farmers plant peanut very late after the rain ends, prepare the land well, and plant the peanut much deeper. In our trials, as discussed earlier, we have attempted to plant the second field crops, including peanut, as early as possible to get the crops in before the rain ended. Land preparation is carried out while the soil is wet, which could not be done as well as it is by the farmers. Rainfall also compacted the soil resulting in more rapid loss of soil moisture. For the farmers, land is prepared by plowing three times with water buffalo, each plowing followed by harrowing, followed by the fourth plowing that makes a slightly deeper furrow between rows. Seed is dropped in the furrow and covered by soil when the next row is plowed.

There is normally no rainfall during the first two months after the peanuts are planted. The peanuts appear to use residual soil moisture left from the rainy season, until the early rainfall comes in February-March, when they reach the flowering stage. The soil type, which has a high water table, might be important for sustaining soil moisture so long after the rainy season. The key factors for success appear to be careful land preparation and soils with a high water table. With farmer cooperation in 1982-83, the project has tried out this technique in the farmers' fields in Khon Kaen and satisfactory results were obtained. In 1984, farmers in several villages will voluntarily try this system in their own farms.

Promising Cropping Systems and Acceptance of the Farmer

Results described above are based on field trials conducted over the period of about 6-8 years, mainly in Khon Kaen province. The testing period may be too short if the rainfall and climate conditions which fluctuate greatly from year to year and place to place are taken into consideration. Tested sites in Khon Kaen do not truly represent the whole Korat Triangle. However, villages selected as the tested sites differ greatly in terms of topography, soil types, climatic, and socioeconomic conditions. Topography and soil types in the tested villages are representative of those in the Korat Triangle.

Many tested cropping systems still show a high degree of instability of production. It was noted that in a certain village, results of several cropping patterns were better and more stable than other villages. Although a fluctuation in yields was observed, most of the cropping systems tested were agronomically feasible and economically profitable. However, these promising cropping patterns were still not socially acceptable to certain farmers in certain areas. Farmers will adopt only the cropping systems that fit their resources and environmental conditions, which vary considerably from family to family, place to place, and year to year. Therefore, the adoption of new cropping systems by the farmers also varies greatly from family to family and place to place, depending upon the farmer's resources and environments. Farmers under rainfed conditions appear to adopt only pieces of information or new technologies rather than whole packages of technologies. It is therefore necessary for the project to provide the farmers with a variety of alternative cropping patterns, each fit to certain ecological, socioeconomic, and cultural conditions of the farmers.

From several years of testing, the cropping systems which can be identified as the promising ones are listed as follows:

1. Intercropping of cassava with peanut or mungbean.
2. Peanut-mungbean or mungbean-peanut double cropping in an upland area.

3. Growing peanut or mungbean before rice in upper paddy fields.

However, it does not mean that all these promising cropping systems identified will be accepted by all the farmers in the region. The farmer's adoption of these new systems depends not only upon agronomic factors but also socioeconomic and cultural factors. These promising cropping systems will be accepted and practiced by the farmers who have resources and environmental conditions that meet the systems' requirements. The agronomic, economic factors, and some social factors which controlled the farmer's adoption of these systems are identified and discussed in a previous section of this report. The following discussion will be focused on certain social factors that influence the farmer's acceptance of these promising systems.

(1) Labor availability. In the existing system of monoculture of cassava, kenaf, and rice, labor demand is well distributed throughout the growing season (Figure 4). Labor allocated to rice production gets high priority, since rice is the staple food. Farmers will adopt only the systems in which the labor requirement does not compete with that for rice production. Farmers will not grow intercrops if their limited labor supply has to be allocated for raising rice, seedbed, and land preparation (i.e. in June or July). The systems, then, are suited to those farmers who have enough labor (large family or hired labor) for doing both crops.

(2) Cassava price and land holding. The price of cassava root fluctuates greatly from year to year depending upon the world market. Normally the price range will be 0.40 - 1.00 Baht per kilogram of fresh root. With a high cassava price, the systems become less attractive to the farmers since they earn enough income from cassava. Farmers feel that they have to expend a lot of extra effort and resources to get only a little additional income from growing intercrops.

The intercropping systems are also less attractive to farmers with large land holdings, because all of the time and labor are devoted to cassava production and sufficient income is obtained from cassava. In contrast, small holders earn badly needed additional income from intercropping of field crops with cassava.

(3) Riskiness. Although the systems of double cropping of field crops in upland areas looked promising, the systems do not appear sufficiently reliable to be adopted by farmers, particularly where cassava yield and price are high. It involves greater risk, high cash inputs, and more labor than cassava monocropping, though the net income from double cropping is higher than most of cassava alone.

(4) Culture and beliefs. In the systems of double cropping such as growing mungbean before rice, the first crop will be planted early from the last week of April to the second week of May in order to harvest before the heavy rainfall occurs in August. Generally, there are some cultural prohibitions in certain villages which influence the adoption of cropping practices, such as not plowing paddy fields before a representative of villagers request permission from a ghost in a village

on Wednesday the last week of April. Therefore, the systems that require plowing earlier than that date will not be practiced by the farmers.

In addition, there are eleven ceremonies (Figure 5) in a year (Polthanee, 1983), each ceremony having a different purpose. There are three village ceremonies which affect intensive agriculture: Bun Songkran, Bun Prawed and Bun Bongfai. These ceremonies are essential, because they request the best rainfall distribution and forecast the rainfall for the coming year. Hence, in some villages the farmers will not plant before these ceremonies occur during March-June.

NEEDS FOR AN INTERDISCIPLINARY APPROACH

It is now clear that the farmers' adoption of new cropping systems is controlled not only by physical and biological factors but also by socioeconomic and cultural factors. There is a need, then, for social scientists to work with biological scientists if we are to solve the problems faced by the farmers. In recent years, the importance of social science in agricultural development had become widely recognized. Zandstra et al. (1977), for example, assert that one of the major achievements of the IDRC supported Caqueza rural development project in Colombia was the recognition that socioeconomic factors were as significant as biological factors in farmers' response to agricultural innovation.

Our cropping systems research project recognized the role of social scientists in agricultural development at the beginning of the project. Due to the limited social science staff at the university, however, the only social sciences involved in the early stage of the project were agricultural economists and agricultural extension. Several other social scientists from different fields are now included in our research teams. Agriculture is complex, and we need specialists of all kinds, both in natural and social sciences, to work together. However, the interdisciplinary team is still poorly developed. For the Rainfed Cropping Systems Project at Khon Kaen University, we adopted the concepts of human ecology introduced by A. Terry Rambo of the East-West Center and Agroecosystem Analysis developed by Gordon Conway of the Centre for Environmental Technology, Imperial College.

The farmer, in reality, lives in the complicated world. Figures 6 and 7 illustrate the components of a typical small farm in Southeast Asia (Conway, 1982). At the core of the farm is the farm household, and its surroundings contains the farm resources which the household owns. Farmers utilize their resources with a variable number of inputs to produce crops, livestock, crafts, and other farm produces which are either consumed by the household or marketed as the farm output. The farm household and the farm also interact with many other "systems" outside the farm. The farm household gets used to their complicated world where they live and try to make a profit from it. Generally, the farm household gains knowledge of farming partly from their ancestors and partly from their own trial and error. Overall, the farm household has a wide range but incomplete and sometimes superficial knowledge.

Today, most agricultural scientists, by contrast, come from urban backgrounds and their university training is highly specialized. They become plant breeders, entomologists, or agricultural economists. They soon lose sight of the farm as a system and are unable to relate their specialist knowledge to that of other scientists or even to the everyday practice of the farmer. The individual agricultural scientist generally has a narrower range of knowledge, but it is deeper and, within its range, more complete. Therefore, we need a variety of highly trained specialists working together if we are to understand the complexity of the farmer's world. They have to view and understand this complexity as a system, not from some highly specialized aspect. Moreover, we also need ways of getting these specialists to understand each other better and to work together efficiently as an interdisciplinary team on problems faced by the farmers.

Human Ecology

Human ecology is the study of the relations between people and the natural world in which we 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 separate subject matter are deeply interrelated. Although there are many different conceptual approaches to the study of human-environment interactions, Rambo (1983) suggested that the "system model of human ecology" appeared to have particular utility from the standpoint of designing interdisciplinary research projects on human interactions with tropical agroecosystems. The model was designed in recognition of the fact that social scientists and natural scientists are professionally equipped to study distinct conceptual entities. Each specialist should continue to work within their area of professional competence, always bearing in mind the need to relate his or her 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 ecosystem. Each system is made up of several mutually interacting components as illustrated in Figure 8 (Rambo, 1983). 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 not only affects the other components in the same system but also affects the other system, causing changes in both systems. Human ecology is not a discipline. Instead it is a perspective, a way of looking at people's relations with the environment. This perspective is distinguished from other conceptual frameworks by a number of major features: (1) it employs a systems viewpoints on both human society and nature; and (2) it describes both the internal behavior of ecosystems and social systems and their interactions with each other in terms of flows or transfers of energy, materials, and information. It is concerned with understanding (3) the organization of systems into networks and hierarchies; and (4) the dynamics of systems change.

It was in 1981 when the concept of human ecology was first introduced to the Cropping Systems Project at Khon Kaen University. A series of workshops on human ecology were later jointly organized by the

East-West Environment and Policy Institute (EAPI) and member institutions of the Southeast Asian Universities Agroecosystem Network (SUAN)[1]. The cropping systems project took part in most of the series either as participants or cosponsors.

From the human ecology workshop the participants or researchers learned theories and concepts in biological, social sciences, and relations between these two systems. They cannot really recognize how these theories will be applied to the real situation. They need some exercises in order to learn how these theories or concepts work. The project uses an "agroecosystem analysis" approach as an exercise to improve interdisciplinary perspectives of the staff.

Agroecosystem Analysis

The method of agroecosystem analysis used to improve cross-disciplinary knowledge of our research teams was developed by Gordon Conway (1982). The basic procedural steps are described in detail in Gypmantasiri et al. (1980), Conway (1982), and KKU-Ford Cropping Systems Project (1982). This approach offers organizing 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. The appropriate concepts are those of the ecosystem and the agroecosystem.

Through a special seven-day workshop, the system is analyzed 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 (Figure 9). 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 measured the distribution of income or production among farmers.

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[1]SUAN is a loose and informal association of six institutes and programs from academic institutions in the region involved in the promotion of transdisciplinary research using the human ecology perspective in natural resource management and rural development. The following constitute SUAN: Cropping System Project (CSP)/Farming Systems Program (FSP) at Khon Kaen University and the Multiple Cropping Project (MCP) at Chiang Mai University in Thailand; Center for Natural Resources Management and Environmental Studies (CNRMERS) at Institute Pertanian Bogor (IPB) and the Institute of Ecology (IOE), Padjadjaran University in Indonesia; Program on Environmental Science and Management (PESAM), University of the Philippines at Los Banos and Cordillera Studies Center (CSC), University of the Philippines College of Baguio (UPCB) in the Philippines.

The workshop procedure allows agricultural, socioeconomic, and management issues to be raised simultaneously and for a cross-fertilization of ideas to occur. As a consequence, a series of critical questions were raised and collectively recognized. These questions should then be converted into testable hypotheses.

Over the past four years, a series of four workshops on agroecosystem analysis have been held in Thailand, focusing on distinct ecological regions. The outputs from each region-specific workshop on agroecosystem analysis are the key questions or hypotheses which will serve as the contextual framework of the research. The next step is the testing of the hypothesis in laboratory or field experiment or extension trials as illustrated in Figure 9. Several years of experience from our project seemed to suggest that the conventional research methodology did not produce satisfactory results. The modified methodology is needed for solving the problems faced by small farmers. The Farming Systems Research approach appears to have several advantages over the traditional method.

Farming Systems Research (FSR)

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 fit to farmers' circumstances and goals. To overcome the problems, researchers have come to realize that they have to consider real farm circumstance as well as the dynamics of farmer decision making 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 was discussed in detail by several workers (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 in a holistic manner. It requires involvement of an interdisciplinary team of natural and social scientists. The approach has been widely used for developing appropriate technologies for small farmers.

In summary, our project places emphasis on small farmers and views their farms as the system. An interdisciplinary research team of social and biological scientists was formed. The interdisciplinary approaches were 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 systems of sciences. However, what the researcher gained from the human ecology workshop were primarily the theories and perspectives. It is difficult for them to realize how these theories will be related to a real situation. The agroecosystem analysis workshop allows researchers from different disciplines to interact with each other, bring up issues for discussion, and finally, identify the problems which will become topics for research. The complicated and interrelated problems identified need to be solved by a kind of interdisciplinary approach, FSR. The relationship of these interdisciplinary approaches: human ecology, agroecosystem analysis, and FSR, is illustrated in Figure 10.

RAINFED FARMING SYSTEMS RESEARCH PROJECT

The typical Asian farm households, as discussed earlier (Figure 6), earn their income from activities on and off the farm. Farm activities normally involve not only crop but also animal production. This is also true for small farm households in Northeast Thailand. A recent survey of income structure of Northeast agricultural households (Table 1) showed that a significant percentage of their cash income was from livestock. In order to address the real needs of small farm households in the Northeast, researchers should also take the animal science component into account. We, therefore, expanded our project's scope by integrating animal science studies into the previous cropping systems research program. The project uses the FSR approach to develop improved farming systems practices acceptable to small farm households in the Northeast. This Integrated Farming Systems Reseach Project started in 1984 with the financial support from USAID and consists of three main parts--crop, animal, and social sciences.

Objectives

Because it is university-based, teaching and research oriented and not directly areas development involved, the Khon Kaen University FSR project aims to produce some outputs that can be used by development or action agencies. These action agencies, which are our immediate clients, will implement and pass on the generated outputs to the farmers. The project visualizes four kinds of outputs which are formulated into the specific objectives of the project as follows:

(1) To develop and test farming technologies and define the type of farm system and its environments where those technologies will be suitable and most beneficial.

(2) To derive classificatory information on agroecosystems and farming systems, their environments, the types of problems they have, and how they allow or constrain various types of technological solutions. This type of knowledge is very useful to planners and policy makers.

(3) To develop and test methodologies for doing (1) and (2), and to put these in a form that can be used by action agencies and applied in the field.

(4) To promote training and communication with action agencies so that (1), (2), and (3) get widely applied in Northeast Thailand and throughout the country.

Research Activities for FY 1984

The standard methodology is used in this project, which normally involves four stages: descriptive, design, testing, and verification/extension. However, these stages are not distinctly separated, and the overlapping of activities among these steps always exists.

Our experience in the previous cropping systems project indicated that to develop appropriate technology, we must have a good understanding of the farm households and their decision making, as a lot more could be learned from the farmers. Our research emphasis in the first year of the project (FY 1984) is thus placed on understanding the existing farming systems practiced by the farmers. These will be done by examining selected existing farming systems in certain areas outside the project village. The project probably will select one village in Khon Kaen province as its base for on-farm research and in-depth studies. Site description, the initial step in FSR, will be carried out in the project village using the Rapid Rural Appriasal (RRA) technique, followed by monitoring of farming practices and household record keeping. Monitoring activities are aimed at a better understanding of how the farmers utilize their resources and defining constraints and opportunities for improvement. Testing of some promising cropping patterns will be continued from the previous cropping systems project. In brief, research works for FY 1984 will include (1) site description of the project village; (2) testing of technologies; and (3) studies of existing farming systems.

Coordination of the Project

Our interdisciplinary team draws staff with different disciplinary backgrounds from the faculties of Agriculture, Humanities and Social Science, and Public Health. Two groups of personnel, administrator and researcher, are formed from this research team. Each group is further divided into two types of personnel. Apart from the FSR Advisory Committee, which serves as board of trustee, there are two committees, the Financial Control Committee and the Project Administrative Committee, which are responsible for administrative work of the project. The researcher group is also made up of two types of people who are either "system" or "component technology" researchers. The system researchers are those who view the farm as a system. That group of researchers has gone through several seminars or workshops on human ecology and agroecosystems analysis and has gained some system and interdisciplinary perspectives. The component technology researchers are those who are willing to work on special or discipline-oriented topics, depending upon their training. However, the topics have to relate to the systems research.

To promote interaction among the scientists, the project has regular meetings at two levels: the project level and the component or section level. At the beginning of the project, the group meets weekly to discuss the research activities and administrative matters. Later, when it gets started, we meet fortnightly, primarily for discussing research issues.

LINKAGES

Linkages with action agencies and other institutes are considered an important function of the project. As a continuation from the Cropping Systems Project, the FSR project already has strong linkages with action agencies. The key institutes are the Department of Agriculture, especially the Farming Systems Research Institute and the Field Crops Research Institute, the Department of Agricultural Extension, and the Northeast Regional Office for Agriculture and Cooperatives, particularly the NERAD and the EEC projects. There has been an increasing demand for contributions from the project by several action agencies. During the past eight months, the project members received 15 invitations to give presentations at training programs or staff meetings held by different agencies, mainly on cropping systems and concepts of farming systems research. Some project members were also invited to join the committees or working groups established by these agencies. There were also quite a number of visitors to the project seeking information on cropping systems and Northeast agriculture.

An important step in close cooperation with the Department of Agricultural Extension has been made. Apart from giving presentations in their training programs several times, the KKU FSR project has launched a joint program on multilocational testing of groundnut after rice without irrigation with the Khon Kaen Provincial Agricultural Extension Office. The Department of Agricultural Extension has sent a staff member to work fulltime with the project on this program, hopefully to examine a better approach in technology transfer and ways to improve linkage between research and extension.

KKU has also played a significant role in assisting the Farming Systems Research Institute in national coordination of FSR. Two project numbers represent KKU in the National Farming Systems Working Group. We have helped plan the First National Farming Systems Workshop held at Surat Thani last April, and will host the Second National Farming Systems Workshop early next year. Close linkages with Chiang Mai University and Kasetsart University were also maintained. We have been sending our newsletters to these institutes and the agencies previously mentioned regularly. We also sent trip reports to personnel in other agencies working in the respective topics.

Linkages with foreign institutes are also maintained. The project has been collaborating with IRRI, ICRISAT, East-West Center, and key institutes of Indonesia and the Philippines in the SUAN. An important collaborative work with ICRISAT is the rainfall analysis of the Northeast. The East-West Center has supported three project members to work on a conceptual framework of farming systems and agroecosystems. Linkages with U.S. universities sharing interest in FSR are also being established.

CONCLUSION

Recognizing that the majority of the farmers are heavily dependent on rainfed agriculture, the project focused its interest on the small farmers who have very limited resources. The project aims to increase the farmers' income through crop intensification. Several potential cropping systems utilizing the full use of the whole growing season were developed. The testing procedure was modified from the conventional approach in order to meet the urgent need of agricultural development of the Northeast. Field testing was carried out simultaneously in the university's experimental farms and in the farmers' fields with farmers' participation.

Although promising cropping patterns were identified, the adoption of those patterns by farmers varied from place to place and year to year. Evidence suggested that social factors were as significant as biological factors in farmer response to agricultural innovation. Additional social scientists from different fields were recruited in the research team. The challenge is how to improve cross-disciplinary knowledge of the team members. The concepts of human ecology and agroecosystem analysis are used in improving the interdisciplinary perspectives of the team. Human ecology provides the concepts and theories in biological and social sciences, particularly the linkages between these two systems. Agroecosystem analysis serves as a laboratory exercise for scientists to interact with each other. From this interaction, key questions emerge. Each key question is then converted to testable hypothesis and will be used as research topics. The FSR approach was employed for developing appropriate technologies suitable and acceptable to small farmers.

The original objectives of our cropping systems project focused on cultivated areas of the whole Northeast. However, as a result of agroecosystem analysis, it was suggested that the region can be classified into four different agroecological systems, i.e., the Korat Triangle, the Mekong Provinces, the Western Hills and the Southern Hills. It is the Korat Triangle that covers the major land area of the region and has the most critical problems of rainfed cultivation and where improvement appears most difficult to achieve. Hence, our target system in the future will be the Korat Triangle.

The studies of existing farming systems and farmers' practices are also very important and useful to researchers. The techniques and experience from the farmers can be used to transfer existing systems to other locations or to form new potential farming system. For dissemination of new technology to the farmers, the technique of "farmers teach farmers" appeared to be very effective, as in the case of growing peanut after rice without irrigation.

Work done during the past ten years, though giving variable results, has provided us with a lot of useful information and considerable experience. Farmers will adopt only the technologies that fit their resources and environmental conditions. Small farmers with limited resources and unpredictable and variable environmental conditions can adopt only pieces of information or technologies, rather than whole packages of technologies. It is, therefore, necessary for the project to develop a variety of technologies so that the farmers can choose only those that fit their circumstances and goals.

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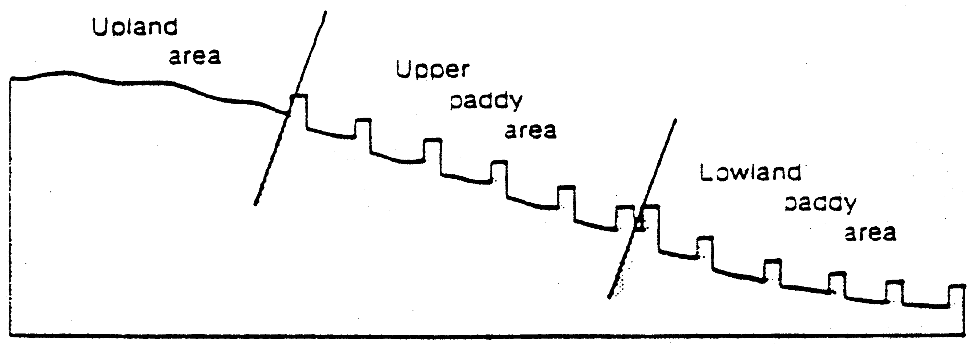

Figure 1. Simplified profile diagram of the agricultural landscape in northeast Thailand.

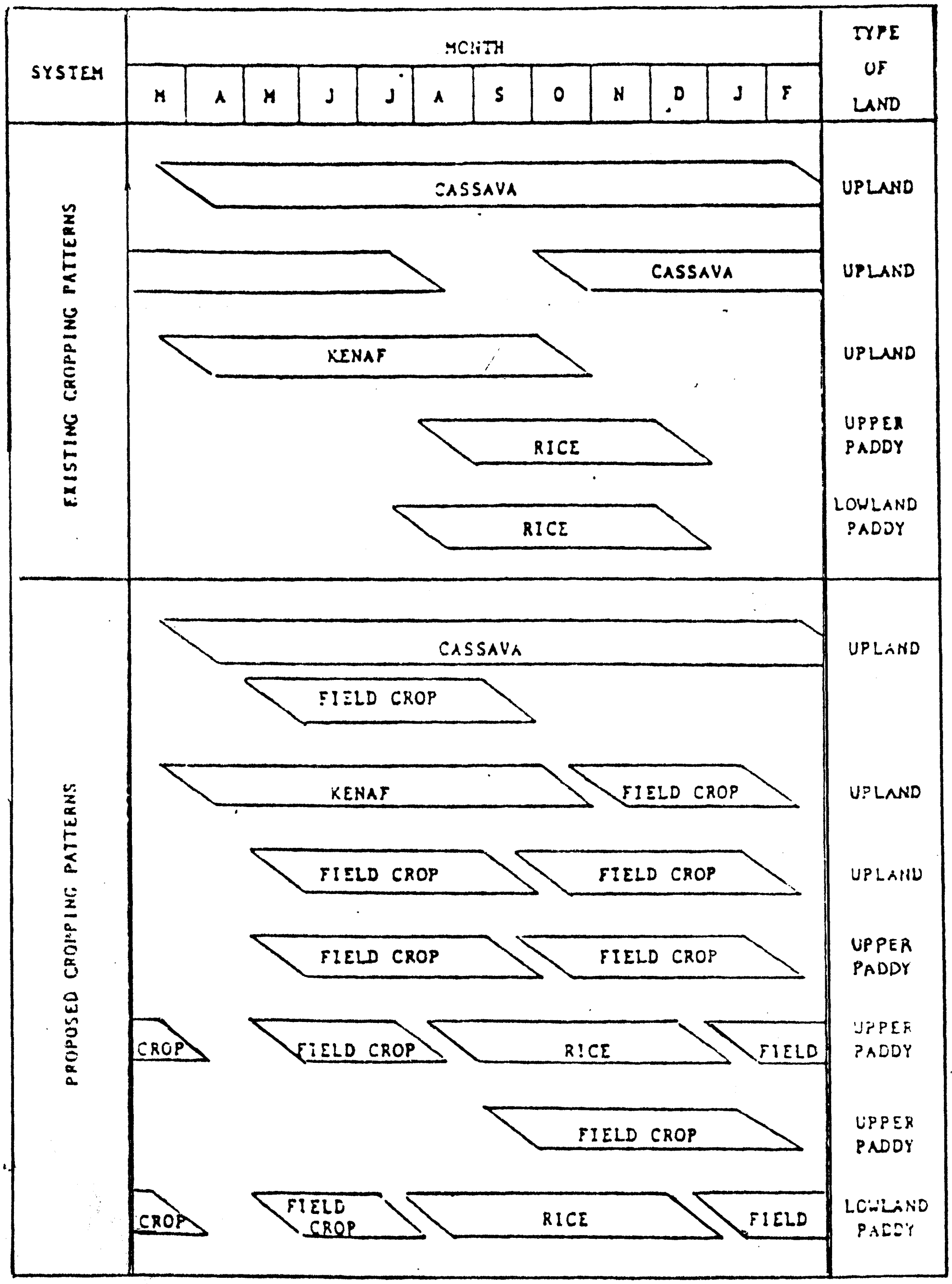

Figure 2. Diagram of existing and proposed cropping systems.

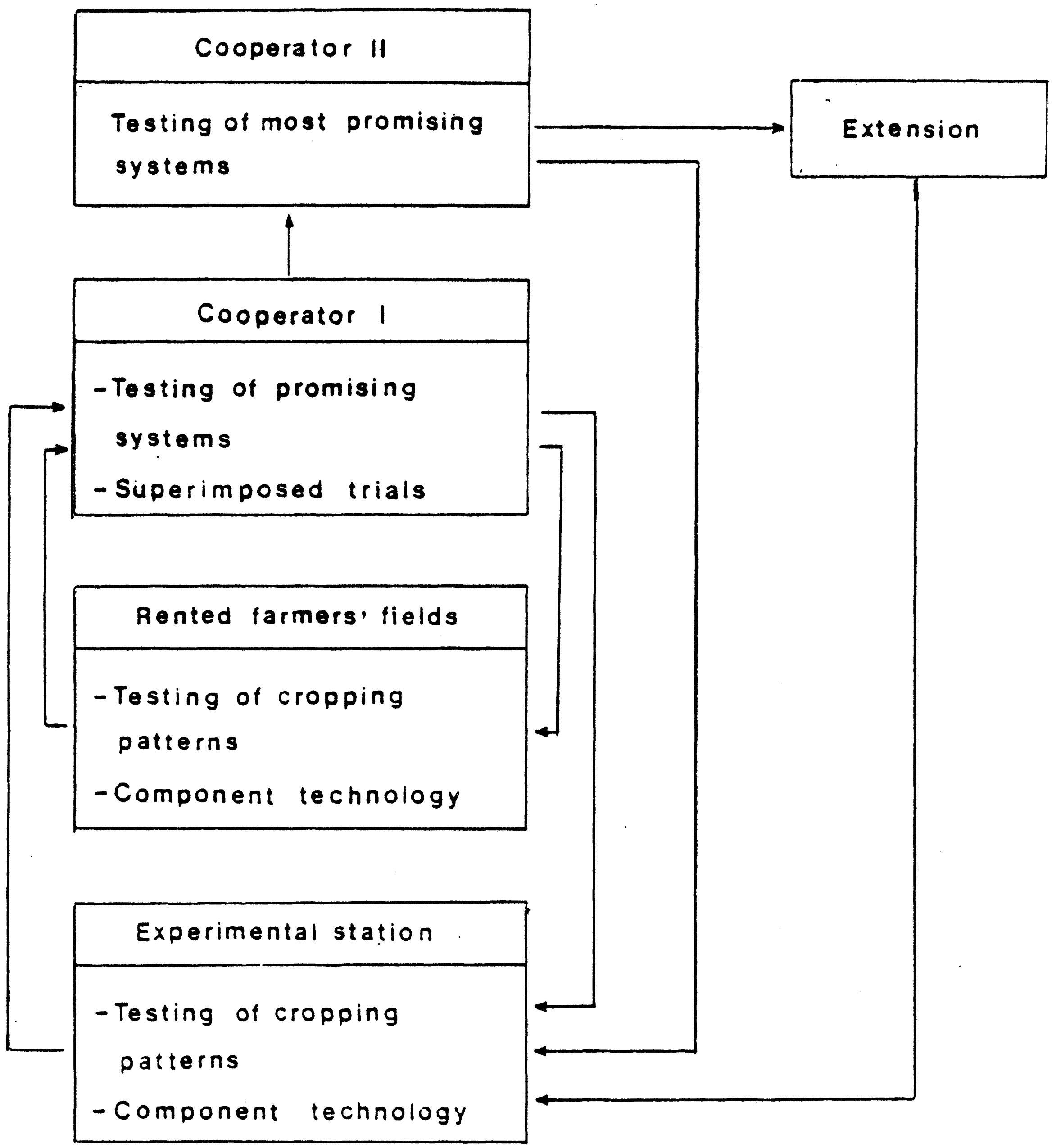

Figure 3. Diagram of the testing procedure.

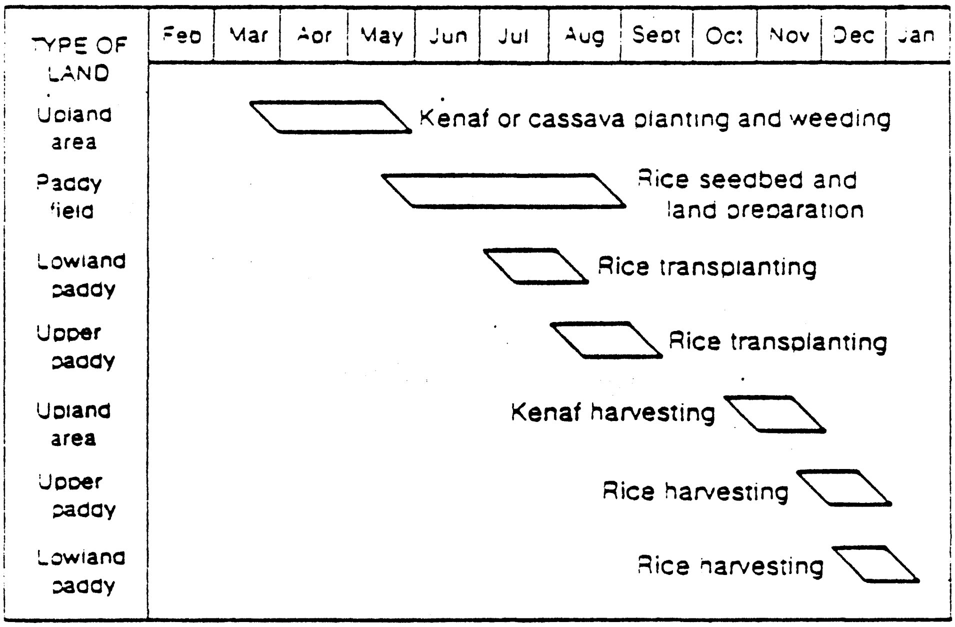

Figure 4. Seasonal distribution of labor for a farmer cultivating small plots on lowland paddy, upper paddy, and upland.

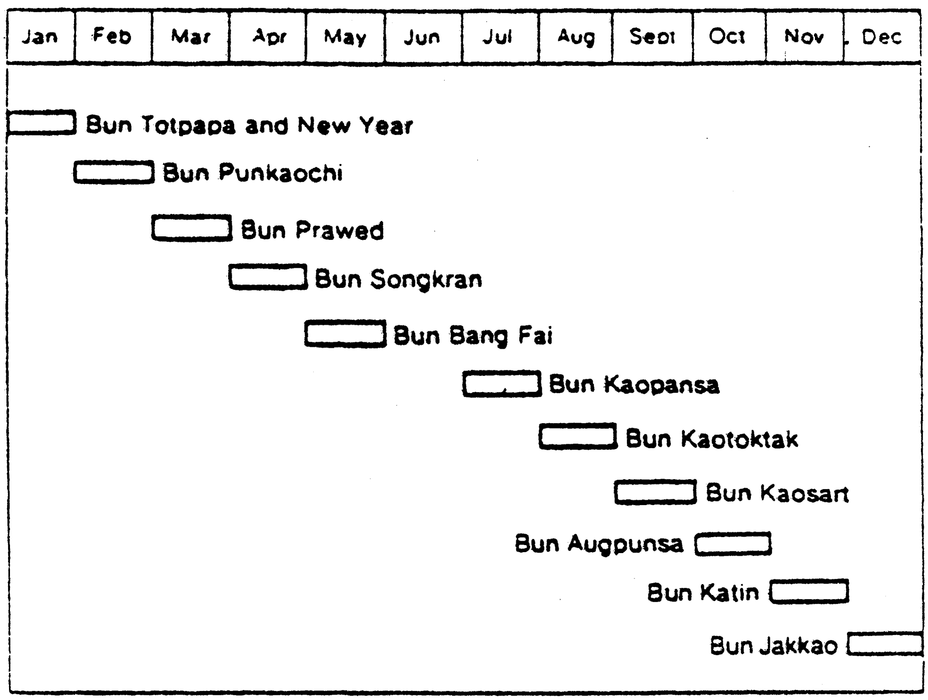

Figure 5. **Annual calendar family and village festivals** (after Polthanee 19[illegible])

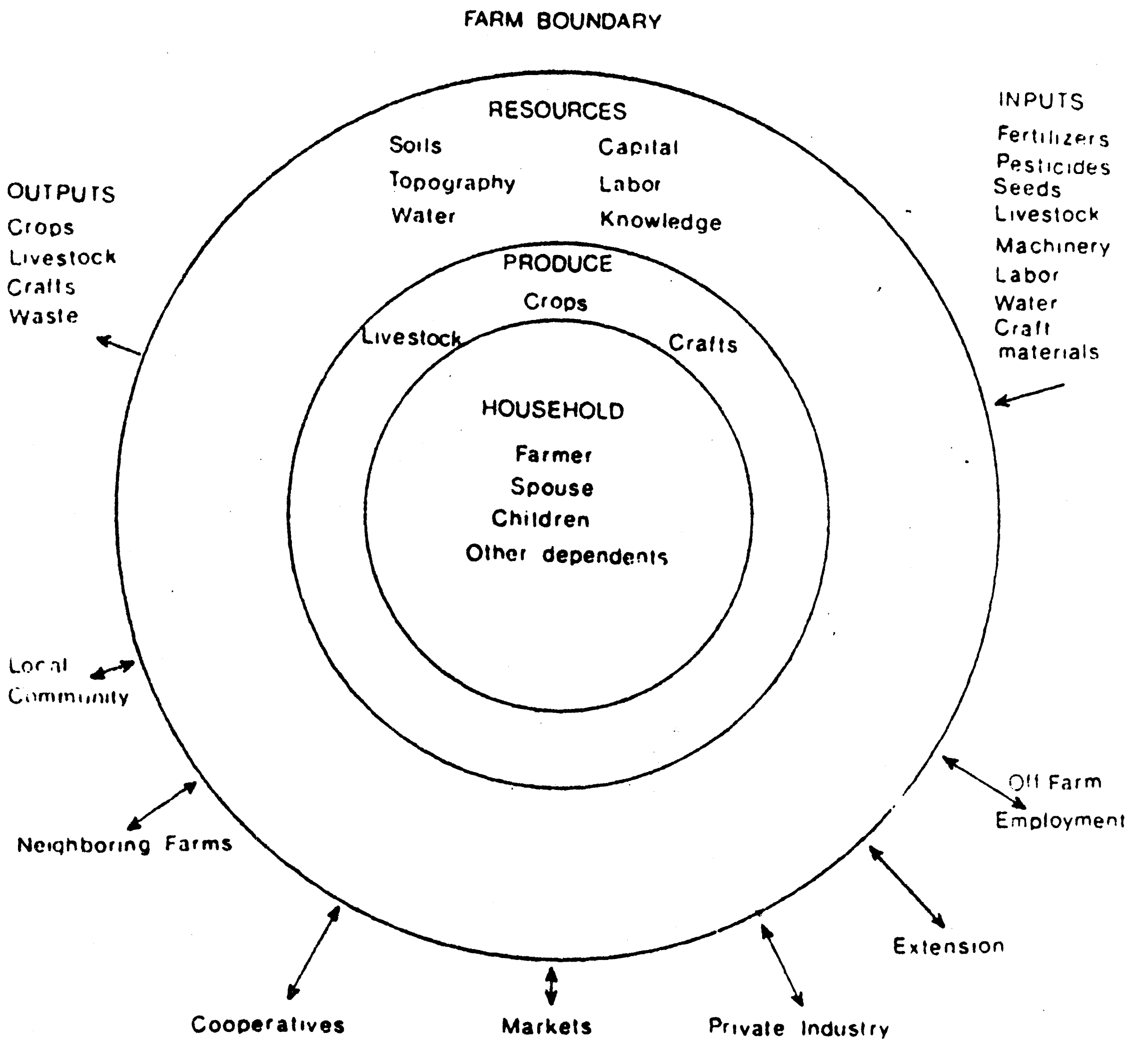

Figure 6. **Generalized model of Southeast Asian farm** (after Conway 1982).

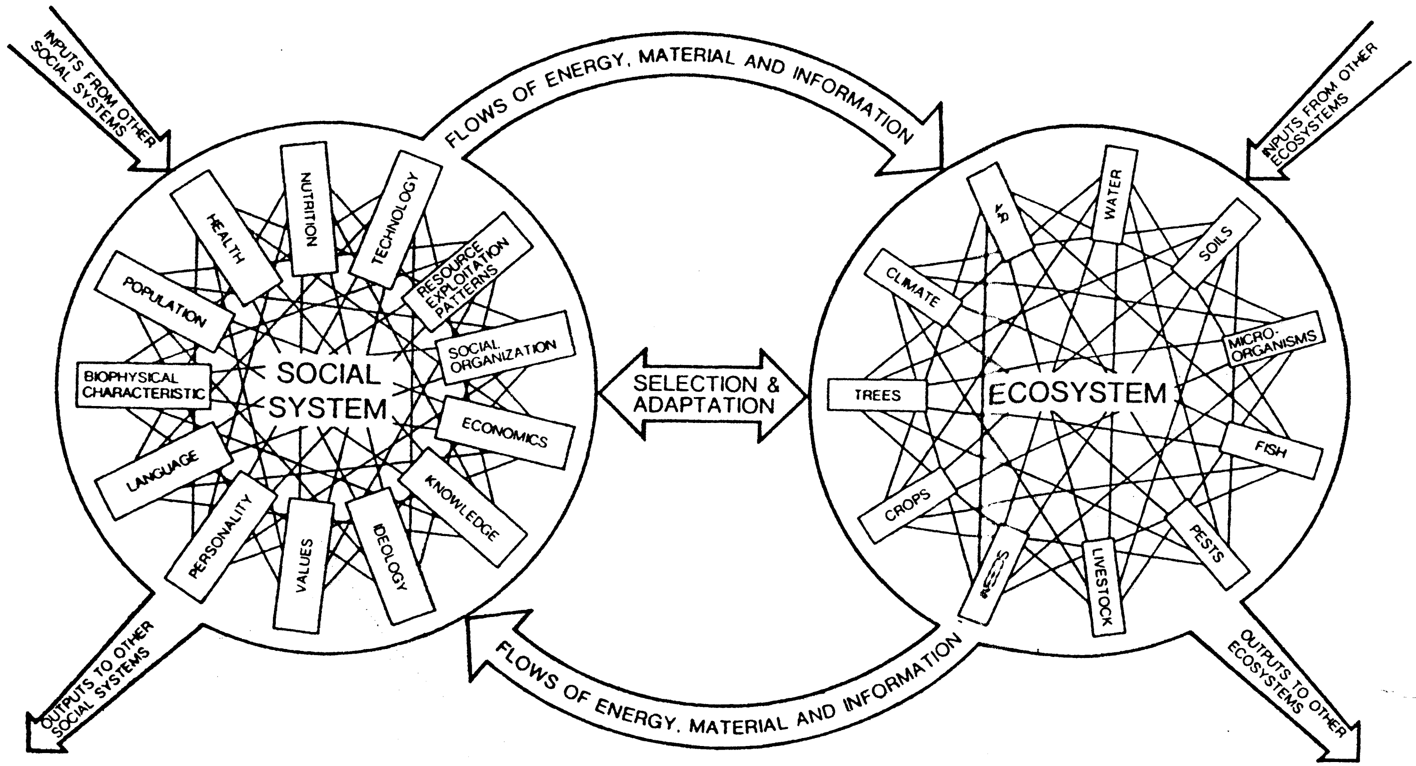

Figure 7. Social system–ecosystem interactions.

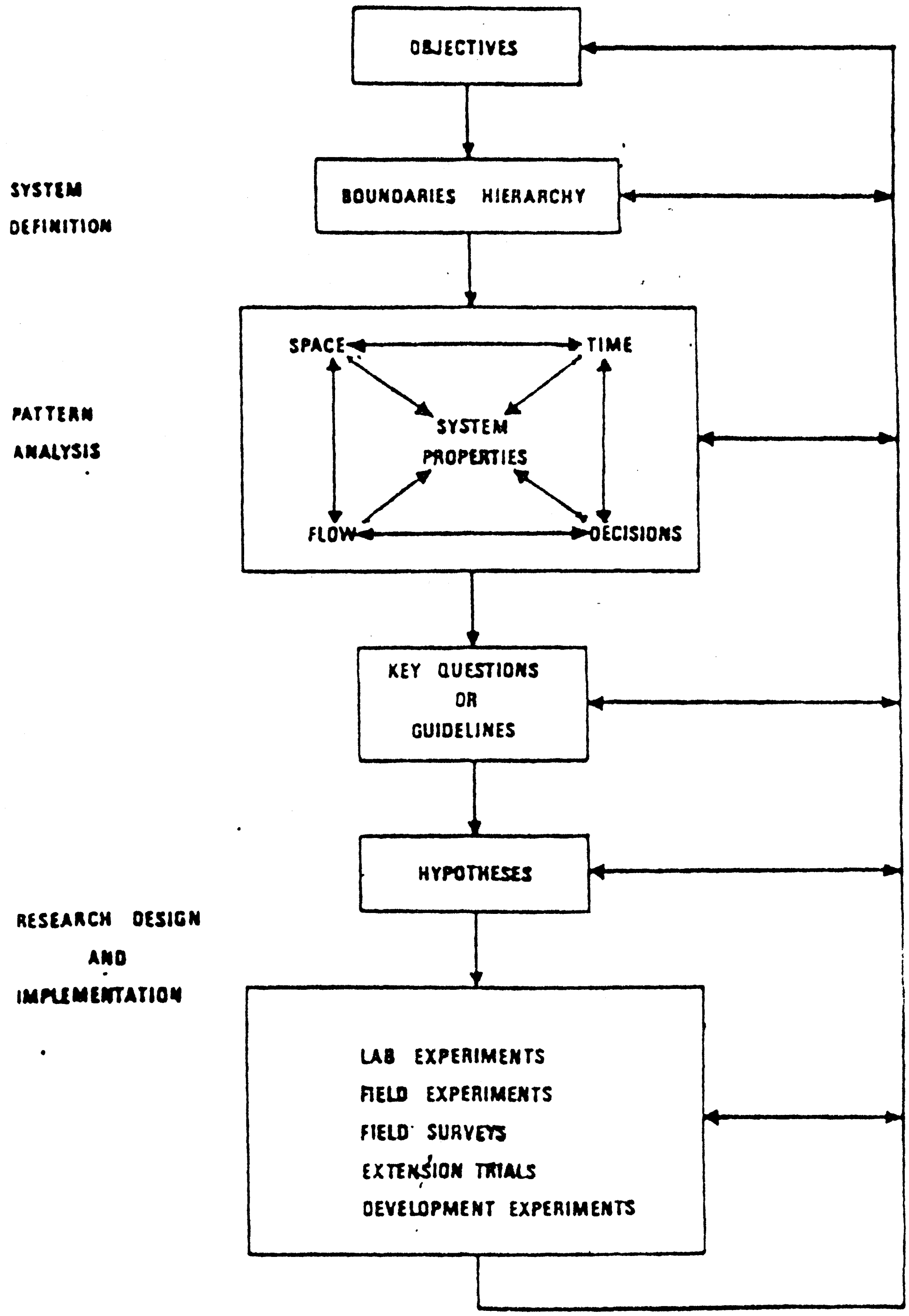

Figure 8. Full steps of agroecosystem analysis (after Conway 1982).

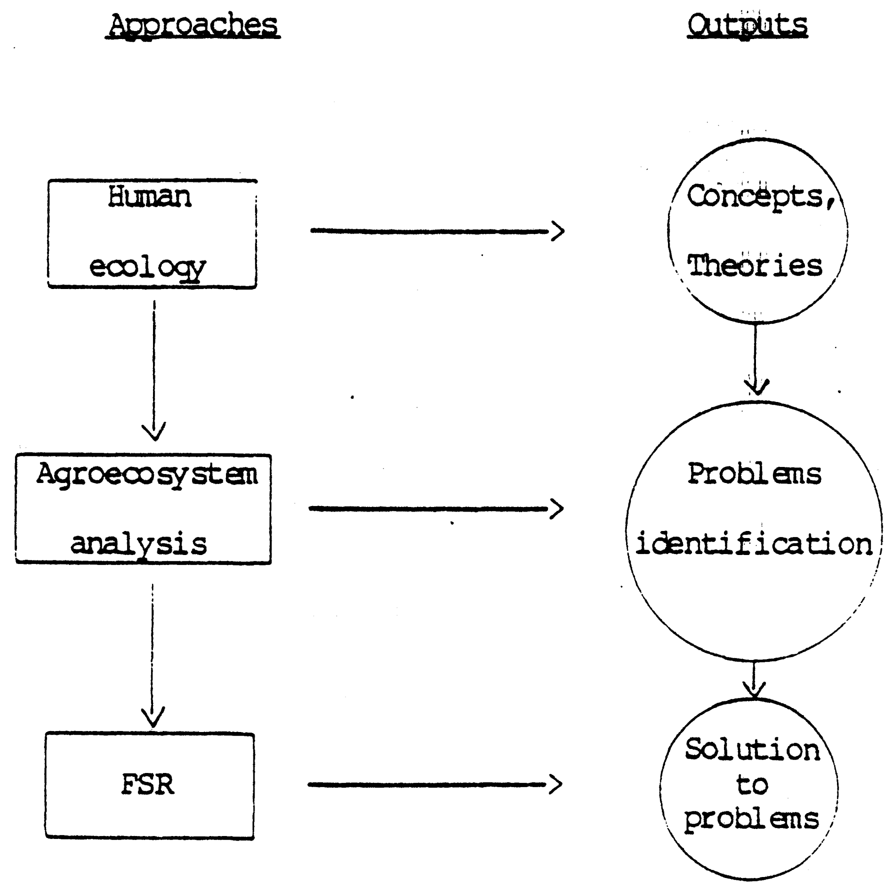

Figure 9. Relationship of human ecology, agroecosystem analysis and FSR.

Table 1. Average cash farm income of agricultural households in Thailand in 1981 (in Baht/farm)

Regions		Livestock	Crops	Others	Total
Northeast		2,777	11,862	417	15,056
	%	18	79	3	100
North		3,073	18,430	983	22,486
	%	14	82	4	100
Central		4,192	36,479	1,952	42,623
	%	10	86	4	100
South		3,375	16,108	683	20,166
	%	17	80	3	100
Average		3,220	19,077	909	23,207
	%	14	82	4	100

Source: Agricultural Statistics of Thailand Crop Year 1982/83. Office of Agricultural Economics, Ministry of Agriculture and Co-operatives, Bangkok, Thailand, 1983.

THE SEMI-ARID AREAS OF SYRIA: FARMING SYSTEMS IN DECLINE
Issues in Research Design

Ronald Jaubert

INTRODUCTION

Low rainfall zones in developing countries are among the areas where applied agricultural research and development programs have been most limited. Few of these low rainfall areas have benefited from successful improvements and their situation is often critical. In the last few years however, after major crises have occurred, such as in the Sahel areas, more attention is being paid to semi-arid and arid areas. The latter, where problems are often most complex with regards to technical, social, and policy aspects, are a most challenging field of application for FSR. Meanwhile, the design and implementation of research aimed at solving the problems of these areas raises particular issues differing in several respects from those addressed by most FSR programs. The aim of this paper is to present and discuss several of these issues through a case study in Syria.

The low rainfall areas of Syria, those receiving less than 350mm of annual rainfall, include large steppe areas and a wide semi-arid cultivated belt. In the latter, sheep and barley are the main products and may extend to and beyond the 200mm isohyet (Map 1). It is this area which is the focus of our study. The study area represents approximately 50% of Syria's cultivated area and is where 25% of the rural population live. The semi-arid cultivated areas, although of low priority in national development policies, represent an essential component of Syria's agricultural sector. Their contribution to the national agricultural production represents approximately 90% and 50% of the barley and sheep production respectively. The study areas raise challenging problems for the country's agricultural future and FSR provides a valuable basis for meeting these problems.

THE PROBLEM

Previous studies show that the semi-arid cultivated areas have very low productivity, a substantial outflow of labor, and did not contribute to the increase in national agricultural production in the last 20 years (FSP, 1979, 1980, 1982; Metral, 1980). In the 1950s, however, the study areas, in particular the eastern plains, were considered as Syria's bread basket (Hannoyer, 1980). Thus the past two or three decades are marked by profound changes. In order to identify the main factors which have led to the present situation and access the future prospects of the semi-arid areas, we conducted a complementary diagnostic study focused on the dynamics of recent changes.

An Increase In Land Use Intensity Followed By A Fall In Productivity

Villages in the semi-arid areas of Syria originate from recent settlement. At the beginning of the 19th century the Damascus-Aleppo road used to mark the limit between cultivated land and the steppe areas controlled by nomadic tribes (Lewis, 1955). Settlement in the semi-arid areas began after 1860 and, until the 1950s, was confined to the western areas (Map 1). In these areas, farming systems long remained very extensive. A cereal, generally wheat, was followed by several years of fallow, and livestock, mainly sheep and camels, were sent to steppe areas for six months or more every year. Settlement in the study areas was favored by the authorities ruling the country in those days in order to gain more control over areas controlled by nomads. The Ottoman administration, first, deliberately settled immigrants, such as the Circassians, in the steppe areas. Later, under the French mandate, farmers were given ownership after five years, of land which they brought under cultivation (Hannoyer, 1980). These measures, plus several other factors such as the arrival of new nomadic tribes from Iraq and Saudi Arabia, led to a large inflow of settlers. Population densities in these areas currently range between 20 and 50 persons per km2, which is high considering the agroecological potential (Samman, 1978).

In the eastern areas, the Jezireh, settlement and cultivation only began after the introduction of tractors in the 1950s. Between 1950 and 1960 over two million hectares of steppe were planted to barley which is grown without fallow in many cases (Hannoyer, 1980; Jaubert, 1983). In the process, nomads grazing these areas, most of whom became semi-nomads, gained an abundant source of summer and winter feed for their sheep. Flocks were becoming their main source of income, with the decline of camel caravans. Cultivation replaced traditional grazing areas, but the introduction of mobile water tanks allowed use of grazing areas south of the Euphrates which were previously inaccessable to sheep because of the lack of water. In contrast to the western areas, settlement and cultivation in the Jezireh did not lead to high immigration, and population densities are around 10 persons/km2 (Samman, 1978).

Mechanization, which began to spread to other cultivated areas of the country in the 1960s, also had a marked effect in the western semi-arid areas. The practice of fallowing was greatly reduced, or even dropped; only around 30% of the total cultivated area is now fallowed, and barley became the main crop. The livestock system also changed as a result of fragmentation of flock holdings and the 1958-1961 drought; the average size of individual flocks has fallen to 20 or 30 head. The movement of sheep to steppe areas is reduced and most of the population is now fully sedentary. In the Jezireh, large semi-nomadic flocks sent to steppe areas in the spring are still the majority.

The last two or three decades were marked by a sharp intensification of land use, which has had consequences for the equilibrium of the agroecological system. In many areas barley yields have fallen by 50% or more in the last 20 years (Jaubert, 1983). While in the early years of cultivation barley yields could reach or exceed 2t/ha (Hamidie, 1959), they presently hardly reach one ton in good years and the average is less than 600 kg/ha. In the absence of significant changes in rainfall since land use was intensified, (ICARDA, 1982) this decline in yields is most probably related to a serious loss of soil fertility.

The problem of degradation has not been restricted to cultivated areas. In the western semi-arid areas 20 to 30% of the land cannot be cultivated and is used for grazing livestock. These areas are usually overstocked and vulnerable. Degradation of the steppes is closely related to the expansion of cultivation in the semi-arid areas. The expansion of farming occurred on the best rangelands which increased stocking rates on less productive steppes. Furthermore, the decline in barley yields favored this expansion onto marginal lands which accelerates the process of degradation.

"Mining" Agriculture Becoming A Secondary Source Of Income

The decline of productivity affecting the semi-arid cultivated areas is not surprising considering farming practices. Indeed, throughout the study areas, agriculture is a "mining" activity. In most cases neither fertilizer nor sheep manure are applied on cultivated lands, while most of the biomass produced (straw and grain) is removed from the fields. Non-arable areas, which are usually common lands, are intensively grazed and there is little, if any, management of pastures for the long term benefit of the range (Cocks, 1985). Although attempts were made to reintroduce the traditional system of controlling grazing, steppe areas are generally overstocked.

The adoption by farmers of "mining" practices could only pay in the short term and the consequent fall in production soon affected farm income, in particular in western areas where farmers had little or no opportunities to increase their cultivated area. The development in the mid-1960s of other sectors of the economy and improvements in transportation in the study areas provided an alternative source of income. Since 1965, migration and off-farm employment has become increasingly important. Farmers first found work in nearby cities and in Lebanon; after 1973-1975 the gulf countries, in particular Saudi Arabia, became a major source of employment. Men usually leave their village for 3 or 4 months per year. Thus migration, which is generally temporary, did not halt the process of fragmentation of land holdings. Fragmentation of land holdings and increasing off-farm incomes have resulted in agriculture becoming a secondary source of income mainly operated by women and children. Until recently, this phenomenon mainly affected the western areas but is now developing in the eastern plains. It is worth noting that off-farm incomes have had a limited effect on agricultural production, since they are mainly spent on consumables. The decline of the study areas is also apparent in, and related to, their place in national development policies.

The Semi-arid Cultivated Areas Are Marginal In National Development Policies

The 1950s in Syria were marked by a fairly rapid growth in agricultural production, which was largely due to the expansion of cultivation in semi-arid areas (IBRD, 1955; Hilan, 1969). Indeed, before land reform, the semi- feudalistic structures prevailing in the high rainfall areas were a major constraint to improvements (Amin, 1982). The production of these areas, where agricultural implements were often similar to those described by roman agronomists, was low and stagnant

(Weulersse, 1946; Hamidie, 1959). Conversely, mechanization in Syria was first brought in on a large scale in the semi-arid areas and these benefited considerably from agricultural investments made in the country (Hannoyer, 1980). However, in the space of a few years, the semi-arid areas moved from a leading to a marginal position as regards development efforts.

Land reform, importation of agricultural inputs, the generalization of mechanization in high rainfall areas and the expansion of irrigated areas, stimulated the reversal which took place in the early 1960s (Metral, 1980). Although substantial increases in production have been achieved in these areas, their potential is still far from being fully exploited. Furthermore, areas presently under irrigation only represent 20 to 30% of the national potential (Arar, 1984). As a result, high rainfall and, even more so, irrigated areas have become the main focus of agricultural development efforts in Syria. Under the present five year economic plan (1981-1985) over 60% of the funds available for agricultural development are allocated to the Euphrates irrigation project, while no investments were forecasted in the semi-arid areas (OFA, 1981). Along the same line, the supply of agricultural inputs, which is government controlled, is restricted to high-rainfall and irrigated zones.

The present orientation of development policies has strong justification. First, high-rainfall and irrigated areas have a far greater productive potential than areas receiving less than 350mm of annual rainfall. Second, priority is given to major import replacement commodities and raw material for developing the national agroindustry. Neither sheep nor barley, although essential commodities for the country, fall in these categories. Nonetheless, the absence of efforts and the "laisser-faire" policy in the semi-arid cultivated areas is a serious threat for the country's agricultural future.

The Urgent Need For An Effort To Be Made

The present situation and the future prospects of the study areas are critical, not only for the villages concerned, but also for the country as a whole. The ongoing degradation process of land resources jeopardizes agriculture in the semi-arid areas and consequently will seriously offset, at the national level, advances made in areas presently receiving most attention under the development policy. The problem is already apparent in cereal production. New varieties, such as Mexipack, and fertilizer application in high rainfall and irrigated areas, have allowed large increases in wheat yields. However, between 1960 and 1975, according to FAO sources, Syria's cereal production showed a 12% decline mainly as a result of declining barley production. Although the planted area was expanded, between 1960 and 1975, barley production in Syria has declined at an average annual rate of 4.2% (Labonne and Hibon, 1978). Furthermore, taking into account the country's very high rate of population growth, the study area represents a potential for the future which needs to be preserved.

Thus, although semi-arid areas have a low potential compared to other areas of the country, there is an urgent need for an effort to be made to arrest their degradation. However, previous experience in development efforts clearly shows that when agriculture is a "mining" activity and, even more so, a secondary activity, farming systems are most difficult to improve. In this respect, the present course of changes is rapidly increasing the difficulties facing introduction of improvements in the study areas.

ISSUES IN RESEARCH DESIGN

Arresting degradation is a complex issue in which technical, social, and policy aspects are closely interrelated. FSR, as an holistic and multidisciplinary approach, provides a valuable basis for meeting the problems faced in the semi-arid areas of Syria. Substantial progress has been made in defining FSR methodology. Research projects, however, are generally focused on increasing the productivity of smallholders in areas where other groups of farmers have adopted more productive practices. In the case of the semi-arid areas under study, the situation and problems to be met are quite different, and raise particular methodological issues.

Policy Related Issues and Implications For Research

Developmental strategies can be achieved through the dissemination of new techniques, usually based on the introduction of new inputs, and/or the development of relevant policies. Applied research and development projects are generally conducted in areas benefiting from particular attention under current strategies of national development. The latter provide the basic orientation for research. Although there is a scope for policy interaction in FSR, research efforts are primarily focused on the design and dissemination of improved practices that conform to policy objectives.

Regarding the semi-arid cultivated areas of Syria, far from providing orientations for research, current strategies of national development appear to be major constraints on improvements to be made. Consequently, influencing the development of changes in current policies is a main objective for research. Several issues, such as the supply of inputs, farm structures, and the place of semi-arid areas in the national agricultural sector, need to be addressed if improved practices are to be effective in stabilizing productivity in the long run.

Soils throughout the study areas, are generally deficient in phosphorus (Harmsen, 1984). On-station and on-farm trials conducted by ICARDA, have shown that phosphate application substantially increases barley yields and, furthermore, reduces crop failure. However, the supply of agricultural inputs, which is government controlled, is limited to higher rainfall and irrigated areas. The removal of this constraint is a precondition to the use of phosphate fertilizers by farmers in the dry areas. In this respect, planners and policy makers are the main target of the phosphate trials set up in the 1984/85 season by ICARDA and the Soils Bureau of the Ministry of Agriculture (FSP/MAAR, 1985).

Besides the supply of agricultural inputs, other more complex policy issues will need to be addressed. Presently, there is a serious incompatibility between farmers' short term strategies and the national community's interest, which is to preserve the productive potential of the dry areas. This incompatibility is largely related to factors which need to be corrected through specific socioeconomic measures.

In the eastern plains, where settlement started after 1950 (Map 1), cultivation was developed under a share-cropping agreement between nomads, whom became semi-nomads, and contractors. Presently, a large amount of the land is still cultivated under a similar agreement (FSP, 1982). An important characteristic of these areas is that most of the land is state owned and neither semi-nomads nor contractors have security as regard to land. The present mode of exploitation is a major factor underlying the development of short term cropping strategies and is a severe constraint on the adoption of new practices aimed at stabilizing productivity in the long run. Furthermore, stabilizing productivity will require a better integration of flocks in farming systems. But, under the present mode of exploitation flocks and crops are controlled by different parties.

In the western areas, farmers have also adopted short term cropping strategies. However, socioeconomic characteristics differ from those found in the eastern plains, in particular in that most farmers own the land they cultivate and holdings are much smaller. Before mechanization was introduced in these areas in the 1960s, farming families were living at a low subsistence level and were among the poorest in rural Syria (Weulersse, 1946). In the late 1950s, fallows used to represent 60% of the cultivated land in the 250-300mm rainfall zone of Aleppo province compared with the present 32% (Jaubert and Oglah, 1985). Labour was the main factor limiting the size of the cropped area. In the absence of alternative sources of income, the introduction of tractors led to a sharp intensification in land use. Population densities range between 30 and 50 persons per km2. It is in these areas that agriculture is becoming a secondary source of income, which limits incentives for farmers to invest in this activity.

Preserving the productive potential of the semi-arid areas raises the question of what to produce in relation to the needs of the country. As mentioned in the previous section, sheep and barley are not considered to be priority commodities. The country is faced with an increasing food deficit and efforts are focused on major import-replacement commodities such as wheat, maize, sugar beet, and dairy cattle. However, alternative products in the semi-arid areas are severely limited by agroclimatic constraints. In this respect higher rainfall and irrigated areas offer a much greater flexibility. Nonetheless, the increase in the national sheep population in the last 15 years mainly resulted from increases in sheep numbers in the higher rainfall and irrigated areas (FSP, 1979). In a country with a large variety of agroclimatic zones, such as is the case in Syria, optimizing the use of the national agricultural potential requires that complementary products be produced in the various areas of the country according to their capability. In this respect, the semi-arid cultivated areas need to be integrated into national agricultural plans, which is not presently the case.

Stabilizing productivity in the semi-arid areas requires changes in current national agricultural development policies. On the one hand, the effect of technical changes will depend in a large measure upon the extent and quality of socioeconomic measures taken to support them. On the other hand, relevant policies will depend upon the available technical solutions and the potential of the area. Both issues need to be explored simultaneously and require close collaboration between research and policy-making institutions.

A Systems Approach Focused On Management Practices

The management of existing resources, in particular land, is a central issue regarding the future prospects of agriculture in the semi-arid areas. Applied agricultural research projects are usually based on the assumption that farmers efficiently use existing resources. As a result, limited gains can be expected from a reallocation of these resources. Research efforts are mainly geared to introducing new inputs in order to alleviate factors limiting productivity. These developmental strategies aimed at increasing the productivity of well-tuned systems do not, in most cases, imply major changes in current land use patterns and livestock management practices.

In the case of systems in disequilibrium such as those found in the study areas, more complex changes need to be made. As shown by the ongoing process of degradation of land resources, current management practices lead to an exhaustion of the resource base. The use of fertilizers will offset declining nutrient levels but will have a limited effect with regard to poor soil structure, low microbial activity, and declining organic matter levels. These are all assumed to be important components in the loss of soil fertility which occurred after land use was sharply intensified. Beside the introduction of new inputs such as phosphate fertilizer, stabilizing productivity will require changes to be made in land use patterns and grazing practices.

In the drier zones (those receiving less than 200mm of annual rainfall) it is probable that cultivation should be dropped and barley replaced by permanent pastures. In areas of relatively higher rainfall, studies by ICARDA have shown that cropping systems can be improved by alternative cropping patterns based on two-course rotations including a legume crop (Keatinge, 1985). Legumes can be used as a replacement for fallow in the case of barley/fallow rotations or as a break crop when barley is grown continuously. The inclusion of legumes contributes to maintaining soil fertility and in addition, in the case of forages, supplies livestock feed.

Regarding non-arable grazing lands, which are an important source of livestock feed, studies conducted in the 250-300mm rainfall zone of Aleppo province show that primary productivity is well below its potential (Cocks, 1985). In order to stabilize the productivity of these areas there is a need to develop appropriate grazing practices.

Replacing barley by permanent pastures in the drier zones represents a drastic change in farming systems and requires the design of a new feeding cycle for livestock. Such radical changes will certainly be most difficult to implement all at once. Dropping cultivation, to be acceptable to farmers, will have to be implemented through a sequence of gradual changes.

In areas where barley cropping can be maintained, cultivated and uncultivated areas are closely linked through the system of feeding livestock, and complementary changes need to be made in both land use patterns and grazing management practices. Barley is a main source of supplementary feed during the winter, and stubbles are grazed in the summer. Grazing lands are the main source of livestock feed in the spring (Jaubert and Oglah, 1985). In order to reduce stocking rates on uncultivated lands, there is a need to provide an alternative source of grazing. This could be fulfilled by a forage legume such as vetch, peas, or lathyrus, three species currently being tested at ICARDA. Beside soil and climatic characteristics, the selection of appropriate species for grazing will depend on when flocks should be removed from grazing areas. Furthermore, grazing areas, which are located on communal lands are seen as a free commodity. Therefore, to be economically attractive, the introduction of forage legumes for grazing will need to be associated with improved grazing practices at the community level aimed at stabilizing and increasing the productivity of the range in the long run.

With regard to improvements in grazing practices, the diversity of farms, particularly in stocking rate per hectare of arable land, is an important aspect. In the 250-300 mm rainfall zone of Aleppo province, stocking rates range from 1.2 to 11 head per hectare (Jaubert and Oglah, 1985). Farms with high stocking rates are more dependent upon communal grazing lands than those with low stock rates. As a result, in studying the feasibility of new grazing practices at the community level, the diversity of farms and their interaction in the management of grazing lands needs to be taken into account. In this respect, research should be designed at an area level, rather than focused on a particular group of farms with similar circumstances and practices.

In order to identify constraints on changes in land use patterns and grazing practices, there is a need to develop a detailed study of current management practices. A study focused on this aspect was initiated in 1983/84 season in the dry areas of Aleppo province (Jaubert and Oglah, 1985). The results obtained in the first season indicate that the introduction of a two-course rotation including a forage legume, which is seen as a central component of strategies aimed at stabilizing productivity in these areas, raises a number of problems related in particular to labour and the supply of inputs. Farmers already grow small areas of forage legumes (2% of the cropped area) and the cost of labour is said to be the main factor limiting this practice. Unlike barley, legumes in the study area cannot be harvested mechanically and need to be harvested in a short period of time. To be economically feasible, in the absence of adequate harvesting machinery, forage yields need to be substantially increased which requires the supply of fertilizers. Thus, like in drier areas, strategies aimed at stabilizing productivity will have to be implemented through a sequence of gradual changes.

The study of current management practices also indicated areas where improvements could be more easily implemented. This is the case, for example, regarding feeding levels and flock performance. The monitoring of a sample of 19 farms showed that the efficiency of winter feed utilization and reproductive performance of ewes are generally low. The problem is probably related to inadequate levels of feeding during the summer. The system of feeding livestock could be made more effective by providing supplements in the summer and reducing levels of supplementary feeding in the winter, which are presently above requirements. Along the same line, we found a large potential for increasing the use of sheep manure on barley, practices which is presently very limited. Such improvements can be seen as first steps in a strategy based on gradual changes and will help in implementing more complex changes in current management practices.

Zoning and Levels of Investigation

The design of strategies aimed at stabilizing agricultural production in the semi-arid cultivated areas raises a number of issues ranging from management practices at field and flock level to the national strategy of agricultural development. In order to structure a research approach integrating the various components of the problem, several levels of investigation need to be considered. We have defined five levels: the semi-arid cultivated areas, sub-areas, "land management units", farms, and fields and flocks.

The semi-arid cultivated areas are a discrete entity in the overall problem of degradation of land resources and their place in national development strategies. This first level of investigation is essential regarding diagnostic studies and policy related issues. Nonetheless, the study areas are heterogeneous in both physical and social characteristics. Several soil types are found throughout these areas. Population densities range from less than 10 to over 50 persons per km2 and land holdings vary from less than 5 ha to over 200 ha. Barley is grown continuously on some lands, while on others, farmers have maintained the practice of fallowing. The livestock population may include large flocks which graze the steppes in the spring and small sedentary flocks which remain in the cultivated area throughout the year. Some sedentary flocks have access to non-arable grazing lands while others do not.

As a result of the combination of these physical and social characteristics, the complexity of the problem of degradation and alternative solutions varies according to the location. Therefore, in order to provide a more detailed diagnosis and select relevant target areas in which to conduct technical studies, the semi-arid cultivated areas should be divided into homogenous sub-areas.

Zoning projects are usually based on climatic and soil characteristics. However, in the case of the study areas, alternative solutions will also largely depend upon several other characteristics such as, livestock systems, the distribution of land holdings, and tenurial systems. In a given location, land use patterns result from the combination of physical and social characteristics. Therefore, current land use patterns are a main feature to consider for identifying and delineating homogenous sub-areas.

A research program aimed at identifying, delineating, and specifying homogenous sub-areas in Northwest Syria was initiated in October 1983 in collaboration with the Arab Center for Studies in Arid Zones and Dry Lands (ACSAD). The program will prepare a socio-ecological map of the semi-arid areas of Aleppo province using comparative analysis of Landsat imagery, aerial photographs, agricultural and population statistics, and ground verification studies.

Studies focused on management practices are to be conducted at farm, field, and flock level in selected locations representative of principle sub- areas. Zoning of the semi-arid areas of Syria is still in a developmental state. Meanwhile, in order to test a research approach a sub-area was selected in the semi-arid cultivated lands of Aleppo province (Jaubert and Oglah, 1985). The study area was first subjected to a preliminary survey conducted at village level. The results of this survey were used to specify the main characteristics of the study location and select a sample of 19 farms for conducting a detailed monitoring of farming practices and on-farm forage trials. To study the interaction of farms in the management of grazing areas, an intermediate level of investigation was defined between sub-area and farm. The farm sample was selected in a group of four villages where flocks have access to the same grazing lands. This level can be defined as a "land management unit".

CONCLUSIONS

The semi-arid cultivated areas of Syria raise challenging problems for the country's future. There is an urgent need for an effort to be made in these areas, which are currently of low importance in national agricultural development strategies, with the aim of arresting the ongoing process of degradation. The latter jeopardizes agriculture in these areas and offsets, at the national level, advances made in more productive areas presently receiving greater attention. FSR, as an holistic and multidisciplinary approach provides a valuable basis for designing a research approach aimed at assessing and evaluating alternative solutions, which are dependent upon a large number of interrelated issues.

Strategies of national development, which are focused on higher rainfall and irrigated areas, are important components of the problem. Therefore, influencing the development of changes in current policies is a main objective for research. The effect of technical changes will largely depend upon the extent and quality of socioeconomic measures taken in support and the definition of alternative strategies requires close collaboration between research and policy making institutions.

Current farming practices, throughout the semi-arid cultivated areas, are leading to the depletion of land resources. Consequently, beside the introduction of new inputs such as phosphate fertilizers, stabilizing productivity will require changes to be made in current land use patterns and grazing practices. To assess and evaluate alternative solutions there is a need to undertake detailed studies focused on the allocation of existing resources. Furthermore, large changes in current management practices will not be acceptable all at once and will need to be implemented through a sequence of gradual changes. Studies of current management practices are essential for identifying areas where changes can first be made and in defining a sequence of complementary changes.

The study areas are heterogeneous in both physical and social characteristics and zoning is essential to select revelant target areas in which to conduct systems oriented studies. Finally, arresting degradation of land resources raises a number of issues ranging from national development strategies to management practices at field and flock level. In order to integrate into a single analytical framework the various components of the problem to be met, several complementary levels of investigation need to be defined.

The design of a research approach raises issues which differ in several respects from those addressed by most FSR programs focused on small farms in areas of well-tuned farming systems. However, beyond the complexity of these issues, expectation for rapid and spectacular improvements may well be the main constraint to the definition of appropriate research strategies.

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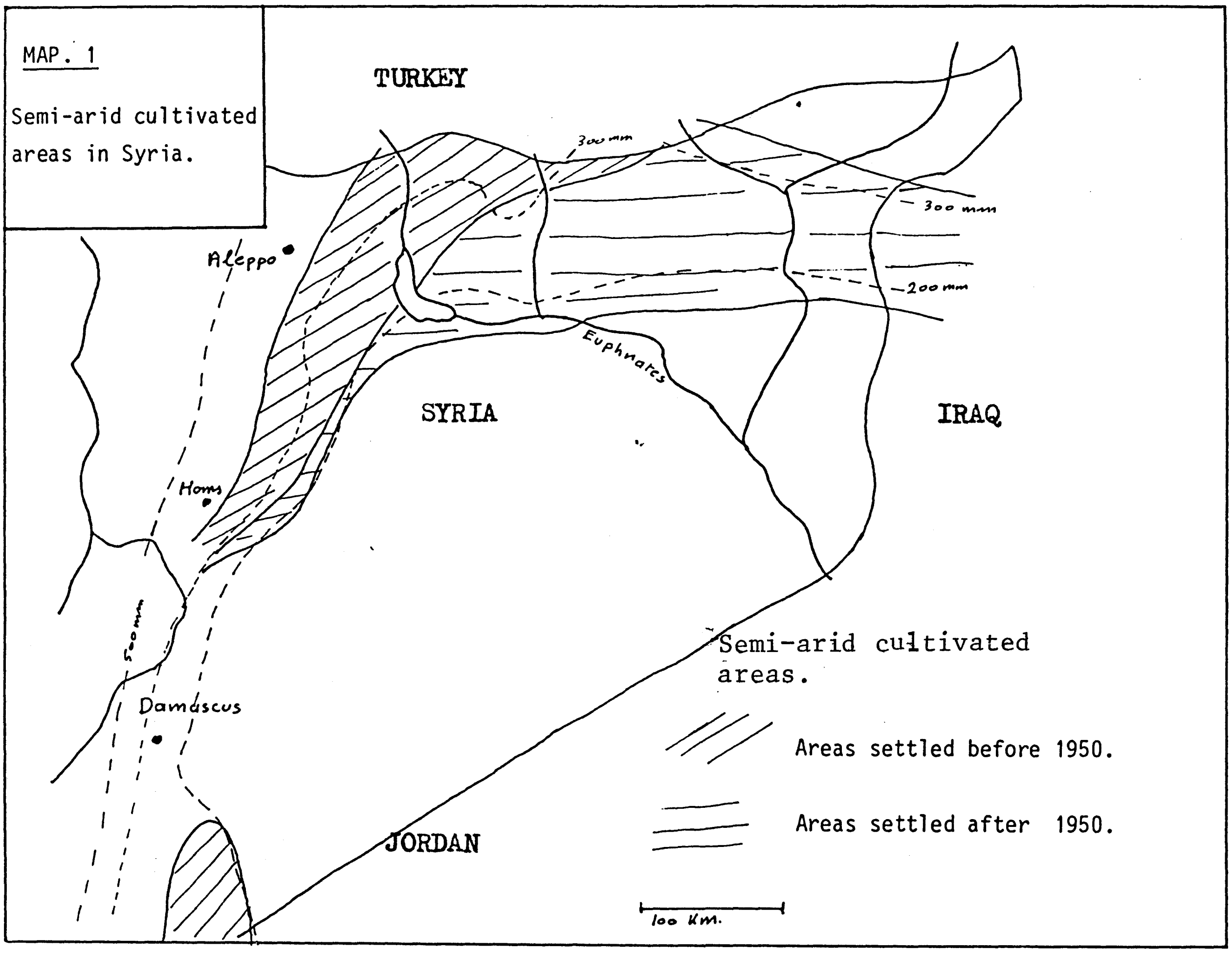

MAP. 1

Semi-arid cultivated areas in Syria.

FARMING SYSTEMS RESEARCH ON ANIMAL HUSBANDRY PROBLEMS
IN TUTUME AGRICULTURAL DISTRICT OF BOTSWANA

Berl A. Koch

INTRODUCTION

The purpose of the Botswana Agricultural Technology Improvement Project (ATIP) is to improve the capacity of the Ministry of Agriculture (MOA) to develop and effectively extend farming systems recommendations relevant to the needs of the small (limited resource) farmer.

There are many components to the ATIP project. Through ATIP an agronomist is serving as the country's research-extension liaison officer to promote improved research-extension linkages. An agricultural economist is stationed at Sebele Content Farm, the main experiment station, to broaden the disciplinary input into agricultural research. The primary feature of the project, though, has been establishment of two multidisciplinary FSR teams, one stationed in Mahalapye, mandated to work in the Central Agricultural Region, and one stationed in Francistown, mandated to work in Tutume Agricultural District. The Mahalapye team began research in the 1982-83 season and the Francistown team began in the 1983-84 season.

Each FSR team is comprised of an agronomist and an agricultural economist research officer provided through a contract between the government of Botswana and USAID, along with counterparts provided by the MOA for each research officer. In addition, an animal scientist and his counterpart are stationed at Francistown. The animal scientists have primary responsibility to work with the Francistown FSR team but also are mandated to work in the Central Agricultural Region with members of the Mahalapye FSR team.

The primary focus of ATIP is on improvements in arable agriculture production technologies. However, livestock are the backbone of Botswana's rural economy. More than 70% of small farmers have cattle and 60% raise smallstock (Singh and Motsemme, 1984). Cattle and donkey traction are used by the vast majority of farmers. Livestock sales are the most important source of income for many farmers and milk plus meat are important sources of high quality nutrients.

Therefore, any study of Botswana's farming systems must include a study of how modifications in livestock practices can contribute to improved farmer productivity and welfare.

Livestock research by ATIP Francistown has a dual orientation toward improving the contribution of livestock to small farmers: (a) improving productivity of livestock production enterprises and (b) taking better advantage of crop-livestock interfaces. The objective of this paper is to describe the approach to research on animal husbandry problems being used by ATIP Francistown. Emphasis is given to farmer selection procedures and an overview of the major survey research and trial carried out during the first year of research. Preliminary results of a livestock practices survey and a plough condition survey also are presented.

FARMER SELECTION

Early on, ATIP Francistown team members decided that, where possible, animal studies would utilize the same farmers as economic and agronomic studies. All team members were involved in selection of villages and farmers.

Based on an observation that intra-village differences in farmer endogenous circumstances were greater than inter-village differences in exogenous technical and human (institutional) circumstances, it was decided to concentrate research in three villages. This also had the advantage of reducing logistical problems in conducting research at several locations. It was felt district-wide descriptive-diagnostic research could reveal if additional technology screening was required to address unique circumstances in particular localities.

An early decision also was taken to concentrate on a relatively small sample of farmers. This decision was based on the view that:

1. Data on, continuous non-registered data, would be valuable in providing a whole farm and household analysis of constraints and opportunities facing farmers.

2. Close researcher-farmer interaction should be maintained to gain insight into farmers' problems and opportunities for solution.

3. Concrete research results were required in a timely manner to gain credibility with experiment station researchers and the MOA.

It was only through a semi-case study approach that viewpoints one through three could be accommodated. A concept of special subject surveys was developed, in which different samples are selected for different subject matter investigations, to deal with sampling error problems where these might be expected. (See ATIP Annual Reports One and Two for descriptions of the special subject surveys conducted to date (ATIP, 1983, 1984)

The village and farmer selection process began with visits to the Francistown Regional Agricultural Office and the Tutume District Agricultural Office. Next, village headmen, local agricultural demonstrators (extension agents), village development committee members, heads of schools and a few randomly encountered farmers were questioned. From these discussions plus extended "tours" in the district, team members gained sufficient knowledge to identify major agricultural and sociological differences and similarities in the district.

It was decided to select villages representing a range of orientations toward agricultural activities. It was also decided there had to be an active agricultural demonstrator (A.D.) in any village selected as an ATIP village.

The three villages eventually selected were Matobo, Marapong and Mathangwane. Matobo, 90 km. from Francistown, can be described as a "traditional" village. There are 284 households in the village. There is no secondary school, no farmers' cooperative and there are few active development programs.

Mathangwane, 30 km. from Francistown, can be described as a moderately progressive village. There are 618 households in the village. There is a farmers' cooperative, there are a number of tractors and it appears that technological and social changes are being readily accepted.

The third village, Marapong, is 65 km from Francistown and is probably the most progressive. There is a farmers' cooperative and a secondary school. Villagers have built their own dam for water conservation and they have formed a development trust to support local enterprises.

Following selection of the three villages a census baseline survey was conducted in each village to select farmers for inclusion in the ATIP study. The survey questionnaire provided information concerning household profile, livestock numbers, type and source of draft power, method of planting, fencing, destumping, and householders working away. Farmers were stratified within villages into four categories according to their access to economic resources. In each village, ten farming households were selected to participate in ATIP Francistown research: two in the upper group, three in the upper middle, three in the lower middle, and two in the lower group. Almost every farmer selected had one, two, or three species of livestock. (Selection procedures are described in more detail in the ATIP Annual Report No. 2 [ATIP, 1984].)

LIVESTOCK COMPONENT OF WHOLE FARM STUDIES

In an effort to gain an interdisciplinary perspective of household activities, a single survey instrument covering household resource flows was designed and administered to all ATIP farmers. The survey questionnaire was administered twice weekly to each farmer by enumerators hired in the research villages. Each enumerator was responsible for five farmers.

During the first few months, attention was focused on arable agriculture production activities. As enumerators became better acquainted with their farmers and the survey instrument, questions were added relating to all household activities. The following information on livestock and livestock activities are collected in the resource use survey:

1. Draft power used by a household, including number and type of animals used, access to draft, equipment used, provision of supplemental feed, salt or minerals, and frequency of watering.

2. Use of household animals for fieldwork or transport, including: number and type of animals used; hours animals worked; equipment used; labor used to manage animals; animal problems; and payment received if animals were used for transport.

3. Livestock inventory changes, including type of animal; reason for change; approximate age of animal; where the change took place; and if an animal died--why and was any of it eaten or sold.

4. Sales or purchases of livestock or livestock products, amount received or paid and to/from whom.

5. Labour time spent tending livestock.

6. Milk obtained from cows and goats.

Because the above information is collected as part of whole farm studies, it can be analysed in conjunction with information on household characteristics (eg. sex and age of household head, household assets, and income) and arable agriculture production activities.

SUPPLEMENTAL MINERAL FEEDING TRIAL

Experiment station research has produced and published a large "body of knowledge" in Botswana concerned with animal feeding, breeding, health, husbandry, housing, management, and training. There is also much published research showing the value of various practices or interventions mentioned above.

The Department of Agricultural Field Services (DAFS) has developed and is recommending various programs and practices based on that research. By following those recommended programs the farmer should be able to increase his/her cash income and improve his/her way of life. However, many programs and practices have been poorly accepted by farmers who own small herds and flocks.

Animal husbandry team members selected one of those recommended practices, supplemental mineral feeding, for further study. Supplemental mineral feeding should be economically and socially acceptable to every farmer producing animals. It requires a small monetary outlay. It does not require a large change in management or husbandry. Current research shows a 30 to 40% increase in the yearly weight gain of growing cattle when they have access to a mixture of salt and bonemeal [APD, 1983]. Also, breeding age heifers receiving a mixture of salt and bonemeal on pasture show a conception rate of 80% while similar heifers receiving no supplemental mineral-mix show a conception rate of less than 40% [Holmes, 1984]. The government is subsidizing both the cost of salt and the cost of bonemeal. Yet, less than 10% of farmers in Central Region and less than 5% of farmers in Francistown Region feed bonemeal and salt to their animals [Nelson, 1980].

Livestock handling facilities owned by farmers are basic and minimal. Therefore, it was decided that a mineral-mix would be offered to all interested ATIP farmers who promised to follow simple feeding directions (written in Setswana). The study is farmer managed and farmer implemented (FM-FI). Performance is being measured in terms of:

1. Average animal mineral-mix consumption;
2. Reproductive performance of females;
3. Survival of young animals; and
4. Survival of adult animals.

Available government statistics seem to be the best control for this study. Reproduction and survival figures are taken from livestock inventory figures being collected by enumerators of the household resource use survey. An individual farmer may be feeding mineral-mix only to goats, donkeys, or cattle, or to all three species, but a separate intake record is kept on each type of animal.

A mineral-mix made up of 25% salt and 75% dicalcium phosphate is being used. (Bonemeal is seldom available at the Livestock Advisory Centers in Francistown Region.) It is mixed and packaged in small quantities (500 grams or less) and delivered to farmers fortnightly. The mineral-mix is 12% phosphorus and 21% calcium. The hoped for feeding rate is 50 grams per day for cattle, 25 grams for donkeys and 7 grams for goats and sheep. Yearly cost of feeding at these levels would be $3.90 per head of cattle, $1.96 per donkey and $0.55 per goat. If subsidized bonemeal is available, the cost of feeding would be many times less. Table 1 summarizes the number of herds being fed in four ATIP villages.

To date, daily mineral-mix intake for cattle varies from 15.2 grams to 56.0 gram per day with an average of 24.3 grams. For donkeys, daily mineral-mix intake varies from 6.4 grams to 65.6 grams with an average of 22.8 grams and for goats it varies from 2.1 grams to 31.0 grams with an average of 10.6 grams. The trial has not advanced enough to measure reproductive performance or animal survival.

LIVESTOCK PRACTICES SURVEY

In order to supplement descriptive-diagnostic information gained through the household resource use survey, a livestock practices survey was carried out among the 42 farmers feeding mineral-mix. All interviews were conducted by the animal husbandry officers. Survey forms were divided by species into three sections, one concerned with poultry, one with goats, and one with cattle. Only farmers owning a particular species answered questions concerning that species. Results of the survey are summarized in Table 2.

It is interesting to note that while 95% of ATIP farmers own poultry, 87% say they rarely or never eat poultry and 46% sold no birds last year. Likewise, in the case of goats, 95% of ATIP farmers own goats but 92% say they rarely or never eat goat and 67% sold no goats last year. Only 72% of ATIP farmers own cattle and 63% of those owners have less than 20 head. Seventy-three percent of cattle owners say they rarely eat beef and 70% sold 5 or less cattle last year.

Ninety-five percent of goat owners do not vaccinate their goats, 92% do not treat for internal parasites but 72% do attempt to protect their goats from tick infestation. One hundred percent of cattle owners vaccinate their cattle for various infections, 90% attempt to protect their cattle from tick infestation but only 10% treat their cattle for internal parasites.

Only 33% of cattle owners have ever fed salt to their cattle and only one out of 30 cattle owners feed salt every day, while 83% of the farmers have never fed bonemeal or dicalcium phosphate to their cattle. Eighty-seven percent of the goat owners have never fed salt to their goats and not one has ever fed bonemeal or dicalcium phosphate to goats. Yet, on the livestock survey forms more than 70% of the farmers said they would buy mineral-mix for their animals if it was available in small quantities at a reasonable price.

Ninety percent of the ATIP herds are watered once per day according to the survey. Fifty-seven percent of the goats and 33% of the cattle travel less than 1 km. to water while only 5% of the goats and 13% of the cattle travel more than 5 km. to water.

The results of the survey indicate that cattle owners have adopted and are practicing many recommended veterinary programs but small stock owners lag far behind. Very few poultry, small stock, or cattle owners attempt to follow any of the recommended programs for controlling internal parasites.

PLOUGH CONDITION SURVEY

A plough condition survey was administered to 29 ATIP farmers who owned at least one single furrow plough. Such a survey seemed justified after casual observation of many ploughs in the district, plus literature reference to poor condition of ploughs [KSU, Farming Systems Research Team, 1981].

Sixteen of the farmers each owned a single plough, eleven owned two ploughs each and two farmers owned three ploughs each. Average age of the ploughs was 14 years. Five of the ploughs were more than 30 years old and the oldest had been in use 46 years. Original cost of ploughs was related to time. The oldest plough was purchased for $5.63 in 1938 while a plough purchased in 1984 cost $86.25 according to the farmer.

Fifty percent of the farmers said a plough share could be used for 20 working days but nine farmers (33% of those sampled) said they purchased a plough share once each year. The average cost of a new plough share was $3.00.

Almost half of the ploughs examined showed excessive wear on the landside and 40% of them had no heel. It had apparently worn off or had been removed.

Forty percent of the ploughs did not have an adjustable hitch. Several farmers with newer ploughs had removed the adjustable hitch as they thought they did not need it. Yet, 80% of those having adjustable hitches on their ploughs, 15 out of 18, said they do use them.

Farmer estimates of ploughing depth ranged from 12 to 30 cm. with an average of 22 cm. The depth wheel appeared to be in proper adjustment on 50% of the ploughs. The wheel was badly worn on 40% of the ploughs and on two ploughs the wheel had been replaced by a wooden slide.

Seventy percent of the farmers said stumps in the lands area were their greatest problem. Only three farmers, 10% of the sample, thought that use of untrained animals was a problem at ploughing time.

Twenty-seven farmers, 93% of the sample, said they had never heard their A.D. discuss plough adjustment and 75% of them had never heard about the plough planter. One farmer in the group had used the plough planter.

CONCLUSIONS

Animal science research has an uncertain role to play in farming systems research in Botswana. Everyone would agree that livestock are a dominant influence on the welfare of rural Batswana. At the same time, this fact has been recognized for so long that exhaustive research on animal husbandry long pre-dates recent interest in farming system research. Recommendations resulting from that research has been most applicable to, and of most value to, the large commercial livestock producer. The feeding of supplemental mineral-mix illustrates the frustrations facing the small farmer when he/she tries to follow the recommendation. The small herd requires only a few grams of mineral-mix each day. Yet, when he/she goes to the Livestock Advisory Center they learn that they must purchase a 50 kg. bag of salt and a 50 kg. bag of bonemeal to make the mineral-mix. They must transport the two bags many kilometers to their home. They have to then devise proper storage facilities to preserve the 100 kg. (100,000 grams) of mineral-mix until it is all consumed by their herd of animals.

The Agricultural Technology Improvement Project has a primary mandate to seek improvements in arable agriculture production technology, but in recognition of the vital role of livestock to small farmers it has an animal science research component. After a single year of research, the ultimate direction of animal science research is not clear. However, a few distinct directions can be identified:

1. Descriptive-diagnostic research on the role of livestock, livestock management, draft use, and livestock inventory changes is being carried out as part of a broader whole farm study of resource flow patterns.

2. Special subject surveys on livestock practices and plough conditions have been implemented to evaluate particular problems or potential solutions.

3. Trials work has concentrated on a single recommendation, mineral-mix feeding, felt to be relevant to farmers with even the most limited resources as they try to increase farm income by improving livestock production in their farming system.

Taken together, research to date represents an effort to identify means of improving the contribution of livestock to small farmers, particularly taking account of an improved crop-livestock interface, but without duplicating the large body of research on cattle herd management and communal grazing. This paper reflects an effort to fit animal science research into an arable agriculture research oriented FSR team.

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Table 1: ATIP Farmer's Herds Receiving Supplemental Mineral-Mix

Village	Cattle (herds)	Donkeys (herds)	Goats (herds)
Marapong	3	3	10
Mathangwane	3	3	10
Matobo	5	5	10
Makwate	1	4	6

Table 2: Livestock Practices Followed by 42 ATIP Farmers

Variables	Poultry	Goats/Sheep	Cattle
Number who own livestock	41	40	30
Own 10 or less %	56	17	40
Own 20 or less %	86	70	63
Never eat the meat %	12	15	--
Rarely eat the meat %	75	77	73
Sold none last year %	46	67	17
Sell less than 5 per year %	41	30	70
Sell less than 10 per year	48	33	80
Castrate excess males %	--	95	100
Castrate with Burdizzo %	--	90	100
Vaccinate for disease %	--	5	100
Treat for ticks %	--	72	90
Treat for internal parasites %	10	8	10
Water once per day %	80	90	90
More than 5 km. to water %	--	5	13
Less than 1 km. to water %	--	57	33
Water from lake or pond %	--	50	43
Water from river %	--	12	27
Feed salt to animals %	0	12	30
Feed bonemeal or dical. %	0	0	17
Feed supplemental feed %	83	33	17
Females reproduce every year %	--	87	40
Limit milk to young %	--	95	97
Die before 6 mo. of age %	--	20	--

RISK PERCEPTIONS AND RISK MANAGEMENT BY FARMERS IN BURKINA-FASO[1]

Mahlon G. Lang, Mike Roth and Paul Preckel

INTRODUCTION

This report[2] discusses the risk perceptions of and risk management by farmers in Burkina-Faso. It describes farmers' risk perceptions, their intraseasonal risk management practices, and their implications for the development of agricultural technology.

During 1982, research was conducted by Purdue University Farming Systems Unit (FSU) in three villages. The villages of Bangasse and Nedogo are located on the densely populated Central Plateau where the fallow system has largely broken down and, of necessity, farmers knowingly "mine the land". Bangasse, the poorest village, receives from 400-500 mm of rainfall annually while Nedogo receives from 700-800 mm. Diapangou, east of the Central Plateau, receives about the same rainfall as Nedogo, but is in a relatively more fertile zone of shifting cultivation. Accordingly, farmers there tend to be more prosperous tnan those in the other two villages.

During 1983, the FSU worked in two additional villages. These are: Poedogo, on the Central Plateau, but in a 800-900mm rainfall zone south of Nedogo, and Dissankuy, near the Malian border in a fertile, relatively land-abundant zone. Significantly more cotton is produced in Dissankuy than in the other villages and higher grain yields permit the export of cereals to other regions of Burkina-Faso. This brought the number of villages to five and provided a wider range of agroclimatic and economic environments in which to conduct research. All FSU survey villages are identified on Figure 1.

To understand the farmer's decision-making framework and thereby to aid researchers in identifying the characteristics of production technologies attractive to farmers, interviews were conducted in 1982 with 30 randomly selected farmers in each of the three villages. An interview form was designed to identify factors farmers consider in making on-farm resource use decisions. The form required from one to two hours to complete and involved both objective and open-ended responses.

The farmers indicated that agronomic factors, principally fertility and water retention, are predominant considerations in cropping decisions. These factors strongly affect both yield and yield variability (risk) of crops. Farmers said they manage intraseasonal risk by incorporating land quality and risk considerations in their cropping decisions.

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[1]Burkina-Faso was formerly Upper Volta

[2]The report is based on research conducted by the Purdue University Farming Systems Unit (FSU) and INTSORMIL.

The findings of the decision-making interviews were largely qualitative. An additional study was undertaken in 1983 to test hypotheses generated by them and to expand upon their findings. Specifically, data on yield variability over time using subjective recall by farmers were collected and used to explain cropping patterns.

This paper is organized as follows. First, the findings of decision-making interviews are reported. Second, the findings of research on yield variability, risk perceptions, and intraseasonal risk management are presented. A final section discusses the implications of these findings for the future of agriculture and agricultural research in Burkina-Faso.

THE ROLE OF RISK IN DECISION-MAKING BY FARMERS

Representative cropping patterns for each village are presented in Table 1. These data are derived from direct field measurement on 30 randomly selected farms in each village.

On the Central Plateau villages of Bangasse, Nedogo, and Poedogo, the cropping patterns are similar. Millet and sorghum are the dominant cereal crops, accounting for about 90% of cropped area. The principal cash crop is peanuts. Sorghums tend to be more important on the southern part of the Plateau, giving way to millet as one moves north. An exception is seen in Bangasse where due to the presence of a dam, there is more bottom land and clay soil than is characteristic of the region. The greater water retention and higher fertility of these soils make sorghum a preferred crop.

In Diapangou, cereals are equally important, although millet and sorghum are generally grown in association. Maize is more important than on the Central Plateau because some of the farmers are cattle traders and therefore have more animal manure with which to support its cultivation.

In Dissankuy, commercial farming is evident in the cropping pattern. Farmers devote more of their land to traditional cash crops and more cereals are marketed than in the case in any other FSU village. Cereals, principally sorghum and maize, occupy 70% of the cropped area while cash crops account for 25%. Cotton is the most important cash crop followed by peanuts and bambara nuts.

During 1982, interviews were conducted with at least 30 farmers each in the villages of Bangasse, Diapangou, and Nedogo. One objective was to identify factors farmers consider most important in their cropping decisions. Specifically, farmers were asked why they did not plant more of each crop and why they planted as much as they did.

Farmers' responses to decision-making questions provided relatively clear decision rules explaining the cropping patterns seen on the Central Plateau villages of Bangasse and Nedogo. While Poedogo was not included in the 1982 study, these decision rules appear to apply there as well.

Maize is planted only around the compound where animal manure and human waste make the land the most fertile. Maize is preferred on this land because it typically yields more than other crops. More importantly, because maize is harvested in August, it meets the family's food needs during what is locally called "the hungry season", the period prior to the harvest of major millet and sorghum fields. Thus, maize occupies a critical temporal consumption niche, particularly in years following a poor harvest season when cereal stocks run low.

Sorghums are generally planted on village and bush fields away from the compound. While sorghum is more drought resistant than maize, it is less drought resistant than millet and is generally planted on land referred to as "sorghum land." This land has better water retention and is more fertile than the marginal land where millet is planted. Farmers plant sorghum on their best soil (excluding compound land) because "in a good year it yields more than millet and it stores twice as long." They would prefer to plant more sorghum, but access to soils of adequate quality is limited. While maize may produce more on such soil in an exceptionally good year, sorghum is more drought resistant and yields more than maize on these lands in normal or poor rainfall years.

Millet is planted on virtually all of the remaining land. On the Central Plateau, these are generally sandy or silty loams, the fertility of which has deteriorated as a result of continuous cropping and poor soil management. While sorghum may yield more on these soils when rainfall is consistent, the superior drought resistance and yield stability of millet make it a preferred crop in normal years. Farmers plant as much millet as their labor supply permits once they have allocated land to maize and sorghum (FSU Annual Reports, 1983, 1984).

Peanuts, the principal cash crop, are planted almost exclusively because they can be harvested and ready for sale soonest after harvest when the head tax is due. When asked why they plant peanuts, farmers simply say "to pay taxes." When asked why they don't plant more, they say "because I would just have to sell them to buy cereals."

While the farmer expresses these decision rules in agronomic terms, he also indicates that risk is a part of the decision. As one moves from the more humid southwest to north in Burkina-Faso, rainfall decreases and the major cereal crop shifts from maize to sorghum to millet. A similar effect is seen west of the Central Plateau where the soil is more fertile. Maize is preferred to sorghum on compound land because it provides more edible kilograms per hectare. Planting maize further from the compound on less fertile soil with poor water retention increases the likelihood that maize will fail whereas sorghum is less likely to do so. On these soils, sorghum is preferred to millet because it yields more in a normal year. Sorghum is not generally planted on "millet land", however, because it is more likely to fail than is millet which, in farmers' words, "will provide a crop even if there is only one good rain." There are intermediate soils on which millet or sorghum may be planted depending on the farmer's willingness to accept risk.

Thus, the farmer, given available land types and labor resources, considers the trade-off between yield expectations and risk in cropping decisions. This decision, which depends on the farmer's risk preference, is used to manage intraseasonal production risk.

MEASUREMENT OF RISK PERCEPTIONS AND INTRASEASONAL RISK MANAGEMENT

The basic assumption of this research is that the farmer's yield expectations and risk perceptions are based upon recollection of yield during recent years. A survey instrument based on yield recall was designed to collect time series yield data for all major crops. This approach was designed to tap the strong tradition of oral history among local farmers. No other time series of yields at the village level were known to the authors. This made farmers' knowledge of production histories the only source of time series information available.

Methodology

During September and October of 1983, 30 randomly selected farmers in each of the five villages were asked to recall production from their principal fields for each major crop for each of the preceeding ten years.[3] The farmers do not have a common measure of surface area. Hence, the methodology was designed to derive information on yields per hectare from units the farmer is familiar with. This was paniers or baskets full of grain received on his principal fields.[4] First, the size of the principal field for each crop for the current year was measured. Next, the farmer was asked if the same crop was planted on that field the preceeding year.[5] If so, he/she was asked what the production was and if the field was the same size. If the field was the same size, the production was recorded and converted to a per hectare yield. If the size of the field had changed, he/she was asked if the field was larger or smaller. In either case, he/she was asked what production would have been had the field been the same size. This answer was then recorded and converted to a per hectare value. This procedure was repeated to secure yield estimates for the 10 year period from 1973-1982.

The interview process was relatively complicated and demanding both

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[3]There is no strong test for the accuracy of yield recall. However, the fact that yield is the major concern of the subsistence farmer and the strong tradition of oral history among those interviewed improves the likelihood of accuracy. Further, there is no other source of time series yield data.

[4]The interviewers were familiar with the kilogram volume of individual farmers' baskets both for threshed and unthreshed grain. The same interviewers collect stocks and transactions data from the same farmers on a monthly basis and had already measured these conversion rates.

[5]A change of fields, through crop rotations, likely causes changes in soil fertility. The effect of this on crop yields is diminished, however, by the tendency of farmers to plant crops in soil regimes to which they are best adapted thereby limiting ranges in fertility for a specific crop.

to the farmer and the interviewers. It is natural to question the capacity of farmers to recall production levels over a ten-year period, particularly when asked to adjust them for changes in field sizes. For this reason, interviewers were closely supervised and cautioned on when to accept farmers' responses during interviews. The farmer himself was told to respond only if he could remember his production levels and to indicate the degree of confidence in his response. If the farmer appeared to be fabricating responses to satisfy the interviewer or if he appeared to tire, the interview was to be terminated. Interviews in Diapangou, Dissankuy and Nedogo provided satisfactory data. However, as a result of a poor season in Bangasse, farmers were unwilling to discuss yields. In Poedogo, cooperation by farmers was poor. The reasons are not clear to the researchers since the same farmers were very helpful in all other survey work.

Validation

As a test of this survey method, several efforts to validate the data were employed. These were:

1) A comparison of average yields based on recall with objectively measured current yields;

2) A comparison of yield trends based on recall to trends anticipated by the researchers;

3) A comparison of the relative yield variability among crops, based on yield recall, with the variability described by farmers in prior interviews;

4) An independent interview with farmers asking them which in terms of yield, were the best and the worst of the last ten years;

5) A comparison of relative changes in yields based on recall among farms from one year to the next (sign test);

6) A comparison of observed cross-sectional yield variability with the same measure based on yield recall; and

7) The interviewers' accounts of how well the farmers felt they could recall their production histories.

Comparison of Yields

In Table 2, average yields based on 10 years of recall are compared to average yields taken by direct measurement in 1982 (Nedogo, Diapangou) and 1983 (Dissankuy). As the data indicate, the observed yields are, in all but one case (peanuts, Nedogo), lower than the mean yields based on recall. There are several reasons for these differences. In Dissankuy, where the disparity is the greatest, there was much less rainfall in 1983 than usual. In Diapangou, the rainfall was relatively late and the effect was similar. As Table 3 indicates, the 10 year yield (recall) trend in Nedogo is negative. This would lead one to expect that average yields based on 10 year recall would be higher than those observed at the period's end.

Comparison of Trends

Table 3 presents trend estimates based on yield recall. The results show negative trends in Nedogo. These are consistent with the hypothesis that yields have been declining on the Central Plateau due to the breakdown of the fallow system.[6] Negative trends are neither evident nor expected in the frontier villages of Diapangou and Dissankuy, where population pressure is less severe and land is relatively abundant. Appendix 1 shows mean annual yields by village.

Comparison of Relative Yield Variability

In the decision-making interviews conducted earlier, farmers reported that millet is the least risky and maize the most risky of crops to grow. Sorghums fall in between, with red sorghum yields said to be more variable than those of white sorghum. The standard deviations presented in Table 2 support these claims. The standard deviations are lowest for millet, followed by white sorghum, peanuts, red sorghum, and maize.

Best Year-Worst Year Recall

In an independent interview with the same group of farmers, each was asked to indicate which of the preceeding 10 years were the best and the worst in terms of yield for each crop. These were then compared with the highest and lowest yields calculated from the yield recall data for each farmer, respectively. The two sets of extremes were consistent, providing support for validity of the yield estimation procedure. Next, comparisons of best and worst years among farmers were made to test for uniformity among responses. The data in Appendix 2 show that 82-96% (depending on the crop) of farmers in Nedogo reported 1977 as the worst year for all crops cultivated. This is consistent with the mean yields reported in Appendix 1. A lesser but still high percentage of farmers (40-65% depending on the crop and village) provided similar responses for what were the best years.

Comparison of Year to Year Changes in Yields

Changes in yields from year to year were compared across farms for selected crops. An increase is indicated by the (+); a decrease by a (-). The results are presented in Table 4. Yields for most farmers declined from 1976 to 1977 due to a severe drought. This is the corollary to the worst year case discussed above. Yields also uniformly declined from 1973 to 1974 in Nedogo and Diapangou but increased in Dissankuy. Strong similarities exist in other years but are mixed among crops and villages. Hence, there appears to be evidence that farmers

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[6] Rainfall is believed to have declined over this period as well, but village level data are unavailable to evaluate its affect on yields.

recalled the exceptional years of good or poor yields at similar points in time. The fact that farmers reported mixed increases and decreases in other years suggests the lack of a predominant factor (a severe drought) or set of factors which strongly and uniformly influenced yields.

Objective Cross-Sectional Yield Measurements

In Nedogo and Diapangou during 1982, and Dissankuy in 1983, yield measurements were taken on all fields for selected crops. In Table 5, the standard deviations of these objective yield values are compared to the standard deviations of yield recall values for 1982. As the table shows, standard deviations of the yield recall data compare reasonably well with those actually observed. Some differences are to be expected for the following reasons. First, the samples of farmers are different. Second, standard deviations based on recall are drawn from principal, and presumably higher quality fields for each crop, whereas the objective data are based on measured yields from all fields. This would lead one to expect lower standard deviations for data based on recall. Third, estimates for small fields, such as those on which peanuts are grown are smaller and subject to greater measurement error.

Farmers' Accounts of Their Own Yield Recall

Interviewers asked farmers to be frank about their confidence in recall. Farmers expressed high confidence in their abilities to recall yields for the preceeding 5 years; they were fairly confident about their recall up to 7 years and were must less confident about their recall beyond the 7 year period.[7]

ANALYSIS OF RISK MEASURES

The remainder of this analysis focuses largely on the village of Nedogo. This is because: 1) the survey data for Nedogo included observations on more crops; and 2) more farmers in Nedogo provided data for each crop for the entire 10 year period. Analysis of these data include four steps. These are: 1) to quantify farmers' risk perceptions; 2) to compare the risk associated with alternative crops; 3) to evaluate the implications of these risk perceptions for alternative crops under drought conditions; and 4) to determine the effects of risk in a representative farm model assuming risk aversion.

In examining the following analysis, the reader should bear in mind that the data are derived from yield histories for crops planted on soils for which they are best suited. For example, maize data is taken from yield histories on compound land, white sorghum data from "sorghum land"

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[7]For the remainder of this paper, 10 years of data are used in the analysis. This is done because the data appear relatively well behaved when examined by earlier validity tests. Further, the data (7 years to 10) contain valuable information on farmers' perceptions of yields even if they are biased relative to actual yields.

and millet data from yields on lower quality soils. Thus, the data do not reflect the risk one would assume in planting a crop on land for which it is marginally suited. The farmers' cropping decision rules offer insight regarding the direction of bias. To plant maize on lower quality land would increase the risk of crop failure. Therefore, yield variability for maize is likely understated if the farmer considers planting the same crop on other than compound land. The same argument applies to data collected for white sorghum, though to a lesser degree than for maize. Alternatively, millet, usually planted on the worst soils, may be a less risky crop if planted on better soils. Thus, the analysis does not consider all the information used by the farmer in making marginal cropping decisions.

The variation measures presented to this point have included both interfarm and annual variation. While such measures are useful for broad comparisons of yield variability at the village level, they are not, because of interfarm variation, appropriate estimates of the risk levels perceived by an individual farmer. To secure appropriate estimates, data were adjusted to remove the variation resulting from differences in mean yields among farms.[8] The resulting measures, used in the remainder of this analysis, are therefore lower than those in Table 2.

Standard deviations of yields (excluding interfarm variation) for individual crops are presented as risk measures in Table 6. These values are consistent with farmers' claims about the relative riskiness of major crops. In Nedogo, the highest risk is associated with maize. This is followed by red sorghum, peanuts, and white sorghum. Millet has the lowest risk. Similar relationships are seen in Diapangou. The only result differing greatly is the low value for maize in Dissankuy.

The standard deviations of yields for millet and sorghum do not vary greatly by village. Thus, the higher coefficients of variation in Nedogo reflect lower yields rather than greater yield variability. This places the farmers in Nedogo at a disadvantage in two ways. First, lower yields limit the ability to cushion themselves against a bad harvest. Second, higher variability relative to those yield levels increases the insecurity of food stocks. Thus, a bad season in this zone is more devastating than in other villages.

The data show that the crops with lower yield also have lower yield variability. It is not clear that differences in variance are so great that a crop with low average yields would rationally be chosen over those

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[8]Adjustments were made by applying the transformation

$$(X_{ijk} - X_{jk})\ (X_k/X_{jk})$$

to the data where X_{ijk} refers to the ith observation for the jth farmer and kth crop, X_{jk} is the mean yield for farmer j on the kth crop and X_k is the sample mean for the kth crop. This conversion transforms the data from actual yield observations to adjusted deviations around a group mean of zero. Risk measures compiled from this data can be interpreted as the average variance faced by an average farmer free of interfarm variation.

with higher average yields. To determine whether this is the case, the effects of drought conditions on crop yields are simulated in Table 7. In Nedogo, if one assumes that yields fall two standard deviations below the mean, the yield for white sorghum (221 kg/ha) remains higher than the yield for millet (177 kg/ha). However, if one accepts the yield estimates for the year 1985 (derived from Table 3), millet has the highest yield (155 kg/ha) when drought conditions occur. In the other villages, where there is no evidence of declining yields, the higher yielding crops retain the highest yields under drought conditions. These findings suggest that in Nedogo, crops with a low average yield may rationally be chosen over others because they produce the most food in a bad year ("safety first" approach). In the villages of Dissankuy and Diapangou, farmers may have more flexibility to pursue other objectives (e.g. profit maximization).[9]

Coefficients of yield variation (for the 10 year period) were calculated by crop for each farmer. These were then compared for all combinations of crops using paired t-tests. The results are presented in Table 8. They indicate that differences in coefficients of variation are not significant among the major cereals (millet and sorghums). However, the coefficients for maize and peanuts are significantly greater than those for the cereal crops.

These findings indicate that farmers plan their cropping mix such that coefficients of yield variation are constant for major cereals. This implies a willingness to accept more risk if it is accompanied by proportionately higher yields. Yet farmers accept higher coefficients of variation for peanuts and maize. These findings indicate that farmers assume a greater cost in terms of risk in cultivating these crops; the former to assure that sufficient cash is available to pay taxes, the latter to assure food security during the "hungry season."

EFFECT OF RISK ON CHOICE OF CROP MIX

Many of the techniques used to evaluate choice of production technology on the farm do so free of formal risk considerations. Simple partial budgeting, for example, compares net financial benefits across two or more crops or technologies given a set of expected or realized yields. Mathematical programming, which optimizes producer utility

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[9]Attention needs to be drawn to interpretation of these results. The comparison of yields under a drought scenario are based on yield histories for crops planted on soils for which they are best suited. Extrapolation of these results to other soil types alters yield expectations and would likely bias variance estimates. The direction of this bias is hypothesized in an earlier section. Moreover, whether farmers pursue such objectives as maximizing profits or achieving food security depends on levels of food stocks, total household production, wealth, nature of markets, and producer utility. The point of the analysis here is to demonstrate the importance of the trade offs between yields and risk which face subsistence farmers.

subject to a set of farm constraints, again frequently (not necessarily) ignores risk. The result is that highly profitable but risky activities in a risk free analysis appear more economically attractive than would be the case if higher cost due to risk were considered.

To evaluate the effect of risk on choice of production technology, a representative farm model was constructed for the Nedogo region, using mathematical programming. Linear programming was first used to simulate producer behavior based on the profit maximization paradigm and a constraint on minimum maize production. Later risk averse behavior is incorporated to evaluate its effect on cropping patterns. Details on the construction of this model, its assumptions and data utilized are available (Roth, forthcoming).

Briefly, the farm model permits cultivation with three types of tillage operation: manual, donkey, and oxen cultivation. Farmers possess four types of resources: land of various qualities, family labor, animal traction, and modern inputs. Land is disaggregated into five types including swampy land, high quality fields encircling the family compound, village fields, and higher and lower quality bush fields. The farm has a fixed endowment of the first four land types, but is assumed to have an unlimited quantity of lower quality busy land at its disposal. Stocks and flows of labor are disaggregated into weekly time periods to capture critical labor constraints at planting and first weeding. A constraint on minimum area of maize is included to ensure the family has sufficient grain for the hungry season.

Cropping activities included in the farm model were selected from cropping patterns observed on the Central Plateau. A summary of crop activities, land types, and yield levels under traditional management practices are given in Appendix 3.[10]

The attempt to model the cropping patterns of farmers on the Central Plateau was relatively successful. The results presented in Table 9 compare actual cropping patterns with those predicted by the model. The major differences are that more maize and peanuts enter solution under the assumption of profit maximization than is observed in practice. These relatively profitable crops forced some sorghum and millet out of production. In the model, maize replaced red sorghum on relatively high quality land while peanut plantings displaced millet on lower quality land.

A preliminary effort was made to incorporate risk averse behavior in the model. Our primary objective was to incorporate aversion to yield variability rather than price variability. For simplicity, an expected utility maximization problem is assumed. Yields per hectare are assumed to have a joint normal distribution and farmers utility is assumed to be

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[10]See M. Roth and J. Sanders, "An Economic Evaluation of Selected Agricultural Technologies With Implications for Development Strategies in Burkina-Faso," 1984, for an application of the model for evaluating existing and new technologies on the farm.

an exponential function of profits ($U(\pi)=-\exp[-a\pi]$). (The variance-covariance matrix and associated correlation matrix for Nedogo are presented in Tables 10 and 11, respectively). As shown by Freund (1956) this problem is equivalent to a quadratic program where the objective is the expected profits less a constant ("a" from the utility function) times the variance of profits. The constant "a" is frequently referred to as the "risk aversion coefficient."

For this analysis, several values of the risk aversion coefficient were considered. Table 12 displays the model's response for risk neutral producers and for two different levels of "a". These levels were chosen so as to "bracket" the observed cropping pattern as nearly as possible. The two crops which did not satisfy this condition were millet and peanuts.[11]

Maize, with higher expected yields, enters the solution on sorghum land in the risk neutral case. It is drawn back to compound land when risk is incorporated and is replaced by red sorghum which has a lower yield but also less risk. This behavior is consistent with the risk averse attitudes expressed by farmers on the Central Plateau. On the other hand, the model tends to overestimate the area planted in peanuts. This raises some questions regarding the quality of variance estimates for peanuts which are relatively low compared to other sources (SAFGRAD-FSU, 1983).

In the above application, incorporation of risk made only minor improvements in evaluation of farmers cropping behavior. The importance of risk depends on the level of expected yields among crops on a given land type for which the data here are sketchy. If, for instance, sorghum yields more than millet on the poorest quality land (rather than vice versa, Appendix 3) but is riskier, than incorporation of yield-risk trade offs is significantly more important. This is an area where more empirical work is needed. A more useful application would be in the evaluation of new technology where higher yields are often accompanied by increased financial and production risk. The results of the above analysis suggest this is one area where further risk modelling would be useful.

Further analyses are planned. These include: 1) the use of modified risk measures; 2) sensitivity analysis on risk measures and yields; 3) additional constraints on the use of land for peanuts and maize; and 4) attempts to determine the effects of changing yield variances as farmers shift crops from one land type to another.

CONCLUSIONS, IMPLICATIONS AND NEEDED RESEARCH

The objectives of this study were to evaluate the risk perceptions

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[11]The discrepancy for millet is negligible (less than 3%) but not for peanuts. The simulated cropping intensities for peanuts are more than double the observed levels.

and intraseasonal risk management practices of farmers in several areas of Burkina-Faso. A methodology was used which enabled collection of time series information on yields based on farmers recall of yield histories. The results of seven validity tests showed the data to be well behaved and generally consistent among farms.

The methodology appears to offer several advantages over traditional methods of data collection. One, time series information on yields at the village level are scarce, making studies of production dynamics of the household difficult. Two, collection of actual yield data are costly and time consuming. Three, institutional factors frequently constrain the time frame of research and the length of time series which can be developed. The above methodology provides a favorable alternative to these problems, but at a higher cost of inaccuracy. A potentially useful area of application is in 'rapid research appraisal' where researchers, at low costs can monitor technological adoption or evaluate benefits to a technology over time.

Analysis of the data supports farmers' claims that risk considerations play a role in intraseasonal decision-making. There is evidence that aversion to production risk prevents farmers from planting as much maize as they would if they were not risk averse. While these results support the hypothesis that risk aversion prevents farmers from planting higher-yielding crops, another explanation may lie in fundamental characteristics of the farmers' soil resources. An alternative cropping pattern may require putting crops on land for which they are fundamentally unsuited and which would lead to drastic reductions in yield levels and/or extreme increases in yield variability.

These findings show that, while production risk affects farmers' cropping patterns, these effects do not drive those patterns far from the profit maximizing cropping pattern for major cereals. This is not the case for maize. Accordingly, technologies designed to raise maize yields must consider the role of risk in farmers' cropping decisions much more than those designed for millet and sorghum.

Research is still needed to better understand the differences in land quality which lead farmers to refer to "millet land" and "sorghum land." Because the data reported here are drawn from yield histories on land that is presumably best suited to particular crops, there are no data on yield and yield variability when crops are planted on less suitable land. This research would be largely agronomic. In addition to providing insights with respect to the effects of such cropping changes and what farmers mean by risk, such research would add to knowledge about soil chemistry and permit more informed decisions with respect to technology design in this environment.

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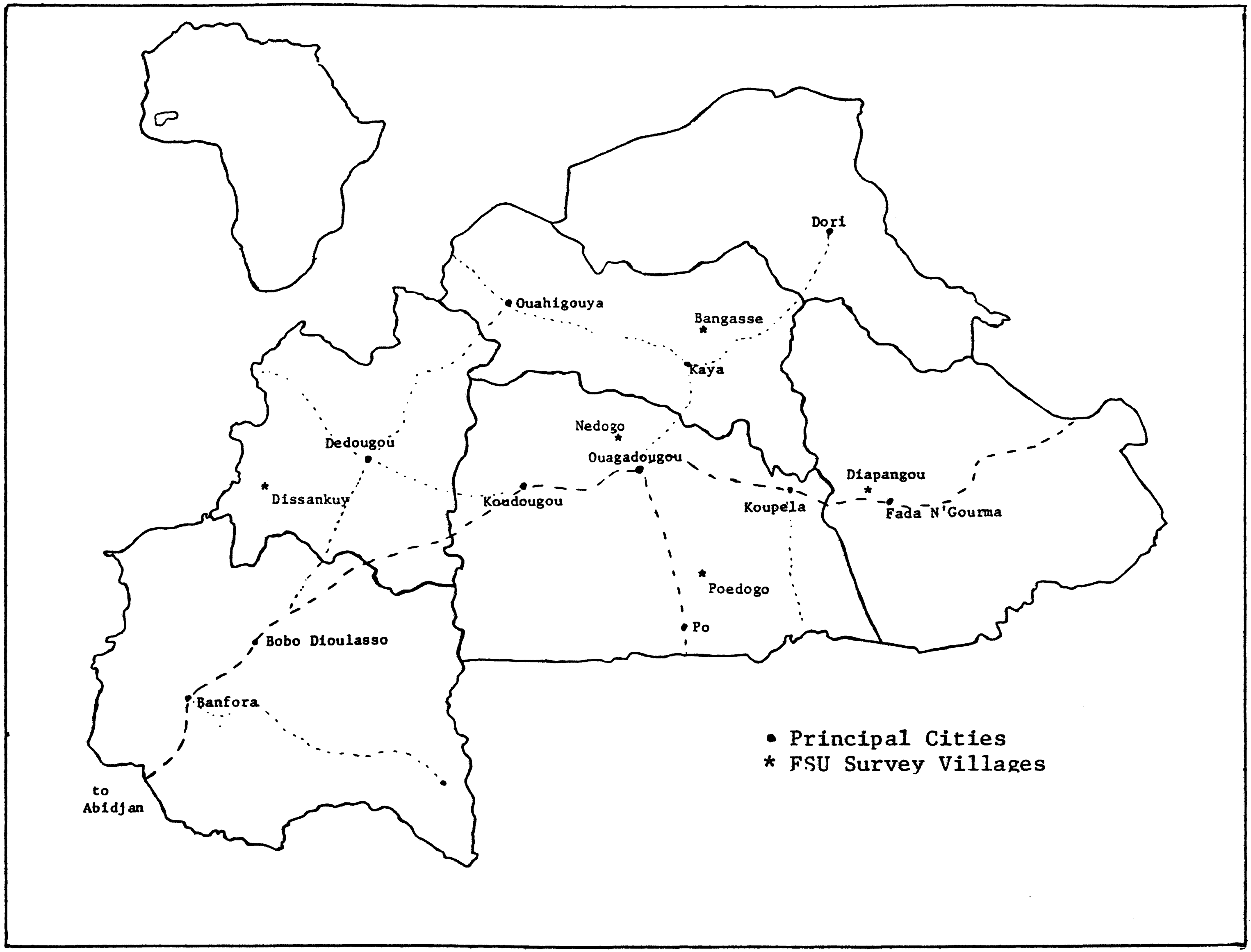

Figure 1: Map of Burkina Faso

Table 1. Area Cultivated and Cropping Patterns Per Farm in Five Villages, Burkina-Faso, 1983.

	------Central Plateau[a]----			Frontier Regions[b]	
	Bangasse (north)	Nedogo (central)	Poedogo (south)	Diapangou (east)	Dissankuy (west)
Total Area Cultivated(ha.)	6.55	6.67	3.77	7.12	5.51
Cropping Proportions(%)					
Millet	46.8	56.7	34.3	20.4	13.8
White Sorghum	39.9	21.2	13.8	3.5	48.3
Red Sorghum	--	10.1	38.8	--	--
Associations[c]	--	--	--	61.7	--
Maize	1.9	2.1	1.5	4.0	6.7
Rice	--	0.3	3.9	0.1	1.2
Peanuts	11.0	8.2	7.1	9.0	6.0
Bambara Nuts	--	1.3	--	0.2	2.5
Cotton	0.4	--	--	--	16.0
Soybeans	--	--	0.5	0.3	--
Cowpeas(sole crop)	--	--	--	0.3	--
Other(okra, roselle)	--	0.1	0.1	0.5	5.5
Total Cereal Crops	88.6	90.4	92.3	89.7	70.0
Total Cash Crops	11.4	9.5	7.6	9.8	24.5
Total Other	--	0.1	0.1	0.5	5.5

(a) The Central Plateau covers an area as much as 250 km wide extending from near the Ghanaian border in the South to the Sahel in the North. (b) The frontier regions refer to areas off the Central Plateau where soils are more productive and population pressures less severe. (c) The millet/sorghum association in Diapangou includes from 75 to 90% millet. The remainder is white sorghum.

Table 2. Average Yields (kilograms per hectare) and Measures of Yield Variability, by Village, Based on Subjective Recall and Objective Yield Measurements.

		Subjective Yields(a)				Objective Yields(b)
Village	Crop	Mean Yield	Std. Dev.	Coefficient of Variation	Sample Size	
Nedogo	Millet	389	176	45.2	240	342
	Cowpeas	27	21	77.4	230	
	White Sorghum	533	265	49.8	220	410
	Cowpeas	47	42	89.3	170	
	Red Sorghum	645	404	62.6	150	518
	Cowpeas	51	51	101.0	120	
	Peanuts	428	231	53.8	220	462
	Maize	1054	662	62.8	260	1040
Diapangou	Millet/Sorghum Association	572	227	39.5	270	384
	Cowpeas	76	73	95.7	240	
	Maize	2415	1105	45.8	290	1706
Dissankuy	White Sorghum	1036	291	28.1	170	617
	Maize	971	291	30.0	140	649
	Cotton	1290	259	20.1	80	

(a) Subjective yields are the product of farmer recall. Thirty (30) farmers in each village were asked to recall yields for a ten year period. Where n=240, ten yield observations were obtained from 24 farmers and six farmers were excluded because data were incomplete. Average yields reported here cover the entire ten year period. They include both temporal and interfarm variation.

(b) Objective yields were obtained by FSU through direct field measurement. Yields from Nedogo and Diapangou (1982) are reported by Jaeger (1983). Yields for Dissankuy are from 1983, an exceptionally dry year for the area.

Table 3. Yield Trends and Yield Growth Rates Based on Subjective Recall of Yields by Farmers in Burkina-Faso, 1973-82.

		Linear Time Trend[a]			Geometric[a] Rate of Growth	
		Y = A + B (yr)				
Village	Crop	A	B	F Sifnif.	Rate (r * 100)	Sample Size
Nedogo						
	Millet	627**	-3.06	.60	-.42	240
	Cowpeas	161**	-1.73*	14.2*	-6.47*	230
	W. Sorghum	1638**	-14.26**	5.34**	-2.11*	220
	Cowpeas	261**	-2.77**	6.28**	-6.45**	170
	R. Sorghum	1880**	-15.93	1.94	-1.92	150
	Cowpeas	240*	-2.44	2.28	-4.43	120
	Maize	4514**	-44.65**	10.11**	-3.47	260
	Peanuts	1813**	-17.86**	10.41**	-3.61**	220
Diapangou						
	Millet/ Sorghum Assoc.	532	0.52	0.01	0.57	270
	Cowpeas	240*	-2.10	1.63	.001	240
	Maize	255.0	27.87	1.52	1.99*	290
Dissankuy						
	W. Sorghum	1592**	-7.17	0.85	-0.80	170
	Maize	887	1.09	0.02	.003	140
	Cotton	241	13.54	1.82	1.00	80

(a) Two stars (**) indicate coefficients are significant at the .05 level. One star indicates significance at the .10 level.

(b) The geometric growth rate was calculated from the equation $Y = a(1+r)^t$. using the least squares method.

Table 4. Comparisons of Year to Year Changes in Yields Among Farms, Yield Recall Data, Selected Crops[a]

Village	Crop	Sample Size	Change	73 to 74	74 to 75	75 to 76	76 to 77	77 to 78	78 to 79	79 to 80	80 to 81	81 to 82
Nedogo	Millet	25	(+)	7	9	11	-	24	13	13	8	7
			(-)	16	12	14	24	-	9	10	16	15
	White Sorghum	22	(+)	6	5	7	3	21	5	14	9	12
			(-)	13	16	15	19	1	14	6	11	8
	Red Sorghum	15	(+)	3	7	1	1	15	7	6	5	5
			(-)	9	7	13	14	-	6	6	5	7
	Peanuts	23	(+)	8	7	12	4	21	9	12	12	11
			(-)	13	16	9	19	2	13	11	9	10
	Maize	26	(+)	4	4	9	1	24	17	13	7	16
			(-)	17	18	16	24	2	9	11	17	10
Diapangou	Millet/ Sorghum Association	27	(+)	7	15	10	8	10	14	12	14	7
			(-)	15	9	14	15	14	9	11	11	18
	Maize	29	(+)	6	17	10	7	15	7	16	14	11
			(-)	13	5	9	14	7	14	7	8	12
Dissankuy	White Sorghum	17	(+)	12	3	6	5	8	8	12	6	7
			(-)	3	13	7	10	9	7	4	9	7
	Maize	14	(+)	11	6	5	4	8	8	11	5	10
			(-)	3	6	8	9	6	3	3	9	3

[a]Responses are the number of farms whose yields increased (+) or decreased (-) from one year to the next. Their sum may not equal the sample size due to yields which remained unchanged.

Table 5. Comparison of Objective Cross-Sectional Yield Variation and Subjective Cross-Sectional Yield Variation, Selected Crops.

	Standard Deviation Based On	
Village/Crop	Farmers' Recall 1982	Objective Measurement 1982
Nedogo		
Millet	134	125
White Sorghum	212	287
Peanuts	190	325
Dissankuy		
White Sorghum	290	207*
Diapangou		
Millet/Sorghum**	190	
Millet		153
White Sorghum		229

* Measurements for Dissankuy are from 1983.

** The millet/sorghum association includes 75-90 percent millet. The remainder is white sorghum.

Table 6. Absolute and Relative Measures of Risk by Crop and Village Using Adjusted Recall Data.[a]

Crop	Diapangou		Dissankuy		Nedogo	
	Std. Deviation	CV	Std. Deviation	CV	Std. Deviation	CV
Millet (n)	123[b] (270)	21.5			106 (240)	27.2
W. Sorghum (n)			180 (170)	17.4	156 (240)	29.3
Peanuts (n)					153 (220)	35.7
R. Sorghum (n)					189 (150)	29.3
Maize (n)	710 (290)	29.4	134 (140)	13.8	421 (260)	39.9
Cotton (n)			132 (80)	10.2		

[a]Statistics are calculated from data adjusted for interfarm variation. Hence, the values are lower than those on Table 2 which include variation between households.

[b]Millet/Sorghum Association is 75-90% millet. The remainder is white sorghum.

Table 7. Effects of Yield Variability on Crop Yields Under a Bad Year Scenario

Crop	Mean Yields 1973-1982	Standard Deviations	Mean Yields Minus Two Std. Dev.	Expected Yield in 1985 (a)	Expected Yield Minus Two Std. Dev.
Nedogo					
Millet	389	106	177	367	155
White Sorghum	533	156	221	426	114
Red Sorghum	645	189	267	526	148
Maize	1054	421	212	719	-0-
Peanuts	428	153	122	295	-0-
Diapangou					
Millet/Sorghum Association	572	122	328	576	332
Maize	2415	710	995	2624	1204
Dissankuy					
White Sorghum	1036	180	676	983	623
Maize	971	134	703	980	712

(a) Expected yields for 1985 are calculated from trend equations on Table 3.

Table 8. Significance Levels of Paired t-Tests Comparing Coefficients of Variation for Major Crops, Subjective Recall Estimates for Nedogo, 1973-82.

	Millet	White Sorghum	Red Sorghum	Peanuts	Mean CV
Millet					27.8
(Farmers)					(24)
White Sorghum					28.8
Significance	0.307				
(Farmers)	21				(22)
Red Sorghum					29.2
Significance	0.287	0.141			
(Farmers)	15	12			(15)
Peanuts					36.7
Significance	0.004	0.042			
(Farmers)	22	19	*		(22)
Maize					38.7
Significance	0.001	0.001	0.009	0.076	
(Farmers)	24	21	14	22	(26)

*Insufficient data for computation.

Table 9. Demographic Characteristics, Area Cultivated, Land Use Patterns and Land-Labor Ratios Under Alternative Traction Scenarios, Central Mossi Plateau

(Per Farm Results)

	Representative Farm[a] Central Mossi Plateau			Jaeger-Nedogo[b] (1983)	
Variable	Hand Tillage	Donkey Tillage	Oxen Tillage	Hand Tillage	Donkey Tillage
Demographic Characteristics					
Residents	10.0	14.0	15.0	--	--
Active Workers	5.0	6.5	7.0	4.71	6.64
Total Area Cultivated (HA)	4.80	7.3	8.13	4.41	8.18
Cropping Proportions (%)					
Millet	65.6	68.9	68.1	62.0	63.0
White Sorghum	16.6	11.0	9.8	15.4	18.5
Red Sorghum	12.5	4.8	1.7	12.7	8.6
Maize	3.1	6.2	8.5	2.0	2.4
Peanuts	1.7	8.8	11.6	5.4	5.5
Bambara Nuts	--	--	--	1.8	1.2
Rice	0.5	0.3	0.3	0.5	0.1
Land-Labor Ratios:					
Area Cultivated/Worker	0.96	1.12	1.16	0.94	1.23
Area Cultivated/Resident	0.48	0.52	0.54		

[a]Representative Farm refers to a farming system which has been developed from farm data collected by ICRISAT, IRAT, Purdue SAFGRAD/FSU, etc. The information was incorporated in a mathematical farm model which produced the results shown here.

[b]Nedogo is a Purdue SAFGRAD survey village located about 30 kms from Ouagadougou on the Central Mossi plateau.

SOURCE: Roth and Sanders, "An Economic Evaluation of Selected Agricultural Technologies With Implications for Development Strategies in Burkina-Faso", 1984, p.16.

Table 10. Variance-Covariance Matrix for Yields, Based on Subjective Recall Estimates, Nedogo, 1973-82.[a]

	White Sorghum	Red Sorghum	Millet	Maize	Peanuts	Cowpeas	Rice
White Sorghum	24,438						
Red Sorghum	19,781	35,713					
Millet	7,794	8,671	11,214				
Maize	33,991	38,669	18,376	177,450			
Peanuts	10,440	14,025	6,700	26,199	23,495		
Cowpeas	1,764	1,660	1,083	4,793	1,389	433	
Rice	12,179	16,949	13,679	43,229	13,808	4,137	54,556

[a]Those estimates are derived from the correlation matrix in Table 11 and variance estimates in Table 6.

Table 11. Correlation Matrix for Yield Estimates Based Upon Subjective Yield Recall, Nedogo, 1973-82.[a]

	White Sorghum	Red Sorghum	Millet	Maize	Peanuts	Cowpeas	Rice
White Sorghum	1,000						
n	220						
p	0.001						
Red Sorghum	0.6476	1.0000					
n	120	150					
p	0.001	0.001					
Millet	0.4779	0.4407	1.0000				
n	200	150	240				
p	0.006	0.001	0.001				
Maize	0.5322	0.4507	0.4175	1.000			
n	220	150	240	240			
p	0.001	0.001	0.001	0.001			
Peanuts	0.4177	0.4692	0.4131	0.3916	1.0000		
n	180	120	200	220	220		
p	0.001	0.001	0.001	0.002	0.001		
Cowpeas	0.5497	0.3824	0.5160	0.6155	0.4400	1.0000	
n	170	80	150	170	140	170	
p	0.001	0.208	0.085	0.001	0.001	0.001	
Rice	0.4344	0.5307	0.5565	0.3358	0.3646	0.6291	1.0000
n	30	30	30	30	20	10	30
p	0.084	0.063	0.003	0.004	0.092	0.026	0.001

[a]These estimates are based on yield recall data adjusted for inter-farm variation (see Table 6).

Table 12. Cropping Patterns Under Observed, Risk Neutral and Risk-Aversion Assumptions, Donkey Traction Solution, Nedogo.

(Percent)

	----------------Profit Maximization Assumed-----------			
Crop	Observed[a] Cropping Pattern	Risk[b] Neutral Pattern	Risk Aversion Coefficient ($.10 \times 10^{-10}$)	Risk Aversion Coefficient ($.90 \times 10^{-10}$)
Millet	(63.0)	(68.9)	(64.6)	(64.9)
White Sorghum	(18.5)	(11.0)	(11.3)	(19.2)
Red Sorghum	(8.6)	(4.8)	(8.5)	(0.3)
Maize	(2.4)	(6.2)	(2.8)	(1.9)
Peanuts	(5.5)	(8.8)	(12.5)	(13.5)
Rice	(0.1	(0.3)	(0.4)	(0.3)
Total Hectares	8.18	7.30	7.07	7.28

[a]Cropping percentages are taken from Jaeger (1983).

[b]Cropping percentages are taken from Table 8 for the donkey traction solution. A representative farm linear programming model was used to generate the results.

Appendix 1. Change in Average Yields for Various Crops Over Time Calculated From Farmers Subjective Recall of Yields, Three Villages, 1973-1982[1]

	Nedogo					Diapangou		Dissankuy		
	Millet	White Sorghum	Red Sorghum	Maize	Peanuts	Millet/ Sorghum	Maize	White Sorghum	Maize	Cotton
1982	371.3	505.7	595.3	1014.4	388.5	559.8	2655.6	1011.4	1015.4	1315.6
1981	406.1	485.5	633.8	929.7	387.9	630.1	2654.2	1068.4	932.7	1317.0
1980	429.8	556.4	676.6	1113.1	420.6	579.9	2429.1	1060.1	1034.9	1392.4
1979	417.4	548.3	674.6	1063.1	404.8	569.4	2287.8	958.9	971.5	1329.6
1978	393.5	554.1	637.2	962.5	423.6	543.0	2392.4	972.6	896.0	1312.5
1977	205.6	275.0	315.1	393.0	223.7	517.5	2231.3	988.2	929.6	1240.3
1976	383.8	515.3	582.9	1015.3	443.9	565.0	2351.2	1037.8	974.4	1216.5
1975	388.3	550.6	778.1	1106.2	464.3	585.8	2479.1	1078.0	997.8	1322.0
1974	438.6	654.5	738.8	1345.9	560.9	558.7	2198.9	1122.9	1011.1	1242.1
1973	457.3	680.9	815.7	1592.3	566.4	606.9	2467.9	1062.5	950.4	1210.5
x	389.2	532.6	644.8	1053.6	428.4	571.6	2414.7	1036.1	971.4	1289.9
n	24	22	15	26	22	27	29	17	14	8

[1]Average yields reported for each crop were calculated only for those farms reporting a complete history of yield information. Some farms in a village sample cultivated a crop only periodically; others not at all. Hence n=24 says that 24 farms could recall a complete history of yield information.

Appendix 2: Validation of Farmer Recall Data Using Independent Observations of Good-Bad Year Scenarios.

		Best Years[b]			Worst Years[b]		
	n[a]	Best Year	Second Best	%	Worst Year	Second Worst	%
Nedogo							
Millet	24	1973(8)	1974(2)	42	1977(22)	1982(1)	96
White Sorghum	22	1973(7)	1974(2)	41	1977(18)	1981(0)	82
Red Sorghum	15	1973(3)	1975(3)	40	1977(13)	1976(1)	93
Maize	26	1973(10)	1974(6)	62	1977(23)	1981(1)	92
Peanuts	22	1973(7)	1974(6)	59	1977(18)	1981(0)	82
Diapangou							
Millet/Sorghum	27	1981(6)	1973(3)	33	1977(6)	1978(3)	33
Maize	29	1982(13)	1981(7)	69	c/	c/	
Dissankuy							
White Sorghum	17	1974(9)	1975(2)	65	1979(2)	1978(1)	18
Maize	14	1980(7)	1982(1)	57	c/	c/	
Cotton	8	1980(4)	1979(1)	63	c/	c/	

[a]Number of farms with a complete 10 year yield history for which statistics were computed.

[b]Best years correspond to the first and second highest yields taken from annual averages computed in Appendix 1. Worst years correspond to the first and second worst years of production. Figures in parenthesis are the number of farmers who in an independent survey recalled the respective year as being the best or worst accordingly. Percentages are the proportion of farmers whose recollection of best and worst years allign with best and worst years computed from yield histories.

[c]Incomplete information is available on farmers' independent recall of good or bad years.

Appendix 3. Yield Levels for Sole Crops and Crop Mixtures by Type of Land and Traction Technology Assumed for the Central Plateau Representative Farm

Type of Land	Crop Mixture	Hand Tillage
Swamp Land	Rice	850
Compound Land	R. Sorghum	850
	W. Sorghum	770
	R. Sorghum/W. Sorghum	638/185
	Maize	1000
Red Sorghum Land	R. Sorghum	640
	R. Sorghum/Cowpeas	640/55
	W. Sorghum	590
	W. Sorghum/Cowpeas	590/55
	Maize	625
White Sorghum Land	R. Sorghum	430
	R. Sorghum/Cowpeas	430/45
	W. Sorghum	450
	W. Sorghum/Cowpeas	450/45
	Millet	420
	Millet/Cowpeas	420/45
	W. Sorghum/R. Sorghum	340/105
	Millet/W. Sorghum	315/115
	Maize	350
	Peanuts	520
Millet Land	W. Sorghum	310
	W. Sorghum/Cowpeas	310/35
	Millet	340
	Millet/Cowpeas	340/35
	Millet/W. Sorghum	255/78
	Peanuts	480

INLAND FISHERIES IN DEVELOPING COUNTRIES: AN OPPORTUNITY FOR A FARMING SYSTEMS APPROACH TO RESEARCH AND MANAGEMENT

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INTRODUCTION

In spite of decades of overall fisheries development and national economic growth, most small-scale fishermen in developing countries still live at or below poverty level (Smith, 1979; Panayotou, 1980.). Development efforts have focused almost exclusively on large-scale marine fisheries or aquaculture because many projects are commodity specific. Small-scale fishermen operating in the inland and coastal lagoon fisheries have not received the attention needed from scientists and government planners to improve their socioeconomic conditions. The present condition of most fisheries is deteriorating because of over exploitation. Appropriate management strategies need to be identified that will protect the viability of these biological systems, as well as improve the well-being of the fishing communities.

The efficiency of many conventional management approaches has been seriously questioned in recent years, as most have failed to achieve their objectives. This paper attempts to explore a possible application of farming system research (FSR) to fisheries development. As indicated by Gilbert, Norman and Winch (1980) there is little activity concerned with agricultural and rural development which cannot claim some relationship with FSR, however tenuous. FSR can be broadly defined as any research that treats the farm or the household unit in a holistic manner (1980). This paper sets out a methodology to expand the concept of FSR to apply to artisinal fisheries for riverine systems.

IMPORTANCE OF INLAND FISHERIES AS A SOURCE OF FOOD AND INCOME

Focus on fisheries management is increasing primarily because riverine fisheries represents an important source of animal protein for many nations of the Third World. A riverine fishery refers to the capture of various fish species from rivers for subsistence and commercial purposes (Scudder et al., 1984). In areas of the world that would otherwise suffer from food deficiencies, riverine fisheries constitute a main source for high quality protein. Subsistence fishing from rivers provides an important part of the animal protein requirement in the diet of rural populations in West Africa, East Africa and the Amazon Basin in particular (Emmerson, 1980).

According to FAO, millions of individuals living in developing countries depend upon inland fisheries as a source of food. Fish captured from inland waters represented over 10% of the 72 million metric tons (mt) of the world's marine and freshwater fish harvest in 1980 (Scudder and Conelly, 1984). Inland fisheries provide up to 35% of the total national harvest of fish in many developing nations, particularly those in West and Central Africa, South Asia, the Amazon, and parts of Southeast Asia during this period (Scudder and Conelly, 1984). Production from rivers and lakes in Africa was estimated at 0.7 million tons of fish in 1975 (Welcome, 1979). Inland fisheries provide over 50% of the total animal protein consumed by the people of many landlocked countries. Such is the case of Zambia where, in the later 1970's, annual fish production was estimated at approximately 50,000 mt, as opposed to 21,000 mt of poultry, 16,000 mt of beef, and 3,000 mt of pork (Armstrong, 1978 as quoted by Hayward, 1981b; Scudder, 1984).

In another example, the inland delta of the Niger River plays a significant role in the economy of Mali. Among the agricultural export commodities, fish is ranked fourth after livestock, cotton, and peanuts. Over 80,000 traditional fishermen living in the inland delta of the Niger River depend on fishing as a source of food and income. Total annual harvest is estimated to be approximately 120,000 tons under normal annual rainfall and floods (Operation Peche Report, 1973, Sissoko, 1974).

In the Republic of Niger, approximately 11,900 fishermen were involved in traditional fishing (Burtonboy, 1982). Total annual catch was estimated to be 9,696 mt (FAO, 1971). Unlike in Mali, large numbers of fishermen in Niger are from neighboring countries which makes the problem of management more difficult. Transitory fishermen do not readily adhere to national boundaries and it is difficult to assess their impact on the resource.

The contribution of riverine fisheries in Brazil and India are also quite significant. In the early 1970's, India produced, annually, 2.0 million mt of fish, of which 0.75 mt were from inland waters, with about one-half coming from aquaculture and the rest from the country's extensive river system (Jhingran and Tripathi, 1977, as reported by Scudder and Conelly, 1984).

Inland fisheries are an important source of employment for large segments of populations living in the developing areas of the world. In many countries, fisheries help prevent outmigration to the cities or other economic sectors for jobs. Scudder and Conelly (1984) pointed out that the economic role of traditional fisheries in providing employment opportunities on both a full and part-time basis is often underestimated. Fisheries represent an important mechanism for supporting those who live at the very low income levels, while allowing some people to progress into more lucrative activities. In Zambia, riverine and lacustrine fisheries are reported to function as an important "safety valve" because they have the capacity to absorb the unemployed living in rural and urban areas.

Finally, inland fisheries provide a process in which women play an active role. The transition of most fisheries from a subsistence operation to a more commercialized type has resulted in greater involvement of women in fish processing and marketing. In Mali and Niger, men harvest the fish while women do the processing and marketing of it.

ALTERNATIVE APPROACHES TO FISHERY MANAGEMENT

Fisheries management involves direct and indirect measures for controlling the fishery resource and the fishermen (Panayotou, 1982). Direct management measures include: gear control, catch quotas, limited entry, and site and season restrictions. Indirect measures consist of induced social and planned environmental changes. The traditional analytical concept for the application of biological management objectives is termed the Maximum Sustained Yield (MSY) approach. In fisheries managed under a MSY policy, the objective is to produce the maximum harvest possible on a sustainable basis. Recommendations are based on mathematical relationships which deal with the levels of fishing effort and harvest and with the population dynamics of the fish species involved, without regard to external factors, e.g., environment. The population dynamic models (Beverton and Holt, 1957; Ricker, 1948) are single-species in nature with large data requirements and, in general, are not suited to the assessment of inland, multi-species fisheries, particularly where environmental variability is high.

Of the MSY models available, only the Graham-Schaefer surplus yield model (Graham, 1935; Schaefer, 1957), an application which is based on a time series of fishing effort and harvest data, is general enough to apply to multi-species situations (Turner, 1978; Malvestuto et al., 1980). In the multi-species situation, the surplus yield model can predict MSY, and the associated level of fishing effort, for the entire fishery by considering all the species under exploitation as a single unit. The conventional management measures associated with MSY objectives attempt to protect the fishery resource with the assumption that this will improve the well being of fishermen.

The well being of fishermen is considered more directly in the Maximum Economic Yield (MEY) approach. MEY is a profit maximizing objective in which the focus centers on the costs and returns from fishing rather than on the biological capacity of the fish stock to provide harvest. Under a MEY policy, the fishery is allowed to expand until the difference between the total revenue and the total cost of fishing is maximized. Thus, under MEY, net economic benefit to society is maximized which makes this policy more appropriate than MSY from the standpoint of society. However, Panayotou (FAO, 1982) pointed out that MEY is not tenable in an open-access fishery because the absence of property rights over the resource encourages existing fishermen to intensify their effort and expand in number until no profit exists. Unless measures are taken to adjust the level of fishing effort, the open-access fishery becomes overexploited in the long run. Quantitative relations between MSY and MEY are shown graphically in Figure 1 (Stevenson, Pollnac and Logan: 1982). With either model, realization of the maximum is dependent on being able to control the level of fishing effort. In many instances, controlling fishing effort can be too difficult and too expensive to achieve, as when population density is high and/or fishing effort is spatially dispersed, or sporadic (FAO, 1979).

The Optimum Sustained Yield (OSY) approach endeavours to incorporate biological, economical, and sociological objectives into the assessment and management of fishery resources. In Third World countries, management inputs may be technically and economically viable while resulting in social failure (Sullivan, et al., 1983); OSY addresses the inadequacies of MSY and MEY by meeting the sociocultural needs of the fishermen and their communities. The policy objective of OSY is certainly the most justifiable with reference to fishery development programs where "fishery development" can be broadly defined as the pursuit of socioeconomic objectives through assistance programs (FAO, 1982). The goal of both fishery management and development is to optimize the use of the fishery resource at the individual and community level. According to Panayotou (FAO, 1982), some studies argue that, in areas where hunger is the predominant factor, MSY may be a justifiable objective because there is an expensive surplus of labor with a marginal factor cost equal to zero. The surplus labor can be used for the harvest for subsistence. However, the labor might be more effectively diverted to some other food production activity; and, in any case (MSY or MEY), objectives likely will not be met if the required inputs are not culturally compatible therefore, OSY is the most relevant approach. The problem with the application of OSY policy is that there is no appropriate model for attainment of OSY, i.e., there is no method associated with this fishery management philosophy.

As the following sections suggest, the development of Farming Systems Research and Extension (FSR/E) together with recent emphasis on the functioning of localized, traditional fishery management systems (Scudder and Conelly, 1984), may provide an appropriate model for attaining OSY. FSR/E represents a methodology that can allow for fishermen participation in the design of viable management plans that place the goals of the participants as the highest priority.

THE FARMING SYSTEMS RESEARCH APPROACH TO FISHERIES MANAGEMENT

FSR/E is a systematic approach that views the farmers and their problems in a comprehensive manner and recognizes the interdependencies and interrrelationships between the natural and the human environments (Gilbert, Norman, and Winch, 1980). The primary objective of FSR/E is to improve the welfare of individual farm families by increasing the effectiveness of the farming system in utilizing the limited resources within the context of the entire range of private and societal goals (Shaner et al., 1981; Monu, 1983).

In most developing countries, fishery regulations are designed and enforced by the ministries of agriculture which often give priority to large commercial farming and livestock management programs. Traditional fishermen, lacking political support, are often not well represented at the national level. Consequently, it is not surprising that research on fisheries has been minimal because the fishing communities seldom benefit from public investment. Such failure to include the traditional fishermen in the development process of rural communities around the Third World justifies the necessity to adopt a more wholistic approach such as FSR/E which provides solutions to problems concerning each particular rural activity regardless of its economic importance and political linkage at the national level.

The relation between existing fisheries research institutions and fishing communities is almost insignificant, generally characterized by the traditional top-down relationship which treats fishermen as passive receivers. As indicated by Scudder and Conelly (1984), government institutions continue to stress direct and indirect regulatory measures which reduce the economic efficiency of the fisheries resources. Generally, the enforcement of these regulatory techniques is inefficient and economically irrational as indicated by many studies done in various countries in Africa, Asia, and Latin America. In addition, fisheries personnel are often used to enforce these measures as well as to execute extension programs. This double role has a negative impact on research and extension. Scudder and Conelly (1984) advocate a new approach to management of riverine fisheries which encourages the local community's involvement toward increasing production and raising its living standards. FSR/E provides a solid scientific basis for two-way communication between research institutions and fishermen. The farming systems approach is recognized for providing solutions in the best interest of both private individuals and society, given the conditions of existing resources and constraints.

One important characteristic of inland fisheries is the wide range of factors which affect biological and socioeconomic conditions. Both fish resources and human activities are regulated by seasonal variations in the hydrological cycle of the river. Fishing is an economic activity of the households to meet their requirements in terms of food consumption and income earnings. However, traditional fishing techniques and management must be performed within the limits of the customs inherent to a fishing community. FSR/E has a holistic approach that takes into account fishermen as part of the process; and their knowledge and beliefs are considered as a starting point for basic experimentation that would lead to an improvement of the existing system.

The transition of traditional fisheries from subsistence levels to more commercialized enterprises has resulted in greater division of labor at the household as well as at the community level. Thus, while men specialize in production most women specialize in fish processing and marketing. Other job opportunities include: marketing fishing equipment, equipment repair and transportation. This further specialization has created new problems associated with the distribution, stockage, and transportation of fish. Besides fishing, most households practice agriculture, gardening, livestock rearing, and trading for the purpose of increasing their incomes. The holistic approach of FSR/E provides the research tools for each individual activity, or subsystem, to be viewed in relation to the others.

The use of modern fishing equipment, especially nylon gill and seine nets, has rapidly expanded in many traditional fisheries over the last 30 years. Generally, the new technology was introduced by individual fishermen seeking to increase their harvest efficiency. The fisheries institutions did not play any active role in providing useful information about the types of technology that would be compatible with the productive capacity of the fisheries resources. It is thought that the rapid over exploitation of many traditional fisheries is linked to the introduction of some sophisticated technologies. FSR/E is a good tool for generating new technologies appropriate to fishermen (Byerlee, 1982; Harrington and Winkelman, 1982). Hildebrand (1982) also advocates the necessity for combining FSR/E to achieve such goals.

A CONCEPTUAL MODEL OF A RIVERINE SYSTEM

A river system encompasses many diverse economic and human activities. The key to understanding and managing the system requires knowing how these activities impact on the resource. A further need is to document how outputs from the resource affect the users both materially and in their social relationships with others. It is also important to understand how social organizations and human processes are intertwined with daily fishing activities.

A conceptual model of how the Niger River production and marketing system operates is presented in Figures 2 and 3 (Sullivan et al., 1982). The flow chart illustrates key components of the system and how the system is conceived to operate. The use of a flow chart assists in formulating *a priori* hypotheses about how the system functions for later testing through various scientific methods. The flow chart concept can be particularly useful to researchers and extension workers using FSR/E. With these flow charts, several components of the system can be described individually based on their contribution to the functioning of the system. Key parameters can be identified that need recognition, especially any feedback linkages between components of the system.

The Biological Component

A traditional fishery approach places enormous importance on baseline fish stock assessment including species composition and length frequencies of the fish stocks which document the physical relationships of the fisheries. Catch assessment surveys have traditionally examined catch, effort, and catch per unit of effort in an attempt to quantify MSY. This approach assumes that the productivity of the fishery resource is a function totally of the system. Over exploitation is depicted when increased effort results in decreased catches relative to the productivity of the system. The key variables affecting fishing effort are equipment, capital, and labor and government regulations (Figure 2). The volume of catch has a feedback influence on the stock of fish available for harvest. If the volume of fish caught is too large or of the wrong size, age, or sex category, then the population dynamics could be adversely affected.

The productivity of the river resource for the fish stocks can also be impaired by cropping and livestock systems. Siltation and pesticides in the river from improper cropping practices, especially on fragile and marginal lands, results in low productivity of the resource. Along the Niger River, intensive agriculture (e.g., rice) and irrigation projects are presenting critical problems for maintaining the productive level of the resource. These are key auxiliary variables which need to be evaluated. The FSR/E methodology can be useful in determining detrimental upland agricultural practices and methods for developing technical packages for reducing siltation rates and chemical contamination of the river system.

The Economic Component

Fishing effort on the resource is the major determinant for the volume of catch and productivity of the resource. The fishing effort is a rate variable that can change based on factors influencing effort (connecting dotted lines). Labor allocated to fishing will be a function of what the fishing activity is in the package of all activities done by the individual. Cropping and livestock activities also have an important role to play on the seasonal supply of labor for fishing because of hydrological phases of the river as well as traditional patterns of labor utilization, for example, urban migration patterns.

A unique situation exists on the Niger River system because large numbers of fishermen originate from neighboring countries. The fishing effort expended on the resource is influenced by both local and expatriate fishermen. The local fishermen tend to more subsistence oriented while exploitation of the resource by expatriates requires consideration of the political economy of the region.

Fishing equipment is important to the individual's successful exploitation on the fish stocks. The current stock of investment (both numbers and values) of fishing equipment held by fishermen is important, as well as the rate of change in the growth of the stock of equipment. Fishermen's criteria for investment in fishing is critical to how rapidly exploitation will occur. In the aggregate, an uncontrolled high capitalization rate can be a significant factor in the productivity of the resource, because it can lead to even greater exploitation of the resource (O'Rourke). Age and depreciation rates for equipment and boats is important information to determine replacement rates by fishermen.

The Household Component

The local fishermen are part of elaborate family and village networks that influence how demands for fish are established. Fish have multiple end-uses, and the size and specie of fish caught will determine utilization of the fish.

Household demand for fish will normally be based on nutritional and income requirements that have to be met. Seasonal food requirements will vary because of the influence of climatic conditions on food and cash crops, livestock and fish harvests. The requirements for fish in the diet can be greater during high risk periods of the year (e.g., just before harvest when food stocks are low). Risk levels of fishermen can be measured to indicate how readily a person will deviate from accepted practices.

Household requirements could also encompass social formalities that require an understanding of intra-family and inter-household exchange of food and gifts. Social obligations can be a high priority in how the fishing resource is exploited. These formalities can be significant in how economic values are placed on types of species being caught and their dispositions. These household variables are important in their influence on the Optimum Social Yield (OSY). Subsistence levels of fishermen will determine demand for preferred sizes of fish. Consumption requirements of households and the preference for the size of specie are important factors to know.

The Market Component

The external markets away from the river constitute the commercial aspects of exploitation as well as disposal of fish products. The market values communicated through the pricing mechanism is a significant factor in determining which fish are marketed and in what form (Sullivan and Hunt, 1984). Season of the year and the location where fish are caught influence the form in which fish will be sold.

Two examples are provided from data from Niger on how season of the year affects forms of fish marketed. The major forms of fish are sold in either fresh or processed (e.g., smoked or dried) form. Market data for Niamey, the largest city on the river as well as in Niger, are presented in Figure 4. The vertical lines on the graph demarcate the hydrological periods of the river: March-April--falling water; May-July--low water; August-September--rising water; and October-February--high water levels. (The data are more important for their indication of relative changes rather than actual numbers.) The quantity of fresh fish is highest in the middle of the high water period of January and steadily falls to the lowest levels from May to October. Processed fish marketed is greatest during periods of falling fresh fish supplies. Large supplies of fresh fish are processed during the peak harvest periods for sales later in the year. The volume of fresh fish far exceeds the amount of processed fish marketed in Niamey. Fish from all segments on the river are marketed in Niamey.

Data is presented for an up river market, Ayouru, which is near the Mali border (Figure 5). The market data indicates a reversal in the pattern of fish marketed from that in Niamey. More processed fish was recorded in the market than fresh fish. Limited consumer demand and the lack of refrigeration makes processed fish more prevalent in the remote markets. Ayouru is also a primary market so that fish are sold again in Niamey. The peak of the processed fish sales are in June which is after processed fish sales in Niamey have begun to decline. Interregional trade between these river markets is extensive.

Management of the resource will depend on how great the market pressures are to exploit the resource (e.g. effective aggregate demand). This can be impacted indirectly through the changes in consumers' income, price levels for fish and competing products, income of consumers and their taste and preferences. It is a complex set of relationships, but these relationships can be measured with proper economic analysis of consumer preferences and demand elasticities.

Large amounts of wastage and inefficiencies are identified in this component of the marketing system (Figure 3). Lack of technology and proper facilities can result in higher prices and less usable products than if certain conditions were changed. Any excessive marketing costs will result in lower prices to producers and higher prices to consumers. Food technology measures on degree of spoilage is possible. Fish products are also changed into different forms based on changing market conditions (Street and Sullivan, 1985).

The government, through its policies and regulations, can impact directly on the performance of the marketing system. Regulations create impressions and uncertainties that impact on all participants using the resource. These regulations emit certain responses from fishermen, as well as, from market agents that ultimately cause the system to change.

Feedback Mechanisms

Viable management plans for utilization of the fishery resource need to encompass all the above components to make them viable. The components embody human processes which impact on decisions being formulated and executed whether in fishing, processing, marketing, or consuming. Changes taking place in one component, e.g. household economy, can influence how fishermen will exploit the resource. A fishermen's mesh size of net could vary based on season of the year because of changes in food supplies. If staple foods are not available, greater fishing intensity can take place.

The evaluation of management impacts on the participants can best be achieved by involving the participants to determine all aspects for maximum benefits from the resource. Any changes need to be forthcoming from the existing system that is functioning. It is hypothesized that the FSR/E approach can best fulfill the requirement that participants have major responsibilities in designing and implementing viable management plans.

THE CASE OF MALI'S RIVER FISHERIES

Another example of a unique production system is in the inland delta of the Niger River in Mali, a neighboring country to Niger which shares the Niger River system. The Malian example clearly demonstrates how the FSR/E approach is appropriate given an established traditional management system currently in operation.

The Malian economy depends largely on agriculture, livestock, and fishing which provide a source of employment for almost 90% of the total population. Fishing represents an estimated 3% of the Gross National Product. In 1972, the Ministry of Agriculture estimated the total value of fish captured at U.S. $10 million at the production level and U.S. $17.5 million at the consumption level. Ranked fourth after cotton, livestock and peanuts, fish products accounted for 8% of the total volume of exports (Ministry of Agriculture, Mali, 1973; Sissoko, 1974). A 1973-74 census estimated 80,000 fishermen exploiting the resources of the Inland Delta and the Lake Region for food and income.

Fishing Groups of the Inland Delta

The fishing population in Mali consists essentially of three important groups: Bozo, Somono, and Sorko. The Bozo are a fishing tribe by tradition while the Somono come from various ethnic groups practicing fishing as a profession. These two groups are mostly concentrated in the southern and central section of the Delta and have many sociocultural similarities which resulted from their marital interrelationships and their acceptance of a similar culture and religion. Thus, they live in the same villages, use the same fishing and management techniques, and exploit the same fishing zones under the same traditional regulations.

The Sorko is another fishing group that lives predominantly in the northern and northeastern part of the Delta. Like the Somono, they come mostly from the northern ethnic groups such as the Sonrai and the Djerma. Unlike the Somono and the Bozo, they are less skilled and wealthy, and use inexpensive equipments. The Mali census also indicated the existence of some Houssa fishermen from Nigeria who move upstream each year to exploit this part of the Delta. Like the Somono, the Houssa are very skilled fishermen, and they possess a high level of capital equipment (Sissoko, 1974).

Mobility of the Fishermen

Mobility is an important characteristic of fishing activities dictated by the hydrological pattern of the Niger River (Sissoko, 1974). Fishermen move downstream at a particular time of the year which is a traditional custom of some socioeconomic significance. The main purpose is to increase household production. Each year, after households have partially exploited their fishery resources, each household subdivides into two fishing groups. First, the young and very active fishermen form fishing groups of relatives, friends, or neighbors, along with their wives and children. They conduct six month fishing trips and move along the river, setting up nomadic camps. Permission to fish in these other waters is required from the local authorities in each case.

The fishing trips end when the rising water period begins and the boats are full of dried and smoked fish. On their way back, stops are made at large distribution centers such as Mopti, Diafarabe, Dioro, and Segou, where products are sold. Some fish are kept for their own household consumption during the period of scarcity.

The other group of fishermen, who remained in the village, takes an active part in the exploitation of the reserve zones near the village during their open fishing season. This part of the household is generally composed of adults and older people unable to travel long distances.

Different Types of Property Rights in the Fishing Zones

Most fishing communities located along the river control the fishing zones adjacent to them (Sissoko, 1974). The history of ownership in the Delta area can be defined as: "first in time and space, first in right." The first person to settle on the bank of the river sets the limits of a given segment of the river which gives that person the privilege to control and exploit. Later settlers were required to follow the rules and regulations set by the "waterlord" over the protection, management, and exploitation of the resources. With the increase in the number of new settlers, most fishing zones became properties of the entire community (common properties). Often, the first settlers who own or control the fishing zones may live in the upland section, practicing agriculture, while the fishing village which settled later on the river bank exploit the river resources. Whether the waterlord is a fisherman or not, there is a tacit agreement between the waterlord and the users about how to protect, manage, exploit, and share the resources. Although the fishing zones are regarded as common properties in the sense that they are opened to any member of the community, they are restricted from use by outside fishermen.

Despite present legislation, which declares the river a public property, the Malian Government recognizes the right of the fishing communities along the river to protect, manage, and exploit the resources adjacent to them according to their customs and traditions. Nevertheless, the Government encourages the fishing communities to exploit their fishing zones in mutual harmony. This recommendation is not new to the fishing communities; and over the years, a sense of mutual interest has developed based on the necessity to protect their resources from over exploitation. The Government did not attempt to change the existing rules; rather, use them as a benchmark for fisheries management.

The Reserve Zones

A census was conducted in 1973 of some of the reserve zones about the number of reserves/sectors/subsectors, and their periods of closing and opening, surface areas, and predominant species. The total number of reserves was 219 which represent an estimated surface area of 10,000 hectares (Ministry of Agriculture of Mali, 1975).

Historically, as settlements became larger, the need for organizational and managerial structures became vital for the protection of the community interest. Thus, most villages of the southern and central section of the Delta, inhabited by Bozo and Somono, developed traditional management structures which regulated the use of their resources. They divided their adjacent waters into several "bamo", or fishing zones based on certain characteristics such as the predominance of a particular species (Figure 6). Each bamo was given a name and a specific date or period of closure and opening. Some bamoes were left permanently opened as a source for the community's daily consumption. Flexibility was given as to when to close or open a bamo and how long the reservation would last in case of an unusual situation. In years of low water levels, most bamoes are put in reserve earlier and stay in longer than usual to give the fish stock the necessary time to grow.

The organizational structure for overseeing the management of the reserves is composed of the chief, the spiritual leader and the council. Their role is to: (a) decide which fishing zone will be in reservation; (b) fix the closing and opening date of the reserve zones; (c) provide an effective protection of the resources; and (d) estimate the part of the production that should go to the community for public purposes. In some fishing villages, where most of the inhabitants are relatives, a part of their production from the reserves is sold and the money is used to pay the taxes of the entire community. The spiritual leader is in charge of protecting the resources against magical forces internal or external to the community which attempt to divert the resources away from the fishing zones.

Generally, the reserves are protected by a community watch program; however, there are many cases in which the council selects some of its members as guardians of the reserves. It is in the tradition of the community to respect the rules, and violating them is regarded as a crime and an act of dishonor. Any member of the community, or any outsider who trespasses a reserve zone, is subjected to the payment of a certain fine, usually twice as much as the damage. Repeated crimes by the same individual are reported to the police.

Despite these traditional laws, no fishing village charges exploitation fees to the members of other fishing communities except in a few cases. These rules are intended to protect and to control the resources, and to give local fishermen more privilege than foreign fishermen because each fishing village wants to maximize its production and to minimize the potential danger of over exploitation due to internal pressure. No community imposes fees as long as the others do not.

Between the peak and falling water periods all 5 bamoes are partially exploited by the community. This period coincides with the retreat of the flood from the plains at which time floating and stationary gillnets are effectively used in the mid-section of the river and in the plains. Starting in December, village D puts its "bamoes" D1, D2, D3, and D4 in reservation leaving D0 permanently accessible to the community for its daily consumption and market exchange. Thus,

-D1 is closed December 15, opened February 28.
-D2 is closed December 15, opened March 15.
-D3 is closed December 30, opened April 1.
-D4 is closed January 15, opened May 15.

Other fishing villages fix their fishing schedules in a similar manner with the closing and opening periods at different times. Since all fishing villages interact mutually for the interest of their respective communities, their fishing schedules can be regarded a whole in which individual fishermen have a relatively free access to the reserve zones, as long as they conform to the rules of each particular village.

The Collective Fishing Season

The open season of fishing is also called the "collective fishing period" and is a significant socioeconomic event which takes place from January to June (Sissoko, 1974). Each village opens its reserves according to a schedule and foreign fishermen have access as long as they respect the rules of the village. For almost six months the entire Delta becomes subject to organized fishing in which each village acts independently from the others. Well informed about the opening dates of fishing, those members of the household who stay in the south move from village to village with their equipment. The household production is relatively high and constant during the six month period of fishing. The fish buyers follow this traditional patterns in purchasing their fish.

They travel with their trucks in search of fish for transport to the large consumption centers.

CONCLUSIONS

Traditional fisheries play an important role in providing food and employment for millions of people living in the Third World. Many rural populations in Africa, Asia, and Latin America depend on subsistence fishing as a primary source to meet their protein needs. Despite such economic importance, inland fisheries have received little support from government and international development institutions in the past. The recent interest in inland fisheries as economic systems comes at a time when their biological conditions are being threatened by internal and external factors.

Inland fisheries management has been based on traditional rules and regulations which, for many years, protected the resources as well as the well-being of the fishing communities. However, most of these fisheries have undergone some significant changes which have had serious impacts on their future viability. The growing number of fishermen, due to population increase and entry of foreign fishermen, have led to the inevitable transformation of several restricted fishing zones into common properties. Thus, under the open-access system, the conditions of some of these fisheries have deteriorated to the point of severely declining economic yields.

FSR/E is a conceptual tool for researching the traditional mangagement system. Fishermen's previous accomplishments can be used as a starting point for research on alternative strategies that would improve the protection and the exploitation of community-owned resources. The existing traditional systems can be examined under the umbrella of FSR/E which focuses on a systematic analysis of their physical, biological, and socioeconomic components in a comprehensive manner. Further improvement can be made through extension by helping the rural communities understand more about the nature and interdependencies of these components, and thus, influence fishermen's behavior toward a long term increase in social benefits. The OSY objective may be the target for research and extension offered by FSR/E.

The transfer of technology has proceeded in many riverine projects without previous assessment of the possible effects on the sociocultural and ecological conditions of the environment. The relatively low efficiency of traditional technology is recognized to have been a major factor in maintaining the natural balance of many river systems, despite the growing population pressure. The adoption of certain types of technology has increased the catch per unit of effort, thus causing an imminent threat of over exploitation of resources. FSR/E may be a useful tool for generating appropriate technology compatible with the socioeconomic and ecological components of the fishing environment.

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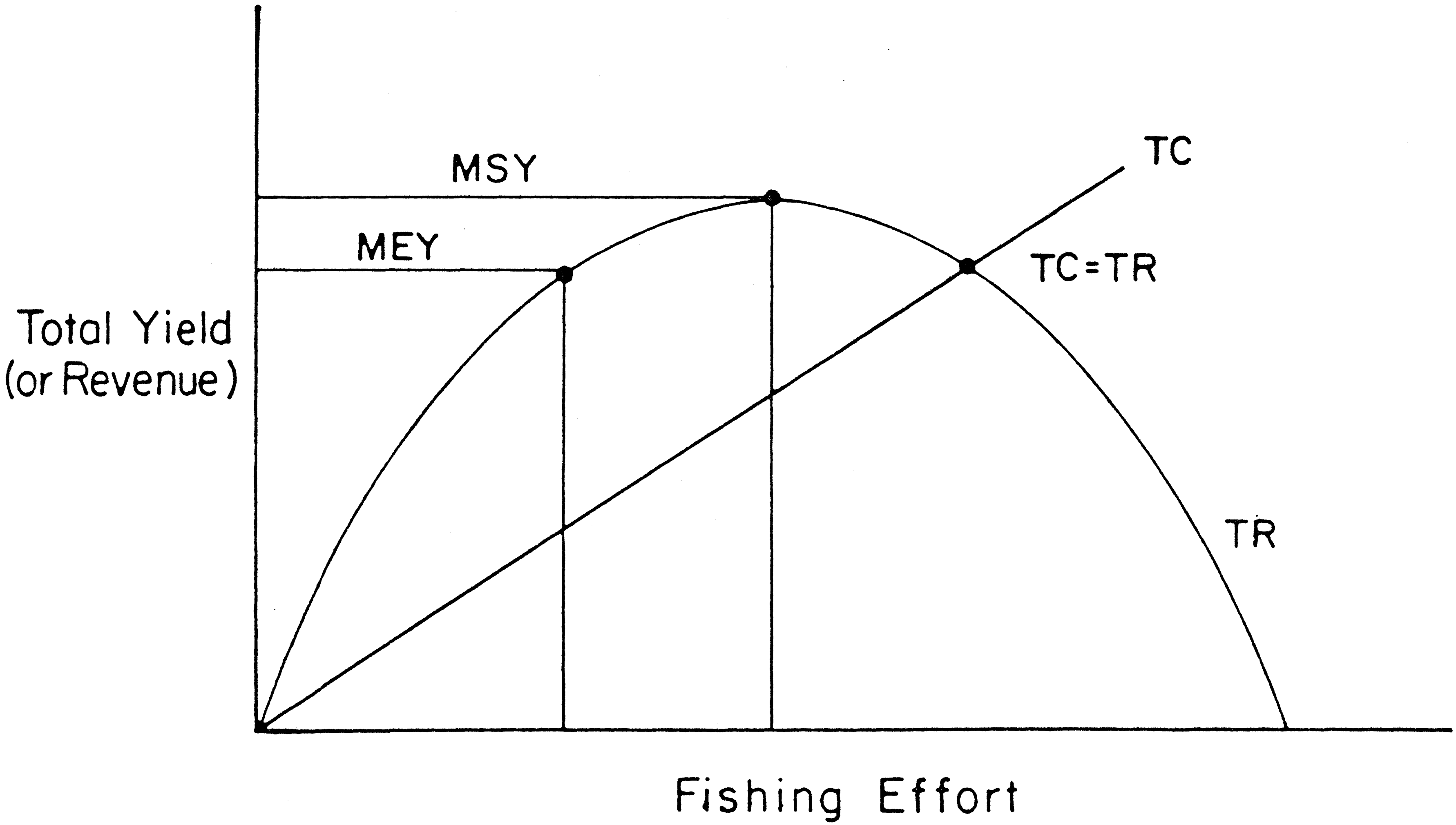

Figure 1. Yield-effort curve for an exploited fishery resource showing how equilibrium
This model is based on the premise that equilibrium yield is equivalent to the rate of increase in population size and that maximum sustainable yield (MSY) is reached at one-half the maximum amount of effort (and half the maximum population size). If yield is multiplied times price, the curve becomes a total revenue (TR) curve. Furthermore, if total costs (TC) of effort increase proportionately with effort, a point is reached where TC = TR. Maximum economic yield (MEY) is achieved when total revenue exceeds total cost by the maximum amount.

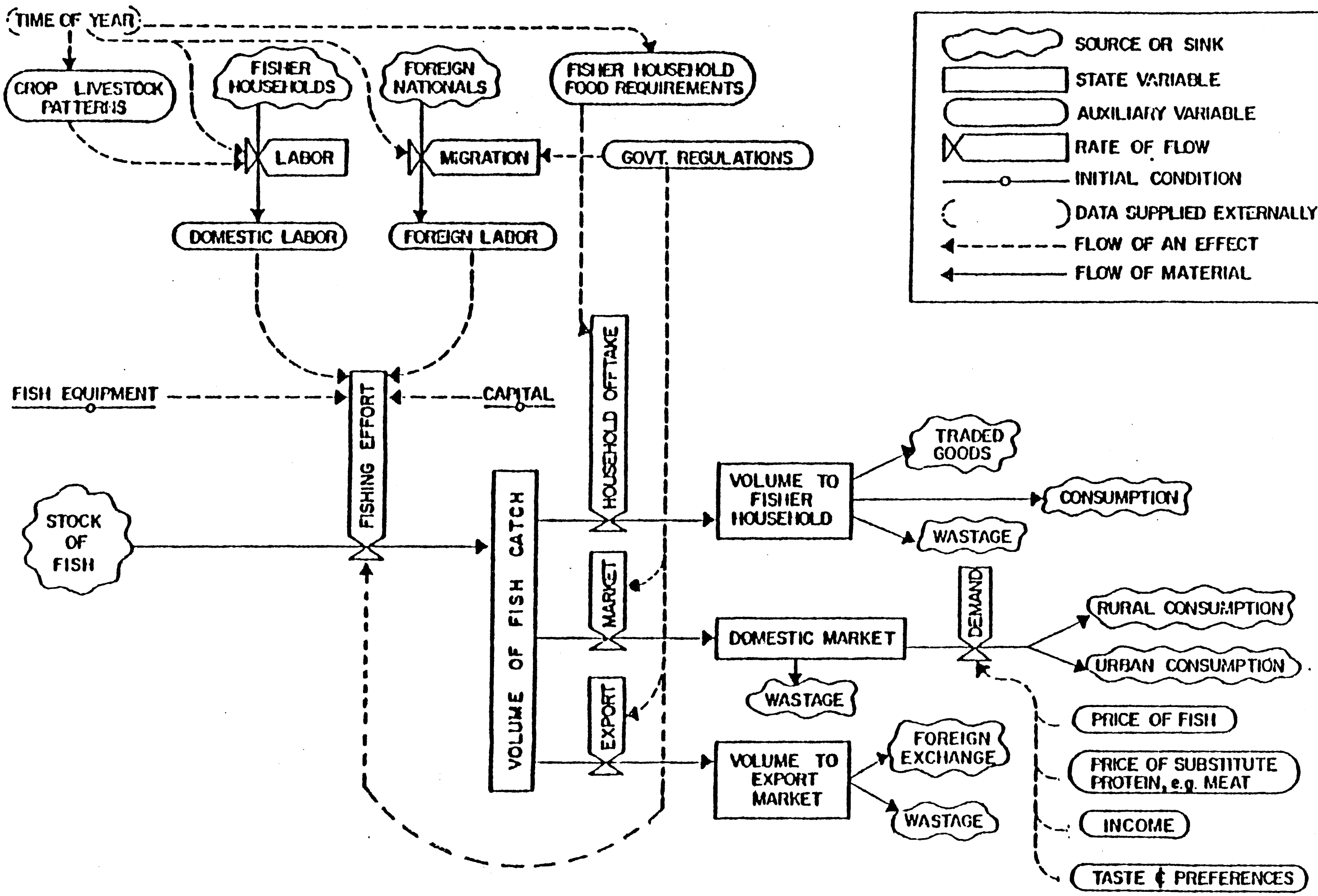

Figure 2. Flow Diagram for Production and Marketing of Fish on the Niger River in Niger.

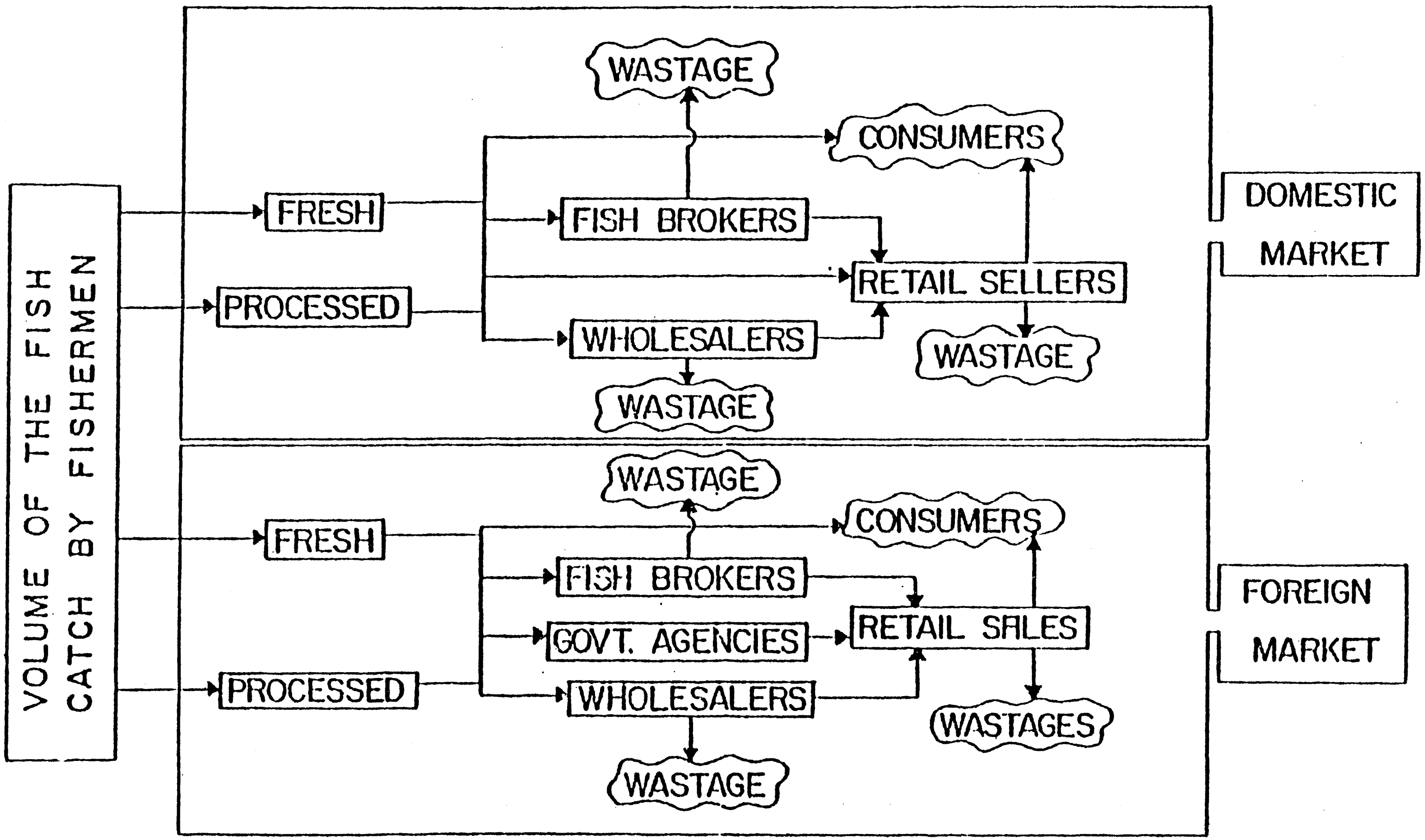

Figure 3. Flow Diagram of Sub-Model for Domestic and Foreign Markets.

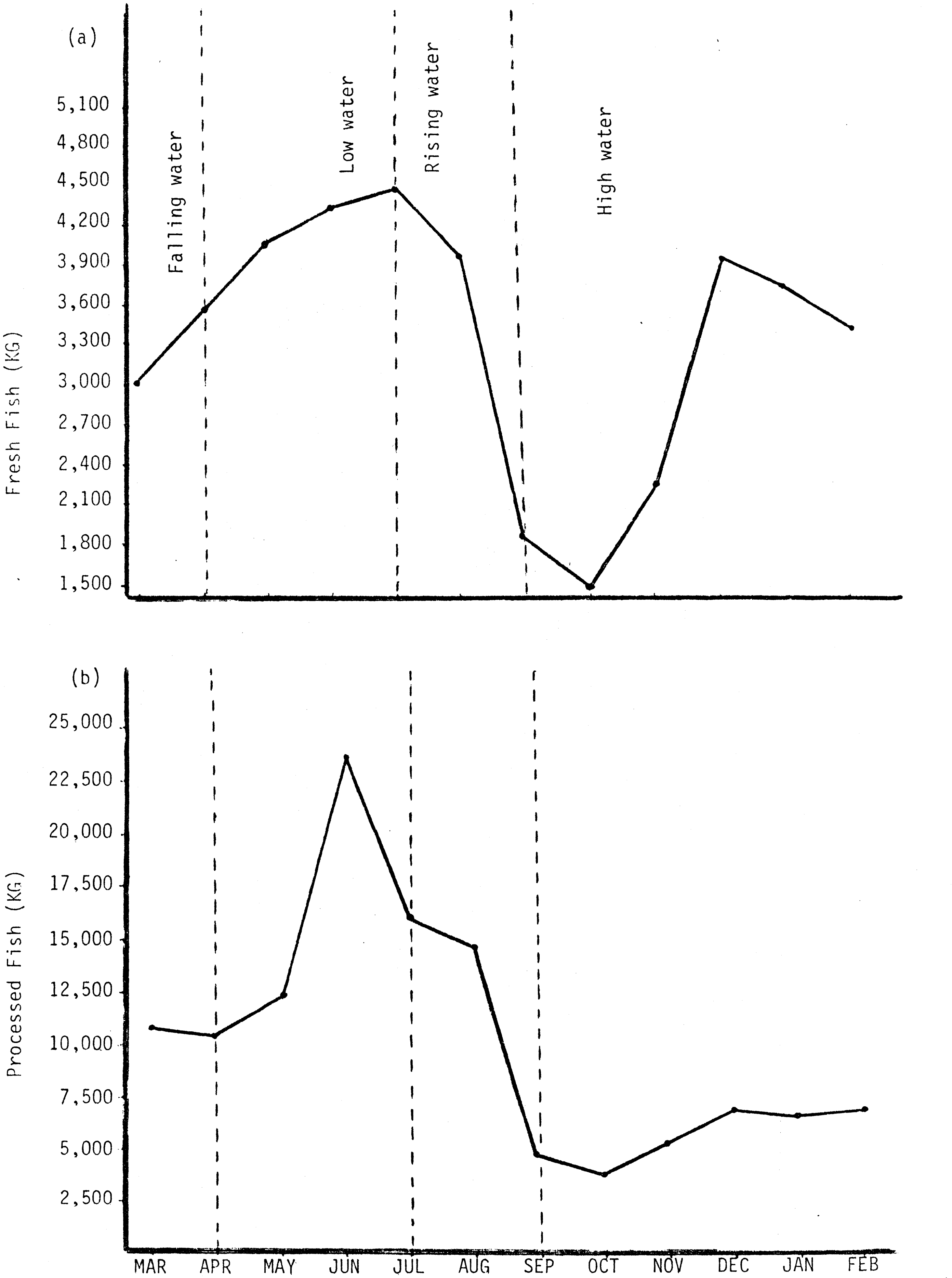

Figure 4 . Quantities of fresh (a) and processed (b) fish reported for the Niamey market in 1981-82, Niger.

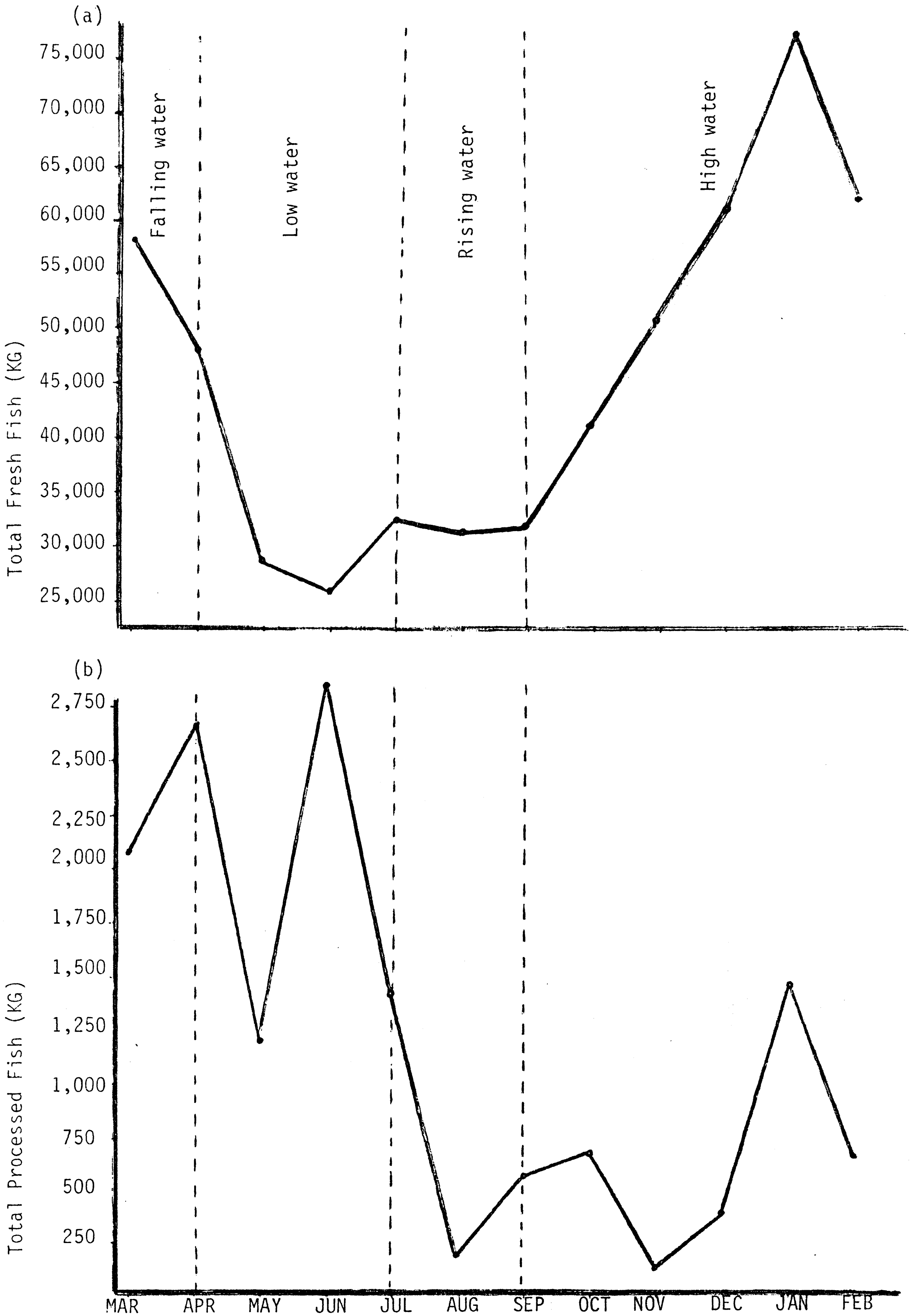

Figure 5. Quantities of fresh (a) and processed (b) fish reported for the Ayorou market in 1981-82, Niger.

(----) Signs indicating the Boundaries between reserve zones owned by a given village
(——) Signs indicating the boundaries between reserves owned by two villages

(P) Common zone between villages generally opened to all fishermen

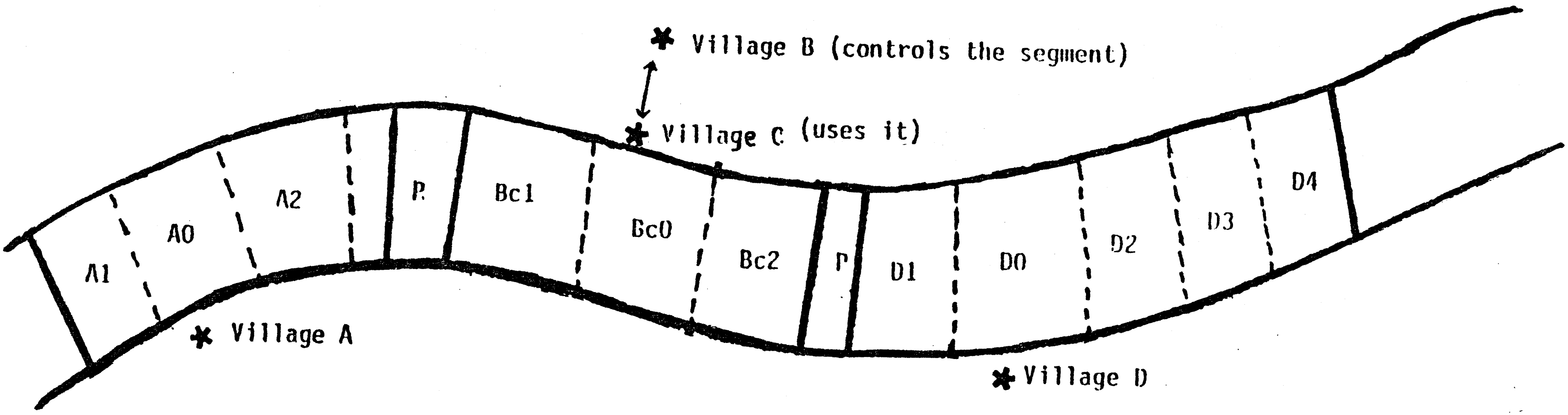

Figure 6. Illustration of some types of ownership and traditional management systems in the inland delta of the Niger River.

DEFINING AGRICULTURAL RECOMMENDATION DOMAINS IN SOUTH-CENTRAL NIGER[1]

Scott M. Swinton and Ly Abdoulalye Samba

INTRODUCTION

A key step in initiating a farming systems research program is to establish a typology of farming conditions. From such a typology, recommendation domains can be defined where the agro-climatic and socioeconomic conditions are sufficiently homogeneous so that they can be served by a single set of technological and management recommendations for each farming system (Byerlee, et al., 1983).

The *Institut National de Recherches Agronomiques du Niger* (INRAN), through the farming systems program of its *Dèpartment de Recherches en Economie Rurale*, was recently faced with the task of defining agricultural recommendation domains for south-central Niger. The agronomic information available included fifty years of rainfall data plus general soil surveys with, however, virtually no detailed soil maps. There existed a modest anthropological literature on farming practices, and marketing patterns as well as one attempt by a geographer (Koechlin, 1980) to identify agro-ecological zones in the region.

This body of literature presented several *a priori* criteria for defining agricultural recommendation domains. Such criteria are based on common characteristics, frequently arising from constraints upon agricultural productivity. By definition, a semi-arid zone is characterized by the limited availability of moisture. This is true of south-central Niger, where virtually all agricultural water comes from rainfall or groundwater. Hence, two obvious criteria to evaluate in defining recommendation domains were the average annual rainfall and the proximity of the groundwater table. A third possible criterion was the soil water retention capacity, for which a fair proxy is soil texture. In addition to soil moisture criteria, a fourth important characteristic to consider was soil fertility.

Whereas agronomic constraints, such as those suggested above,

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[1]This is a modified version of a paper originally presented at the annual meeting of the Institut National de Recherches Agronomiques du Niger (INRAN) in Maradi, Niger, March 12-21, 1984. The authors thank Robert Cocanaugher for his analytical assistance, as well as Robert Deuson, Adam Abdoulaye, John Sanders, Gilbert Numa and an anonymous reviewer for their helpful comments. Thanks are also extended to Mrs. J. Relo who did the French translation of this document and to Mrs. P. Deuson who did the word processing of both the English and the French versions. The research was supported in part by INRAN, by the Niger Cereals Research Project (USAID contract no. 683-0225-82-01 and by the *Projet de Dèveloppement Rural de Maradi*.

describe the limitations on agricultural productivity imposed by the quality of the physical environment, socioeconomic constraints describe the limits of farmers' access to the land, labor, capital, and knowledge which must be applied to the physical environment in order to make it produce. While this paper does not consider socioeconomic bases for defining agricultural recommendation domains, it does use socioeconomic data to evaluate hypothesized domains based on agronomic criteria. Total village population, population density, and farm size were used to measure the relative availability of labor and land. Access to capital and knowledge were more difficult to measure. The criteria adopted for capital were livestock ownership and access to regional markets. The latter was measured by the number of merchants per village. Two other measures were used to estimate farmers' management practices. One was their degree of adoption of the extended agricultural recommendations. A second, ethnicity, was also used due to recognized differences in traditional management techniques between sedentary herding (e.g., the Fulani) and farming (e.g., the Hausa) peoples.

In order to evaluate these possible bases for defining recommendation domains, INRAN's Dèpartement de Recherches en Economie Rurale drew upon a survey of agricultural practices of 348 farms in 37 villages of Madarounfa arrondissement[2] during the 1982 rainy season. The rest of this paper presents the analyses of the above criteria leading to the establishment of three distinct recommendation domains for Madarounfa.

MEAN ANNUAL RAINFALL

As the key constraining production factor, rainfall was the first to be considered as a criterion for defining recommendation domains. Average annual rainfall in Madarounfa arrondissement over the period 1932-1983 ranged from 580 mm in the north (the city of Maradi) to just under 700 mm at the southernmost point along the border with Nigeria. However, the standard deviation of annual rainfall in Maradi was 144 mm (see Appendix, Figure 1) so rainfall actually tended to vary more from year to year in the zone than it did within the zone during a typical year. For this reason, it was decided not to attempt to define recommendation domains in Madarounfa on the basis of differences in average annual precipitation.[3]

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[2]An arrondissement is an administrative unit roughly corresponding to a county in English.

[3]Rainfall during the season surveyed (1982) was unusually light, averaging only 355 mm among eight sites around Madarounfa arrondissement (P.D.R.M., 1983). The season was marked by a damaging dry spell in late July. However, these circumstances do not substantially affect the analyses presented here, as these concern the number of livestock, cropping systems, and technology practiced rather than their results for the 1982 season.

SOIL FERTILITY

The literature on soils in Madarounfa was reviewed for important differences in fertility, texture, and availability of water. Soils in the region are based on stony alluvial parent material from the quarternary period, largely covered by aeolian deposits of Sand (Boulet, 1964). In the ephemeral river valleys (Goulbi de Maradi and Goulbi de Bonsourou or Gabi), soils are composed on newer alluvia, predominantly mica sands, finer sand, and clay deposits (Boulet, 1964). Fertility differences among the four dominant soil series of Madarounfa are not pronounced. All are mildly acidic at the surface (pH 5.8-6.1), and extremely low in organic matter, available nitrogen, phosphorous, and exchangeable bases (Boulet, 1964). Because of the insignificance of differences in fertility, this criterion too was rejected as a basis for defining recommendation domains.

SOIL TEXTURE

By contrast, there is considerable variety in soil textures found in the region, both according to the Hausa terms used by the local farmers and field surveys carried out by French agronomists and geographers. The main difference is between the sandy aeolian cap soils and the compact parent material soils exposed where the windborne cap has been blown away. The former category of highly permeable dune soils include the Hausa classes called jigawa, tudu, and rairai. The less permeable, compact soils include geza, hwak'o, and fadama soil. Madarounfa Arrondissement is fairly evenly divided between the two groups (Figure 2). According to the literature on the region, the compact soils have tended to be much less cultivated. A 1975 study found only 23.5% of the compact soils in Maradi Department to be cultivated, against 74.0% for the sandy soils in Southern Maradi (Koechlin, et al., 1976).

In order to determine whether the observed differences in soil texture have any practical significance for Madarounfa farmers, it was decided to carry out statistical tests on the 1982 data. The 37 villages surveyed were classified as lying in regions of either sandy or compact soils (Figure 2), with compact soils defined to be those classified by Koechlin as Type A. Seven villages represented by 68 sample farms were on compact soils, 26 villages represented by 247 sample farms were on sandy soils, and four could not be classified. As will be discussed later, a subsequent division of the sandy soil category was made according to proximity of the water table (Tables 1a and 1b).

In order to evaluate the farm-level importance of the difference between sandy soils and the compact ones, the percentages of average surface area devoted to different cropping systems were compared using a t-test for significant differences between two unpaired populations. The general term "cropping systems" as used here refers to the summation of all individual systems that include a given crop, whether in monoculture or in association with other crops. For example, "cowpea systems" covers fields sown in monocropped cowpea as well as millet-cowpea, millet-sorghum-cowpea, sorghum-cowpea-peanut, and other associations that include cowpea. Hence it was possible, indeed, almost inevitable, that the sum of mean surface area under different crop systems would exceed 100%. However, this computational convention has no bearing on the statistical results, which appear in Table 2.

As shown in Table 2, significant differences existed in surface area planted in millet, sorghum, and cowpea systems between the 7 compact soil villages and the 26 sandy soil villages. At the 95% confidence level, the mean land area planted in millet systems was greater in the sandy soil villages than in their compact soil counterparts. The opposite was true of sorghum and cowpea systems, which were more widely planted in the compact soil villages than in the sandy soil ones, at 95% and 90% confidence intervals, respectively.

No important differences were noted in the amount of land devoted to peanuts or to monocrops in general in the two soil texture classes.

Crops were not the only aspect of the farming system that differed importantly between the two soil texture classes. Cattle, sheep, and goats were far more common among households in the compact soil villages (Table 3). The t-tests showed highly significant differences in means. This conforms with the observation of Koechlin (1980) that these soils are chiefly used for pasture. From the standpoint of agronomy, it means that families in these villages are more likely to have easy access to manure and draft animal power.

PROXIMITY OF THE WATER TABLE

The other possibly important differences among Madarounfa soils concerns the availability of groundwater. To a certain extent, this is influenced by soil texture and hence is embodied in the difference between farming systems on compact and sandy soils. But the proximity of the water table is also very important, because some crops are able to tap the groundwater supply if it is close enough to the surface. The 1982 survey did not gather data on the depth of village wells, so the location of a village within or outside of a valley was used as a rough gauge of whether it had relatively good or poor access to the subterranean water table. It should be noted that all of the valleys fell into the sandy soil category. However, the characteristics of the sandy valley soils are not identical to those of their upland cousins. The alluvial sands in the valleys are finer and mixed with more clay particles than the coarse, windborne sands found outside the valleys. Hence, they are more likely to retain water longer than the dune soils outside the valleys.

To test for a statistical difference between the sandy soils in the valleys and those outside the valleys, the mean cultivated surface areas under different cropping systems were compared. The results of the tests are presented in Table 4.

Important differences exist between these two subgroups of the sandy soil category. The 11 villages on sandy soils in the valleys have significantly higher percentages of cultivated land planted in millet, sorghum, and cowpeas systems than do the 15 villages on upland soils, at

10%, 5% and 1% levels of error, respectively. At first it seems perplexing that the valley villages should plant more of all three major crop systems and not plant less of any. This can be explained, however, by the fact that the valley villages tend to plant crops in association more frequently than in upland villages. Monocrop systems in general covered a significantly smaller surface area in valley villages than in upland villages, at a 5% level of error.

Differences in livestock ownership were found as well. Farm households on the upland sandy soils tended to possess significantly more cattle at a 1% level of error, than did farms in the valley villages. The pronounced difference in mean number of cattle owned means not only that upland village families must devote more time to caring for livestock, but also that they can count on the availability of more manure and draft animal power. No striking differences between mean numbers of sheep and goats existed between the two subgroups on sandy soils.

Having established the existence of important statistical differences in cropping systems and livestock among the three hypothesized recommendation domains, these categories were further examined for differences in agricultural practices employed. The practices reviewed were those extended to farmers by the Service de l'Agriculture. Among these were the application of manure and mineral fertilizer, field scarification, seed treatment with fungicide, use of improved seed varieties, the row tracer, insecticides, irrigation, and animal traction.

To test whether these practices differed significantly among the three soil-type categories, t-tests were administered to the mean percentages of surveyed fields (n=1086) in each village where the practice was in use. Comparing the compact soil villages with those on sandy soil (both subgroups), the former appeared to receive fewer applications of manure[4] and mineral fertilizer (Table 5). Among sandy soil villages, more fields were manured in the valley villages than in upland ones (Table 6). Considering the smaller size of the valley farms, it makes sense that the proportion of fields receiving manure would be higher. Seed treatment with fungicide, while it does not differ between compact and sandy soil villages, tended to be much more widespread in the upland sandy soil villages than in the valley ones. Although this difference cannot, at present, be explained it does provide further evidence of different agricultural practices from one recommendation domain to another.

SOCIOECONOMIC VERIFICATION

Given the established differences in farming systems among the three

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[4]However, manure as measured here does not include that deposited by animals left to graze in the fields, a practice which is probably more common on the compact soils.

hypothesized recommendation domains, it remained to check whether they differ significantly in their human resources. To do so, the proposed domains were compared using six socioeconomic indicators: village population, as reported by the village chief; population density, persons/hectare on the surveyed farms; farm size; village age; ethnicity; percent Hausa; and the number of merchants per village.

The results (Table 7) indicate that in general, the villages on compact soils are newer and smaller, and have significantly larger farms and fewer Hausa people than do their counterparts on sandy soils. This dovetails with historical fact, since during the 19th century, the independent Hausa communities of the Madarounfa region were confined to the valleys which were more easily defended from attacks by the Fulani sultans to the south. The uplands were settled only after the French conquest of the early 1900's made the open dunes secure for farmers (Grègoire and Raynaut, 1980). The last areas to be settled were the difficult to work compact soils where sedentary Hausa farmers are still moving in to join the semi-nomadic Fulani herders.

For similar reasons, among the villages on sandy soils, those in the valleys tend to be older and larger, and have significantly smaller farms and higher population densities than those on the upland soils (Table 8).

The reader will remark that some of the differences in agricultural practices among the recommendation domains (e.g. higher manure use in the valley villages) can be explained by agricultural intensification in the more densely populated regions.

The valley villages also appear to be better connected with the outside economy. They are better served by major roads. As the t-test indicates, they have significantly more merchants than do the upland villages. As further evidence of their better access to markets, a 1978-79 survey of cereals marketing found that only two out of eight major markets in the Madarounfa arrondissement were located outside of the valleys (Grègoire and Raynaut, 1980).

Before concluding, one important point should be clarified: the t-tests used to demonstrate significant differences between one recommendation domain and another do just that, they do not prove that the choice criteria, soil texture and proximity of the water table, were the cause of those differences. It is entirely possible that some of the variables which have been examined here to substantiate differences in the recommendation domains may play a causal role. Our intention in this paper was not to demonstrate causality, but rather to establish that real differences in farmer circumstances exist between recommendation domains defined using certain environmental criteria.

SUMMARY

Four agronomic criteria for defining agricultural technical recommendation domains have been examined here: average annual rainfall, soil fertility, soil texture, and depth to the subterranean water table. Of these, the last two proved to be the definitive criteria, based on t-tests of differences between sample means in the examination of data on cropping systems, livestock ownership, and agricultural practices. The three resultant proposed recommendation domains: compact soils, sandy valley soils, and sandy upland soils, also proved to differ significantly according to four measures of socioeconomic characteristics: population and population density, farm size, ethnicity, and access to markets. It can be concluded, therefore, that these categories provide a sound basis for selecting villages that represent distinct agricultural recommendation domains.

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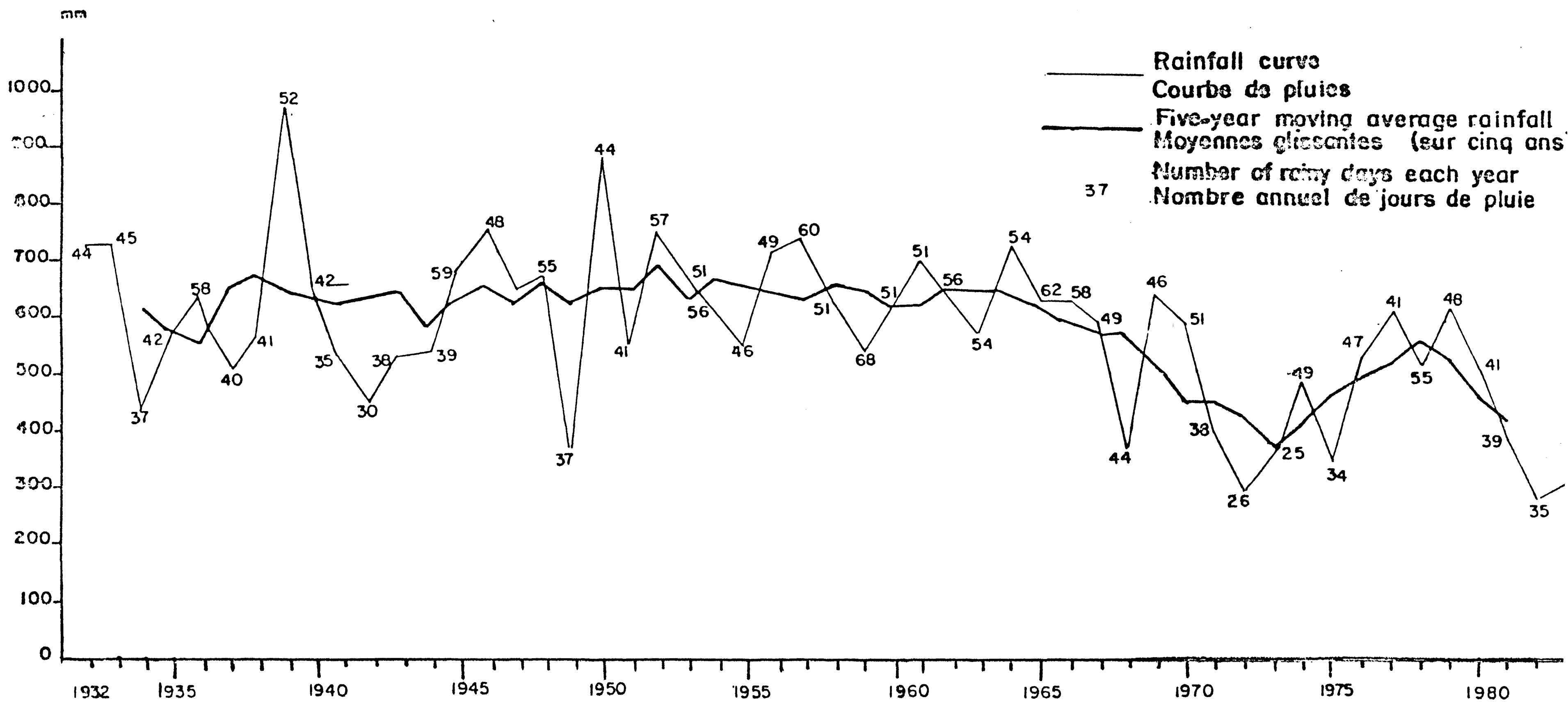

Figure I. Annual rainfall (mm)
Note: Graph adapted from Koechlin, 1980, Figure 2 after p. 4

Graphique I. Pluviométrie annuelle (mm)
Note: Graphique d'après Koechlin, 1980, Graphique 2 après p. 4

MARADI NIGER 1932–1983

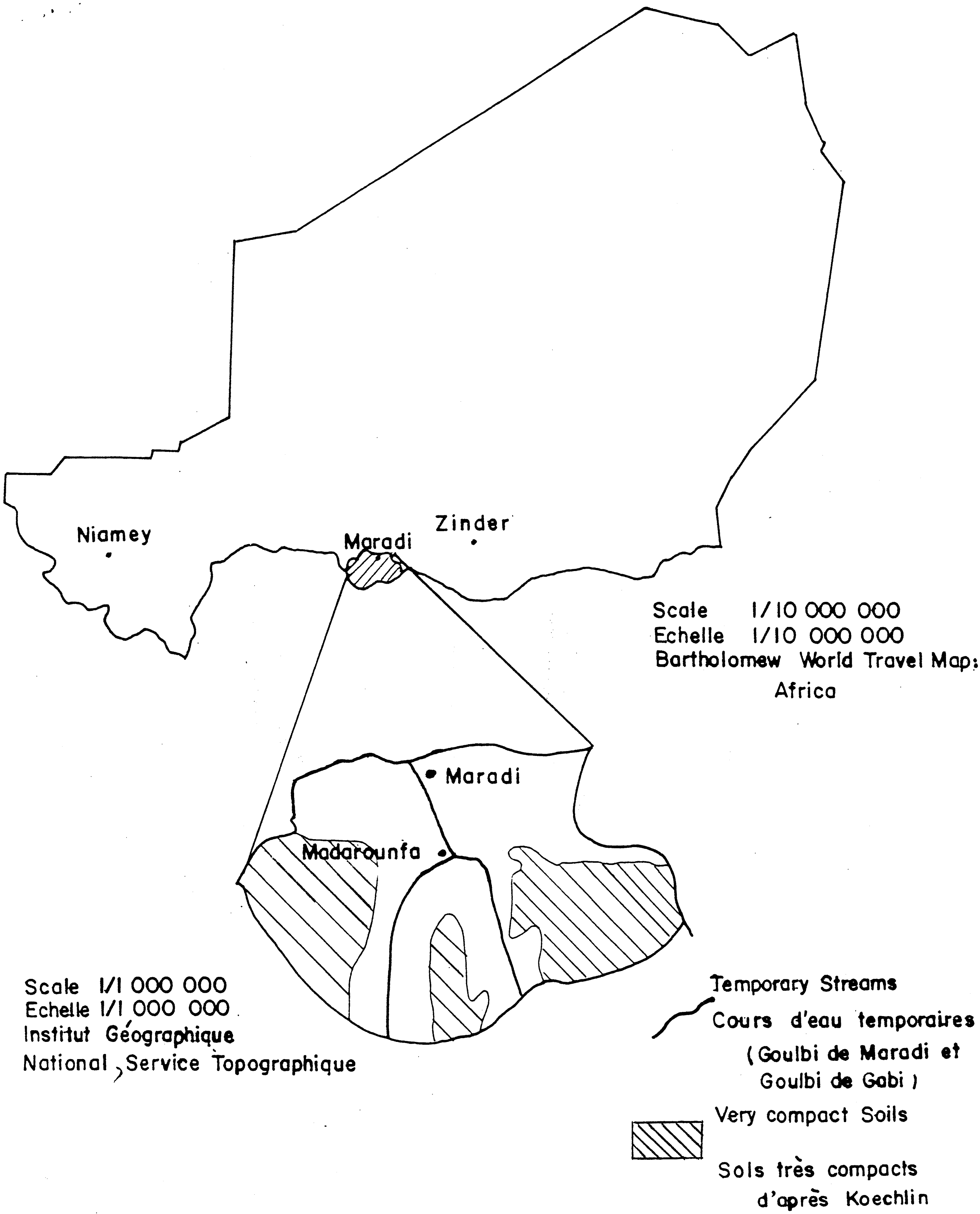

Figure 2 Madarounfa Arrondissement NIGER

Graphique 2 L'arrondissement de Madarounfa situé dans le territoire national du Niger

Table 1a. Classification of 33 villages by soil texture, proximity of the water table, and location, Madarounfa, 1982.

Soil Texture		Water Table	Location
Compact	Sandy		
7 Villages	11 Villages	Higher	In the valleys
	15 Villages	Lower	Outside the valleys

Table 1b. Thirty-three villages listed by soil texture, class, and location in Madarounfa, 1982.

Compact soil villages	Sandy soil villages	
	In the valleys	Outside the valleys
Wojia	Djiratawa	Daoutawa
Inwala Mani	Maiguero	Dan Gageré
Dagazari	Tokerawa Taboli	Riadi Dan Bizo
Garin Limam	Gangare	Takalmawa
Taplin Guiwa Peilh	Angoual Rounji	Rigial Bagaouari
Kandamo	Dan Abdalla	Rourouka Zaria
Kaima	Dama	Fiyawa
	Kourfin Galadima	Angoual Mata
	Soumarana	Kagara
	Tchikaji	Dan Aliya
	Safo Oubandawaki	Rigial Oubandawaki
		Dan Hajara
		Serkin Yamma Safoa
		Tapkin Marke
		Garin Goulbi

Note: Non-classified villages are: Sabongari Dan Ladi, Dadjin Abdou, Makada Chala, and Sabon Garin Abara.

Table 2. Percentage of mean cultivated surface area in compact soil versus sandy soil villages, by cropping system group, Madarounfa, 1982.

Cropping systems group	Percentage of mean cultivated surface area in -- 7 compact soil villages	26 sandy soil villages	"t" statistic (d.f. = 31)
	%	%	
Millet systems	71	82	-2.15**
Sorghum systems	83	64	2.13**
Cowpea systems	71	52	1.87*
Peanut systems	22	29	-0.79
All monocrops	18	24	-0.73

**Significant at the 5% level of error
*Significant at the 10% level of error

Table 3. Mean number of animals in compact soil versus sandy soil villages, by type of animal, Madarounfa, 1982.

Type of animal	Mean number of animals in -- 7 compact soils villages	26 sandy soils villages	"t" statistic (d.f. = 31)
Cattle	4.3	1.1	3.82***
Sheep and goats	11.4	5.9	4.64***

*** Significant at the 1% level of error.

Table 4. Percentages of mean cultivated surface area among sandy soil villages: valley versus upland villages, by cropping system group, Madarounfa, 1982.

Cropping Systems Group	Percentage of mean cultivated surface area in -- 11 valley soil villages	15 upland soil villages	"t" statistic (d.f. = 24)
	%	%	
Millet systems	88	78	1.99*
Sorghum systems	74	57	2.18**
Cowpea systems	72	40	4.53***
Peanut systems	34	25	1.20
All Mono-crops	14	32	-2.45**

***Significant at 1% level of error
**Significant at 5% level of error
*Significant at 10% level of error

Table 5. Mean percentage of fields in compact versus sandy soil villages by agricultural practice, Madarounfa 1982.

Agricultural Practice	Mean Percentage of Fields in -- 7 compact soil villages	26 sandy soil villages	"t" statistic (d.f. = 31)
	%	%	
Manure	27	46	-1.91**
Mineral fertilizer	11	25	-1.74**
Fungicide	39	39	-0.03
Improved seed	28	20	0.89
Animal traction	33	31	0.16

**Significant at a 10% level of error
Note: Four surveyed practices were so widespread (field scarification x = 94) or else so rare (use of row tracer, insecticide or irrigation, x = 0) that they were omitted from the table.

Table 6. Mean percentage of fields among sandy soil villages: valley versus upland villages, by agricultural practice, Madarounfa, 1982.

Agricultural practice	Mean percentage of fields in -- 11 valley soil villages	15 upland soil villages	"t" statistic (d.f. = 24)
	%	%	
Manure	61	35	3.45***
Mineral fertilizer	20	29	-1.18
Fungicide	20	53	-3.10***
Improved seed	19	21	-0.29
Animal traction	24	35	-0.85

***Significant at 1% level of error

Table 7. Mean values for six socioeconomic indicators in compact soil versus sandy soil villages, Madarounfa 1982.

Socioeconomic indicator	Unit	Village means for -- 7 compact soil villages	26 sandy soil villages	"t" statistic (d.f.=31)
Village polulation	person	216	746	-1.79*
Population density	person/ha	3.8	3.5	0.44
Farm size	hectare	2.85	2.03	1.78*
Village age	year	56	92	-1.10
Proportion of Hausa	percent	63	98	-3.82***
Merchants	number	4.7	19.1	-1.33

***Significant at 1% level of error
*Significant at 10% level of error

Table 8. Mean values for six socioeconomic indicators in valley villages versus sandy upland villages, Madarounfa, 1982.

Socioeconomic indicator	Unit	Village means for -- 11 valley soil villages	15 upland soil villages	"t" statistic (d.f.=24)
Village population	person	999	569	1.37
Population density	person/ha	4.9	3.2	3.76***
Farm size	hectare	1.57	2.37	-2.63**
Village age	year	117	75	1.38
Proportion of Hausa	percent	94	100	-1.41
Merchants	number	32.0	9.7	2.13**

***Significant at 1% level of error
**Significant at 5% level of error

PHYSICAL TECHNOLOGY & FARMING SYSTEMS

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FARMING SYSTEMS RESEARCH IN THE BRAZILIAN SEMI-ARID TROPICS
THE EXPERIENCE OF OURICURI, STATE OF PERNAMBUCO

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INTRODUCTION

Before 1970 the Brazilian agricultural research system was based on a diffuse model, where "each research unit tried to diversify its activity, researching on many different products and attempting to generate a wide array of technologies" (Pastore and Eliseu, 1975). The same authors suggest that this research model is appropriate for situations with the following features: abundance of monetary resources to support the research programmes, and predominance of individualism of the scientists with liberty to choose the research themes according to their interest and feelings. A considerable amount of information can result from such a model, possibly with low probability to generate new technologies. This implies the requirement of a large amount of resources to be devoted to agricultural research, which can fit into rich societies but is not the case with the third world where the resources available for research are scarce.

Another important event preceding the 1970's was the transfer of technology from the temperate climates to the Brazilian tropical environment, as well as the prevailing idea that what is good for the developed world should be good for Brazil.

The increasing demand of food supply in the country, coupled with the expansion of the external market, required a reorientation of the agricultural policy. To meet this need, the Brazilian government decided to modernize agricultural research and to develop an array of national technology based on national problems. As an instrument of this policy, the Brazilian Agricultural Research Enterprise (EMBRAPA) was created in December 1972 (EMBRAPA, 1975). There was a reinforcement of the existing research facilities through financial and technical support, and new research centres were created to cover the needs of the country. As a part of the modernization of Brazilian agricultural research, the emphasis on a farming systems approach was integrated into the programmes of EMBRAPA's research.

The Agricultural Research Centre for the Semi-Arid Tropics (CPATSA) was created in 1975 with the objective of generating new technologies to improve the quality of life of the peasant farmers of the Brazilian semi-arid tropics (SAT). With the creation of CPATSA many questions were raised during the conception of the research programmes, such as: what to do? how to do it? when to do it? and how to integrate the peasant farmers with the global society?

As an attempt to answer these questions, some basic principles were formulated, inspired by international research experiences from other parts of the SAT (Krantz and Kampen, 1976; Dillon et al., 1978 and Tourte, 1977). They were:

1. To work with an interdisciplinary team considering the following research areas: soil and water management, animal traction, cropping systems, animal production, agroclimatology and economics.

2. To develop technologies in each research area and to integrate them for operational scale trials.

The preliminary results on these experiences were reported by Queiroz (1979). Till that time the research was carried out without direct participation of the farmers. However, the participation of the farmer is of fundamental importance to check the adoption rate of the technologies. There has been considerable progress in the direction of CPATSA's research strategy resulting from the valuable experience which is described in this paper.

THE SETTING

Northeast Brazil occupies 18% of the Brazilian territory and according to Reddy and Amorim Neto (1984), 75% of this land is classified as semi-arid tropics. The Brazilian SAT comprises about 1.2 million km2, including parts of the following states: Maranhao, Piaui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, Bahia and Minas Gerais. The Brazilian SAT includes two major agro-ecological sub-regions namely Agreste and Sertao.

It is estimated that 94% of the rural holdings (around 2,300,000) are less than 100 ha and occupy approximately 30% of the area of Northeast Brazil. However, the crop production from small holdings represents more than 60% of the region's basic food supply (Ibge, 1981).

The Agreste is a transition zone between the coastal area and the arid Sertao. Rainfall in the region ranges between 600 and 1300 mm, and the average temperature is lower than that in the Sertao. It comprises about 15% of the Brazilian SAT and is one of the major agricultural production sub-regions of the Northeast. Intercropping is the predominant cropping pattern and a number of crop combinations are used involving the following crops: maize, beans (*Phaseolus vulgaris* L.), cassava, forage cactus (*Opuntia ficus-indica* Mill), cotton (*Gossypium hirsutum* L.) among others.

The Sertao corresponds to a rather dry zone where the rainfall is generally in the range of 400 and 700 mm, and comprises 74% of the Brazilian SAT. The farming systems presently in use in the Brazilian SAT is a result of more than 300 years of experience. Extensive livestock on natural rangelands (caatinga) is a very important component of the farming systems. The carrying capacity of the caatinga, estimated at one animal unit per 15 ha, is very low (Salviano et al., 1982). With the caatinga grazing system, steers are ready for slaughtering when they are around 5 years old and have attained an average live weight of 320 kg.

Cattle, goats, and sheep are raised in close integration with agriculture. The cropped area is normally fenced and crop residues are kept in the field for feeding purposes during the dry season. In general, the water sources are shared by the farm family and the animals. This leads to contamination of drinking water used by the family, mainly during the dry season. Agriculture tends to be concentrated in small areas, generally in more fertile lands or alluvial soils bordering small rivers. The receding cultivation along the margins of the water reservoirs or on the river beds is also common. Intercropping is a common situation for both subsistence and cash crops like cowpea, maize, cassava, castor beans, perennial cotton (Gossypium hirsutum L. var. Maria Galante Hutch.), and forage cactus. They are mixed in a number of ways. Maize, cowpea, and cassava are staple foods for human consumption and sorghum has been successfully introduced recently in the drought prone area as an animal feed crop (Faris et al., 1976).

Despite the great variability of the agro-ecological picture within the Brazilian SAT, there are some common features, as follows:

1. The farm families in general are aside of the services and welfare of the community.
2. The economy of the system is very fragile and a small weather aberration is sufficient to keep some farmers from the field.
3. The majority of households are based on a typical subsistence economy.
4. The farm families normally live isolated in the establishments scattered in the rural area.
5. There is a large predominance of small holdings.
6. Animal and human labor are the main source of power.
7. There is a high evaporative demand (about 2000 mm per year).
8. There is an inadequacy of credit facilities.
9. There are short rainy seasons.
10. Rainfall is intensive and interspersed with unpredicatable droughts.
11. There is high variability of the annual rainfall.

No specific data are available concerning the Brazilian SAT. However, it is reported that 31.4 million people live in the Northeast region, comprising 30% of the Brazilian population. The rural population is about 47% of that total and its annual rate of growth for the Northeast is estimated at 2.5% (Ibge, 1982).

According to Ibge (1983) the Northeast contributes 12.3% to the national product of Brazil, and its participation in the national agricultural, industrial, and services income are 15.5%, 10.8% and 11.2%, respectively. The same source indicates the following distribution of the regional income: agriculture, 16.9%; industry, 30.3%; and services, 52.8%. Table 1 shows the participation of the 14 most important crops of the Northeast in relation to the total of the country, and the increasing rate of their production in the region over a period of 20 years. These figures clearly show the considerable increase of the export and industrial crops, like orange (466.2%), tomatoes (185.6%), sugarcane (177.3%), etc., and a small increase or even decrease of some subsistence crops like cotton (1.6%), beans (1.3%) and maize (- 19.3%).

The experience presented has the following merits: 1) it leads to the validation of on-farm technologies integrating researchers, farmers, and extension agents in the process of regional development; 2) it represents the thoughts and efforts of an interdisciplinary team.

THE RESEARCH PROGRAMME AT CPATSA

The research programme of CPATSA considers the following (Figure 1): 1) evaluation of the natural and socioeconomic resources of the rural environment aimed to assess the traditional farming systems, their boundaries, limitations, and potentials; 2) analytic research, carried out at the experimental station; 3) synthesis experiments, comprising an integration of different disciplines; 4) experimental farming (FS) are undertaken on site and involve all the components of the FS; 5) introduction of improved farming systems (IFS) among farmers in different agroecological situations, and at the same time the testing (validation) of isolated technologies on farmers' fields which serve as a feedback to the IFS studies. As it can be seen from the flow chart, farming systems research (FSR) is a basic component of CPATSA's research programme.

The interdisciplinary team of FSR at CPATSA consists of scientists in the following disciplines:

- Soil and water management
- Intercropping
- Agricultural economics
- Mechanization (animal drawn equipment)
- Animal production
- Agricultural systems

FSR receives consultancy from CPATSA staff in other disciplines, such as: plant protection, agroclimatology, statistics, soil fertility, seed technology, etc.

METHODOLOGY OF FSR

Selection of Farms

A preliminary diagnostic survey was carried out in 1982 involving 400 farms already assisted by the Sertanejo Project[1] (Brazil. SUDENE, 1977), in the region of Ouricuri (7°30' - 8°30' south latitude and 39°30' - 40°30' west longitude), comprising an area of 7,500 km. This survey comprised a global analysis of the availability of technical assistance, credit, inventory, some socioeconomic characteristics, and agroecology (Kilian, 1981; Miranda, 1981 and Mantovani & Riche, 1982).

A sequence of procedures was developed involving a decreasing number

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[1]Government project to promote technical assistance to farmers in the SAT.

of farm families and an increasing number of variables, in order to provide an overview of the region in terms of the resource interactions between the farming systems and the rural services (credit, technical assistance, market, agricultural research, and agroindustry, etc.) (Miranda, 1981 and Pinare & Fuentes, 1984 a and b).

The final procedure resulted in the selection of five farms in 1983, where a detailed analysis was performed, comprising the following steps (Porto et al., 1984):

1. Analysis of the selected farms. The selected farms were analysed in detail for identification of the farm components as follows:

a. Tenancy. It is important to know the tenancy system in order to guide some decisions concerning credit, investment, and legal limits of the systems.

b. Farm size. A topographic map of the farms was made for surveying the total cropped and unproductive areas. All the infrastructures were located on the map, including stream courses, water reservoirs, etc.

c. Natural resources. The survey of the natural resources of the farm was divided into two stages:

1) Present and potential use of the fields; identification of the crops and cropping patterns in use; observation of weed, pest, and disease problems; and analysis of soil depth and fertility. The land use in the last three years was also recorded to give a picture of soil use. Such a characterization of the fields permits an evaluation of the potential in accordance with the capital and labor.

2) Water and other resources. Quantity and quality of water resources were assessed. Forestry products (charcoal, wood, etc.), soil products (bricks, tiles, lime, etc.), which represent additional income for the farmers were also surveyed.

d. Labor. Analysis of the existing human labor and its requirements for the development of the IFS were undertaken.

e. Capital. All the items of the inventory such as animals, infrastructures, perennial crops, machinery, tools, and land were valued to identify the existing potentials and limitations.

f. Liabilities. The short and long term debt to be paid during the implementation of the IFS were recorded in order to be considered in the repayment capacity.

2. Identification of potentialities, limitations and needs of the farm. The analysis of the natural resources, capital, and labor allowed a balance of quantity and quality of the existing resources, experiences of the farmer, needs of investment, links of the farm with the regional services (health, education, bank, market, etc.), and access to the farm all year round.

3. Identification of farm families' needs and objectives. This can be described as follows:

a. Needs of the farm families. These are represented by the basic consumption of the family in terms of food, water, energy, domestic consumption (maintenance of the family) and consumption of life quality (social and cultural services like festivals, entertainments, weddings, etc.) Equally important is the record of the needs of the farm, such as the requirements of inputs and investments to assure the survival and development of the family and farm activities.

b. Objectives of production. The aspirations, objectives, and hopes of the farm families are based on land, labor, and experiences. The farming system is the result of the interaction between the socioeconomic and production system and is expressed in terms of allocation of land for subsistence and cash purposes.

Project Formulation

From the detailed analysis of the diagnostic survey, three kinds of projects were formulated. They are:

1. Project with traditional technologies (Project A). This is a projection of the performance of the farm based on the existing resources and the traditional technologies currently adopted by the farm families. In this project the farmer defines the objectives and describes the traditional technologies. Based on this information the research team simulates the economic parameters in a range of five years.

2. Development project with improved technologies (Project B). This project incorporates the improved technologies available. It has a duration of five years and its performance is compared with Project A.

The farmers and researchers discuss allocation of space and implementation of the improved technologies. The project is entirely implemented on the farm jointly by the farmer and the interdisciplinary team. The farmer participates with the major part of the capital investment (land, fencing, clearing, small roads and buildings), working capital (animals, tools, inputs, equipment, and working animals), labor, and administration of the farm. The research component finances part of the improved technologies, i.e., compartmented reservoir, cistern, lending of the policultor, etc. The necessary investments varies from farm to farm, depending on the needs and availability of farm resources. In the case of the farm discussed earlier the investments amounted to US$ 3,600. The research financing can continue up to the third year. However, for economic evaluation purposes, the financial contribution of the research component is included in the costs. After the third year the farmer assumes the whole project and the research team will provide technical assistance for two more years.

3. Evaluation project - Project R (Doraswamy et al., 1984. This project comprises an economic, social, and technical evaluation of the real situation in order to measure the impact of the improved technologies on the farm and farm family.

Once implemented the set of improved technologies and all the variables within the farm are recorded at different intervals as follows:

Annual survey, comprising the following variables:

- Labor availability
- Space allocation with their respective uses
- Annual and perennial crops
- Use of water resources
- Information on fences

- Inventory of inputs, tools, and machinery
- Inventory of domestic animals
- Land and infrastructure value
- Information on financial assets
- Information on debts.

Monthly survey, comprising the following variable:
- Herd management.

Weekly surveys comprising the following variables:
- Changes in stock number
- Pasture utilization
- Supplementary feeding
- Production and sales of livestock products
- Sales of crop products and other receipts
- Expenditure on inputs and services for crop and animal production
- Expenditure on general management of the farm
- Expenditure on family consumption.

Daily survey comprising the following variables:
- Use of labor in crop and animal production
- Input use
- Use of machinery (animal machines and equipment).

All these variables are precodified and recorded in the proper questionnaires adjusted to a computer system. The data from these precodified questionnaires are directly transferred to the flexible disks with the Research Center's microcomputer Polymax (Poly 201 DP) with 64K bytes RAM memory. The analysis of these variables allows an assessment of three main aspects of the FS: technical (yield, productivity, and new technologies), economic (investments, income, and benefits), and social (employment, training, and improvement in the standard of living).

The aim of the FSR programme at CPATSA, is to transfer this experience to different ecological zones of Northeast Brazil through EMBRAPA's cooperative research network.

The extension service participates in the whole process in a joint action with farm families and researchers leading to the preparation for the process of transfer of technology.

INTRODUCTION OF NEW TECHNOLOGIES

The analysis of the available technologies stage confronts the farmers' objectives of production with the available technologies of the regional research system. It is understood that these technologies have been previously tested in an experimental farming systems. An important requirement in the whole process is that the IFS may give the farmers a condition to resist the drought effects.

The basic technology being used in the sampled farms is a cistern which is a basic requisite for family welfare. This is a protected reservoir for rainwater storage harvested from the houses' roof, or from catchment areas in the ground. The water is used for human consumption only and it is dimensioned according to family demand. It comprises three basic components (Silva et al. 1984): catchment area, filtering system, and storage tank (Figure 2).

Vegetable production under pot irrigation was introduced to improve the diet of the farm family. This activity is generally limited to a small area mainly to meet the household needs. The main crops are tomatoes, greenpeppers, okra, eggplants, lettuce, and carrots. The pots are made out of clay and release 5 litres of water per day on average. The system can also be used for fruit trees (Silva and Porto, 1982).

In situ rainwater harvesting techniques using modified leveled furrows are broadbed and furrows system, Guimaraes Duque system and "W" system. These techniques can be implanted both by animal and tractor power. All these techniques permit zonalized tillage systems clearly demarking a planting, traffic, and water harvesting zone. In all the three systems the furrows serve for traffic and water storage harvested from the water harvesting zone (Porto et al., 1984), (Figure 3).

Runoff water harvesting through a compartmented reservoir is a semi-circular shaped tank with two compartments destined to store runoff water for supplemental irrigation. It has three basic components (Figure 4), catchment area, storage tanks, and planting area (Silva et al., 1984). Supplemental irrigation is carried out by gravity only.

Receding cultivation with furrows and ridges system is a kind of cultivation on ridges and furrows built on the water level of the shores of lakes and dams as the water recedes (Silva et al., 1981).

The crops used were: maize, cowpea, annual cotton, sorghum, common bean, and watermelon. Improved varieties of these crops were introduced with intercropping being the predominate cropping system. Most of these crops are drought tolerant.

A multipurpose tool carrier/tool bar (policultor) has been used for various cultural operations such as land preparation, planting, and weeding. The tool carrier used in the IFS is drawn by a pair of bullock and used for transportation purposes of farm production. The tool bar has been used for low draft requiring use of one animal.

Pasture management is related to the use of caatinga vegetation during the rainy season when it is able to adequately carry the herd. Supplementary feeding includes the combined use of cultivated grass (*Cenchrus ciliaris* L. - buffel grass), legumes (*Leucaena leucocephala* [Lam.] de Wit) and *Cajanus cajan* (L.) Millsp - pigeonpea, crop residues (maize, cotton, sorghum, and cowpea), and other forages like (*Opuntia ficus indica* Mill) forage cactus and (*Prosopis juliflora* D.C.) mesquite. With respect to health management, the main techniques introduced are vaccination and deworming.

RESULTS AND CONCLUSIONS

The economic indicators of the project with traditional technologies (Project A) and the development project with improved technologies (Project B), in one of the selected farms, are presented in Tables 2 and 3. It is expected that the final cash balance in Project B is substantially higher in relation to Project A, and increase in cash balance ranges between US$ 450 in the first year, to US$ 3,700 in the fifth year, representing 169% and 650% increase, respectively. Table 4 presents the estimates of the internal rate of return of the investments in traditional and IFS and in the new technologies. The traditional system is characterized by a very low internal rate of return (2%) while it is substantially higher in the improved system (19%). The internal rate of return of investment in the new technologies is very high and represents 62%.

The data of the evaluation project (Project R), are being processed. However, it is important to consider that the IFS will modify the social and agroecological equilibrium, which characterizes the agricultural exploration, generating new equilibria. The farm family is the only component of the new equilibrium, and is the only one who is able to feel the global modifications introduced by the IFS. It has been observed with the present experience that the farmers began to operate the new animal power equipment and supplemental irrigation reasonably well. These are remarkable examples considering that these technologies are entirely new in this environment. The community has also reported a great interest.

With only one year of implementation of the IFS in rural areas it was not possible to assess any changes in the standard of living of the farmers.

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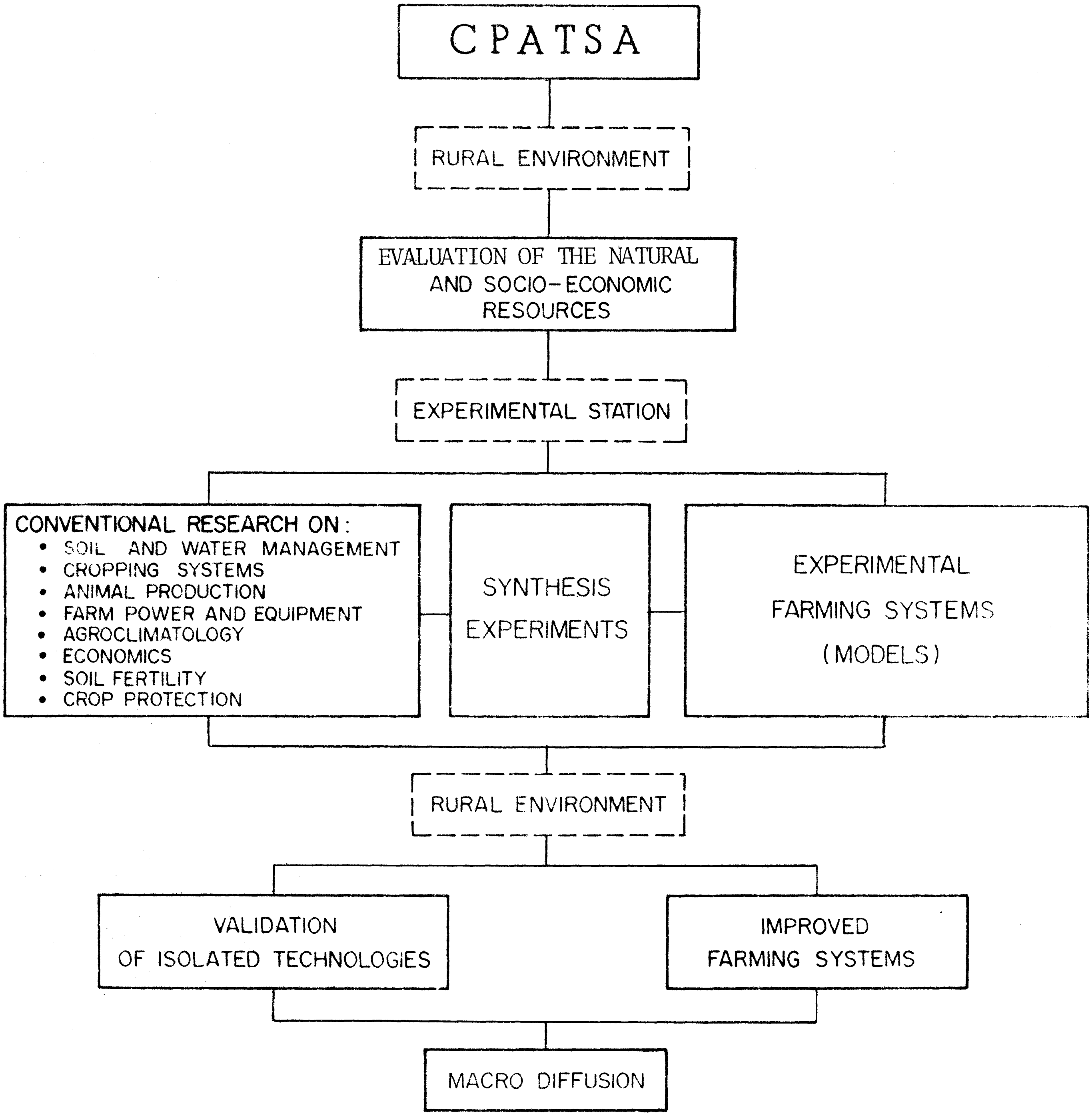

FIGURE 1. Flow chart of the research programme at CPATSA.

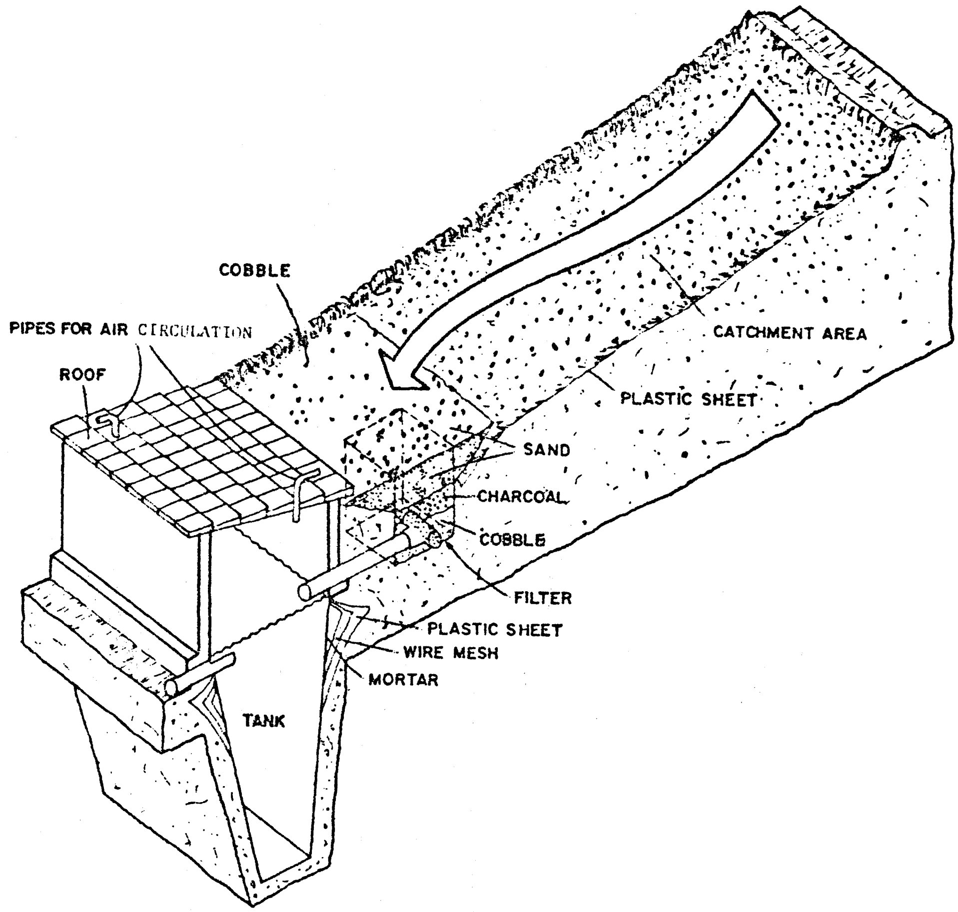

Figure 2. Rural Cistern with Catchment Area in the Ground.

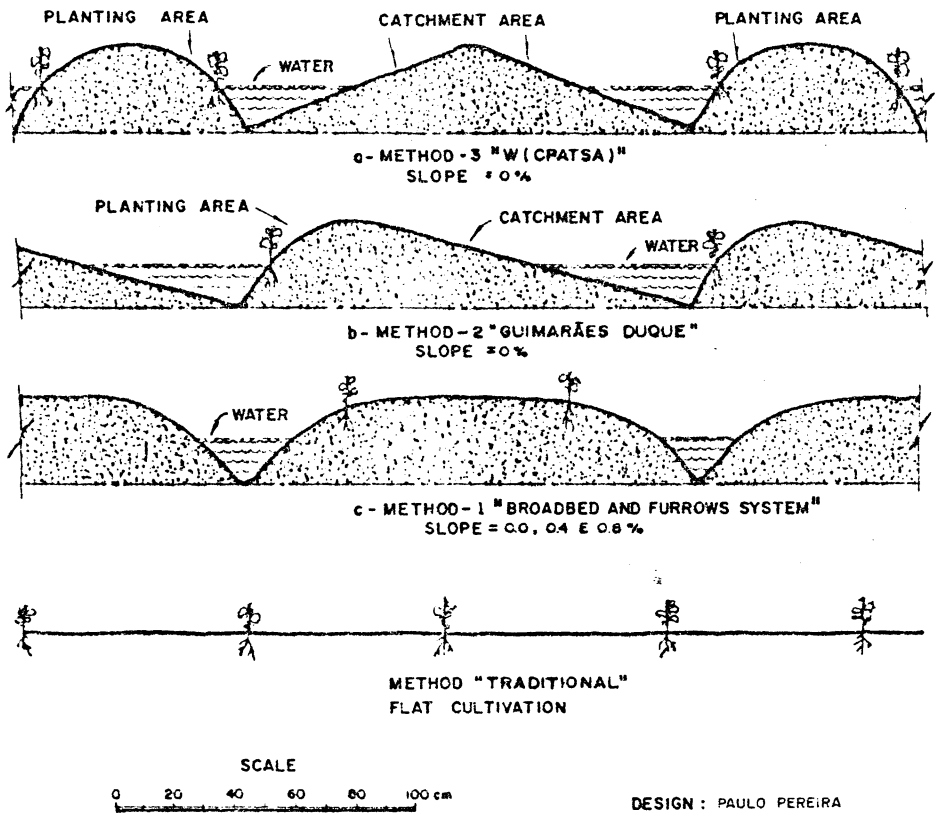

Figure 3. In Situ Runoff Water Harvesting Methods Adapted by CPATSA Designed to Grow Annual Crops in the Brasilian SAT.

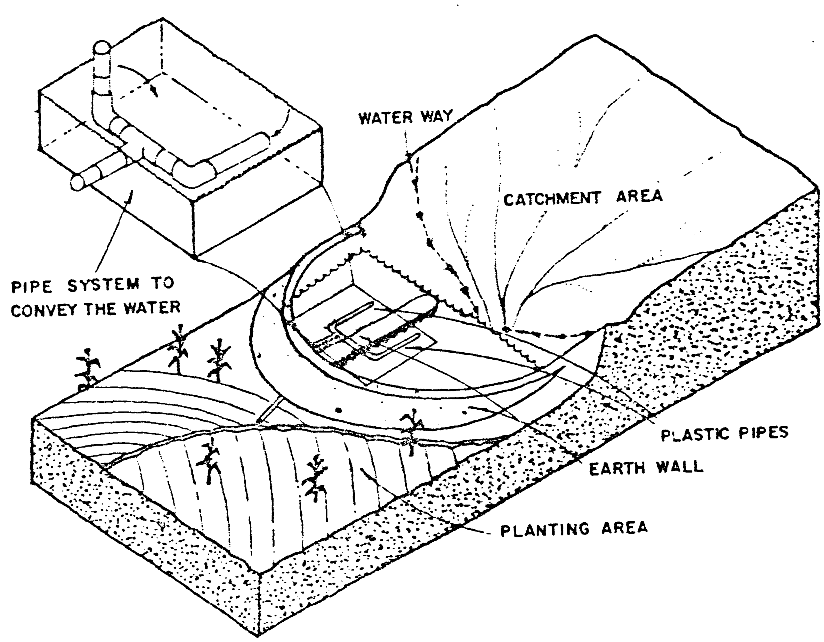

Figure 4. Diagrammatic Representation of the Runoff Water Harvesting System Through Compartmented Reservoir.

Table 1. Production of the Main Crops of Northeast Brazil and Its Relative Share in National Production (Adapted from F. Ibge 1961, 1981).

CROPS	SHARE IN THE NATIONAL PRODUCTION (%)		PRODUCTION OF THE NORTHEAST (1000 t)		
	1960	1980	1960	1980	INCREASE (%)
Cocoa	95.0	94.8	155.4	302.5	95.0
Cotton	48.9	59.1	786.1	798.3	1.6
Cassava	43.4	56.8	7631.5	13324.3	74.6
Beans	28.6	25.6	495.0	501.3	1.3
Sugarcane	35.6	37.8	20234.5	56111.3	177.3
Castor Beans	76.4	55.2	224.7	280.7	24.9
Sisal	99.7	100.0	164.1	235.0	43.2
Banana	30.1	44.0	77.0	197.0	155.6
Maize	11.9	4.1	1027.8	830.5	-19.2
Rice	30.0	15.2	1436.7	1483.5	3.3
Coconut	94.3	95.3	411.7	499.0	21.2
Orange	9.8	8.5	816.7	4623.6	466.2
Tobacco	33.8	18.0	54.6	72.8	33.4
Tomatoes	24.6	18.2	97.7	279.2	185.6

Table 2. Economic Indicators of the Farm "Tabuleiro" (Ouricuri PE) with Traditional Farming System (Value in US$).

ITEM	1983/84	1984/85	1985/86	1986/87	1987/88
1. Gross Income	2,700	3,550	3,740	3,685	4,052
2. Total Cost	3,267	3,323	3,520	3,321	3,506
3. Net Income (1-2)	- 567	227	220	364	546
4. Depreciation	731	731	731	731	731
5. Value of Family Labor	1,723	1,930	1,930	1,930	1,930
6. Annual Investment	---	1,824	29	2,092	782
7. Net Benefit (3+4-6)	164	- 866	922	- 997	495
8. Expenditure on Consumption	1,940	1,940	1,940	1,940	1,940
9. Expenditure on consumption - value of family labor (8-5)	217	10	10	10	10
10. Farm Cash Balance (7-9)	- 53	- 876	912	-1,007	485
11. Payment of Loans	370	76	75	73	71
12. Other Receipts	158	158	158	158	158
13. Final Cash Balance (10-11+12)	265	- 794	995	- 922	572

Table 3. Economic Indicators of the Farm "Tabuleiro" (Ouricuri PE) with the Improved Farming System (Value in US$).

ITEM	1983/84	1984/85	1985/86	1986/87	1987/88
1. Gross Income	3,654	5,293	7,396	7,307	7,852
2. Total Cost	3,248	3,436	3,403	3,235	3,251
3. Net Income (1-2)	406	1,857	3,993	4,072	4,601
4. Depreciation	815	857	880	863	865
5. Value of Family Labor	1,644	1,678	1,512	1,444	1,444
6. Annual Investment	---	1,824	29	2,092	782
7. Net Benefit (3+4-6)	1,221	890	4,844	2,843	4,684
8. Expenditure on Consumption	1,940	1,940	1,940	1,940	1,940
9. Expenditure on Consumption - Value of Family Labor (8-5)	296	262	428	496	496
10. Farm Cash Balance (7-9)	925	628	4,416	2,347	4,188
11. Payment of Loans	370	76	75	73	71
12. Other Receipts	158	158	158	158	158
13. Final Cash Balance (10-11+12)	713	710	4,499	2,432	4,275

Table 4. Initial and Final Value of Capital and the Internal Rate of Return in the Traditional and Improved Farming Systems of Ouricuri Region (PE).

Farm Name and Number	Value of Capital (US$)				Internal Rate of Return (%)		
	Traditional System		Improved System		Traditional System	Improved System	Investment in the New Technologies
	Initial	At the End of the 5th Year	Initial	At the End of the 5th Year			
Tabuleiro 87	11,860	13,307	15,455	17,924	1,9	18,9	61,9

MECHANIZATION IN SMALL FARM SYSTEMS

R. L. Tinsley and M. ter Kuile

INTRODUCTION

Many countries with predominately small farm agricultural systems are placing a major development hope on mechanization. They are expecting this to expedite their agricultural operations, increase yields, and help meet their national agricultural production goals. Mechanization has the potential to greatly increase the farm family's productivity and income. However, the effectiveness of a mechanization program may depend on how much planning is done and exactly what will happen as tractors and other machines are promoted and accepted. This paper will review some informal observations made over nearly a decade of observing small farm systems in Asia and the Middle East. The paper examines how machines are used in small farm environments; how machines affect farm operations; and postulate some questions planners need to consider in determining the best mechanization policy for their country. The paper will pose more questions than provide answers.

CONTRACTED OPERATIONS

In countries where small farm systems have been mechanized, most of the major equipment is available to farmers under contract. A few farmers are able to buy tractors or other machines and they rent the equipment to other farmers. In farm communities where this occurs, the machinery has successfully reduced the farm family's work and drudgery, and increased his productivity. In areas where mechanization has taken place it has taken over as much as 90% of the land preparation work. This has displaced large numbers of draft animals. The displacement of draft animals frees forages for production of animal products or allows forage crops to be replaced with consumable crops.

The use of machinery like many agricultural inputs tends to have relatively short seasons or intensive demand followed by longer periods of lesser demand. In Egypt this was particularly noticeable during the winter-to-summer crop conversion period in May and June. This corresponded to the harvest of wheat and broadbeans and the planting of maize and rice. During this 3 to 4 week period many fields remain fallow past the optimum planting dates, and freshly cut grain is stacked in the village squares waiting to be threshed while continually subject to rat and bird losses. Virtually all of these operations are eventually resolved by tractors, which may be operating 24 hours a day. During the day they will be doing land preparation and at night connected via a belt drive to a thresher for threshing.

Most successful contracting has been through privately owned and operated units. Public sector equipment generally has severe maintenance problems. The contracting of equipment results in several phenoména.

Planning

The need for a farmer to hire a contractor for mechanized work during the peak demand crop conversion periods means the farmer is dependent on an external resource, the tractor operator, over whom there is limited control. This affects their ability to plan the critical activities of land preparation and planting. To evaluate the impact of mechanization the availability of equipment must be viewed as much from the tractor operator's perspective as the farmer's.

Operator's Priority

Suppose a tractor operator has 30 farmers asking for service with fields randomly scattered across the village lands. Furthermore, the operator can only fill 4 requests per day (Figure 1). In what order will the operator proceed to fill the orders? In the order received? Most likely not. To do so would spend most of their time trying to get to the different fields. Suppose further, that the 11th request came from the operator's in-law. Would this influence their decision? Would the operator give priority to the in-law's land and then accommodate those requests near a relative's fields? If so, how can the 3rd farmer, whose land is far from the relatives, plan their basic operations? This could be a real problem for a sociologist to examine.

Tractor Density

The number of tractors available in an area probably depends on straightforward economic analysis from the tractor operator's perspective. Tractor density may be a function of the farmer's returns, which will determine how much the farmer can afford to pay for the services. This sets the price for doing a unit of land. The price per unit of land then determines the number of hectares the tractor operator must work to meet expenses, i.e. the tractor density in tractors/hectares.

If, as commonly occurs in developing countries, the national pricing policy suppresses farmgate prices for agricultural commodities, farmers income will be depressed. This will result in (Figure 2):

- The farmers being unable to pay high prices for contracted work;
- The tractor operator compensates by doing more land;
- The tractor density will be low;
- The time required to finish all the work will be more;
- Planting will be delayed with corresponding yield reduction; and
- Farm income reduced.

A typical example of tractor density may be Egypt where only 4 tractors serve a village of 400 hectares. This would correspond to 200 farmers, or 100 hectares and 50 farmers per tractor. Since a tractor can only prepare 2 hectares per day, it requires 50 days for each tractor to complete the share of the village's land preparation during each cropping season.

The result of this is conversion from summer-to-winter crops or from winter-to-summer crops takes from 2 to 3 months. The planting date for individual crops are usually spread over a month or more. This is usually from just prior to the recommended planting date to 3 or 4 weeks after the recommended plant date (Abdel-Al et al., 1984). In subtropical countries such as Egypt and Pakistan where cropping seasons are fixed by annual temperature variation, or rainfed tropical area where cropping seasons are confined by the end of the rains, delays in planting dates can substantially effect the yield potentials.

Coordination Number

With so few units and so much work to do during these peak periods, the tractor density may define a helpful index, the coordination number. The coordination number is the ratio of the units of equipment to number of farmers seeking its use. The ratio gives the number of farmers whose work the operator must coordinate. It relates to the managerial complexity of mechanization within the farm community. The lower the coordination number the less people are vying for the use of each machine, and the easier the management.

Quality vs Extent

Again, with the limited amount of equipment and high demand for its use, the operators may very rapidly sacrifice the quality of the job for the opportunity to do more land. This could explain why seedbeds of small farms are frequently not as well prepared as experiment stations fields. The "poor" workmanship may not reflect the operators lack of knowledge or skill, but only the pressure from other farmers to have work done. It may also recognize the greatest yield response to land preparation takes place with the first couple of passes, and the response to additional passes is not economical.

The problem could be critical in paddy areas where flotation type equipment is being promoted for seeding, transplanting, or subsurface fertilization. The flotation equipment requires good final land preparation. This is possible on experiment stations but may not be duplicated under normal farm conditions, where even simple flotation equipment like row seeders have had only limited success.

Another example could be wheat establishment in Egypt. Most wheat is planted from mid November to mid December. Early in the planting period, the land is usually well prepared, with possibly some land leveling. Seeds are broadcast and worked into the soil with a large plank. However, as planting becomes delayed into December, the "proper" land preparation may succumb to a more rapid broadcasting of seeds onto the stubble of the previous crop and chiseling with one pass of the tractor. Farmers and operators are now opting for greater extent. Most likely this is a sound economic decision. The yield lost to delayed planting may now exceed the loss from poor land preparation.

Adoption Potential

The use of contract equipment vs self owned equipment may affect the manner in which technology is adopted within a farm community. This would be particularly true of technology with critical timing components such as double cropping rainfed rice in the Philippines. In rainfed areas of the Philippines like the IRRI, Iloilo cropping systems area, each farmer owns their own power source, a single buffalo. Working alone with their buffaloes the farmers may take up to 4 months to prepare all their rice lands. In doing so they may use several different techniques and have their planting dates scattered over several months (Figure 3). They can only adopt the double cropping technology on those fields they establish early. Thus, with internally held resources, there is greater diversity within farms than among farms. Many farmers are able to adopt the desired technology, but only on a limited part of their holdings.

In contrast, in parts of the Mahawali area of Sri Lanka, most of the land preparation is done by contract tillage, using either large 4-wheel tractors or small 2-wheel hand tractors (Figure 4). When the tractor arrives it does all of a farmer's paddy lands. However, it still takes an extended period for the tractor to meet the entire communities' needs. Under these situations only a limited number of farmers are able to plant on time, but they will do so on essentially all their paddy lands. Thus, with external resources, there is greater diversity between farms, than within farms. In either case the incomplete acceptance of technology was not a matter of risk avoidance, or lack of desire on the part of the farmer. It was simply a matter of mustering the power resources.

Community Evaluation

When work is being contracted, the equipment must meet the needs of several members of a community. This requires time, and forces the evaluation of the cropping system on a community basis, instead of an individual farms basis. In reality, the operational units within the community are the few large amorphous farms defined by the area served by each piece of equipment (Figure 1). These amorphous farms can be highly fragmented, and scattered over the entire community.

Policy Consideration

If most of the machines are going to be contracted, government planners may want to consider who would be the best group to own and operate the equipment. The credit system could then be modified to actively encourage the target group to obtain machinery. With mechanization it may be more desirable to encourage equipment ownership by the smallest farmers in the community. The contracting would provide an extra employment opportunity, and promote more economic equality within the community. This would be in contrast with the Egyptian policy of providing mechanization credit only to the farmers with more than 4 hectares, and assuming the machinery will be used most for the owner's own land[1]. When contract work opportunity is provided for the larger farmers, the additional employment could generate additional economic inequality. The large farmers should be able to finance their own equipment purchases.

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[1]Tarik Tawfic, Personnal communication.

FARM SIZE, FIELD SIZE & TERRAIN

In using machinery on small farms or planning its introduction practical considerations are:

- are holdings large enough to have sufficient economic returns to afford mechanization,
- how easily can the equipment get to the fields, and
- how efficiently will equipment operate once in the field.

Farm Size

It may be necessary for the farm holding to be of a minimum size in order for the farmers to be able to afford to mechanize. The minimum size would probably vary among different countries as a function of national economic policies regarding farm prices, etc. In Sri Lanka, two settlement schemes on adjacent tanks, but with different acreage allotments had totally different mechanization patterns. In the schemes with 2.3 hectare paddy allocations, 15 of 18 farmers used tractors to prepare their land. In the other scheme with 0.8 hectare paddy allocations only 2 of 18 farmers used tractors (Tinsley et al., 1983). Of the two areas, the scheme with the larger holding was able to get their land prepared and planted about 2 weeks faster by using tractors, despite having more than twice as much land to do.

Access

In many small farm communities the people live in villages with the fields surrounding, instead of on a homestead within the farm. The actual parcels of land are adjacent to each other, without roads or paths along property lines. Many fields are cut off from tractor accessible roads.

A study on land access in Egypt showed most farmers do get equipment to their fields at some time during the year, but it could require substantial effort (Figure 5). The Egyptian farmers and tractor operators would access different fields by going across fallow fields, driving along the field canal with one wheel on the canal bank and the other 1m into a neighbors crop, or fording the canal on temporary bridges made of crop residues. None of these are really desirable and risk being cut off by a sudden irrigation, or planting of a fallow field. The large water courses of the irrigation system should provide some access along the maintenance roads, but washouts, spoil piles left from cleaning operation, etc. reduced the access along these routes. It is estimated that 50% of the tractor's running time is consumed just in getting to and from fields.

In other areas, terrain features could severely restrict access. In the ancient Philippine rice terraces of Banue, virtually all work is done by hand. The slopes are too steep to get any form of equipment to, even buffalos. Likewise, the coconut lands in Quezon, Philippines can only be serviced with ponies and saddle bags. Even in the Iloilo rice producing areas the large paddy bunds could only be transversed by special buffalo drawn sleds, during the fallow dry season. These sleds were used to transport rice to main road and market. Mechanized land preparation in the area had only limited acceptance. However, once a small portable thresher was available that could be hand carried to the field along the bunds, it was rapidly accepted throughout the area[2].

Operating Efficiency

Once a tractor gets to the field its operating efficiency will largely depend on the ratio of running time to turning and backing into corners time. For a 1/2 hectare field it has been estimated that about 25% of the time will be spent turning[3]. This loss in efficiency combined with the 50% portal-to-portal time mentioned earlier gives an overall operating efficiency of 40% or less. This is why tractors can only do 2 hectares per day and cannot afford to waste time running all over the community to service requests in the order made, but may serve only those fields nearest the first field done each day. These problems of operating efficiency could contribute to substantially less work being done by each tractor than planners originally expected. For example 2-wheel tractors in Sri Lanka were estimated to work 11 hectares in 4 weeks. However, studies showed they actually only did 6 hectares in 8 weeks[4].

FOUR WHEEL OR TWO WHEEL TRACTORS?

If the availability of tractors is dependent on importing ready made units, and this in turn depends on government policy for imports, some consideration should be made for the relative merits of two-wheel vs four-wheel tractors. Two-wheel tractors are hand held tractors in which the farmer walks directly behind the tractor. Most units have rototiller blades and can have a large assortment of implements. They are usually 8-14 horsepower, powered by single cylinder diesel engines. They are used extensively in small farm complexes of Japan, Taiwan, Korea, and Sri Lanka as well as the islands of Crete and Rhodes. Four-wheel tractors are the larger riding tractor with 4 fixed wheels, etc. In developing countries they usually range from 35 to 65 horsepower. In developed countries they can exceed 100 horsepower.

In evaluating the two types of tractors, consideration should be given to the potential density and coordination number. For a given amount of investable capital, more 2-wheel tractors can be purchased than 4-wheel tractors. This reduces the coordination number and allows the tractors to move in more directions at the beginning of the day. Fields are more accessible to 2-wheel tractors, because they are narrower and can move on a smaller path. Usually a 2-wheel tractor, even when pulling a small trailer, can operate on paths of 1.5m, while a 4-wheel tractor will require 3m. Once in the field, the 2-wheel tractors will spend less time turning and backing into corners, and thus have a more efficient

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[2] H. Zandstra, Personal Communication.
[3] N. Illsley, Personal Communication
[4] J. Waheb, Personal Communication

running time. However, they are slower and may not have enough draft power to work in some very heavy soils.

An important aspect to consider is transportation. Both 2-wheel and 4-wheel tractors are usually equipped with trailers and used for hauling goods when not doing field work. However, the 4-wheel tractors are rarely used for hauling agricultural commodities (neither products or inputs). Usually the larger tractors haul commercial loads of bricks, soil, rock etc. In contrast the 2-wheel tractors usually haul agricultural commodities. Marketing milk, hauling seed, and fertilizer to the farm or fields, grain to government markets, and even bussing people along rural roads are common transportation uses for 2-wheel tractors. Somehow the 2-wheel tractor is better suited to the transport needs of small farmers.

In Egypt, the donkey may remain an essential part of the farming system for lack of a suitable alternative for transport. The donkey is now used almost exclusively for transport. They consume large amounts of forage that could be used more productively.

The complete evaluation of when 2 or 4 wheel tractors are best suited for a given small farm environment will require solid economic analysis, taking all things mentioned above into consideration.

ORDER OF MECHANIZATION

Is there a predictable order in which farming operations will be mechanized during development, with some minor variation depending on local physical or economic conditions? In most cases, the first operation mechanized will be land preparation. This bring tractors into an area. Next will be transportation by the simple addition of a trailer to the tractor unit. Most of the transport work will either complement the land preparation work or be done during a non conflicting period. The land preparation and transporting may be the initial limit of tractor field work.

After land preparation and transportation, spraying and threshing become mechanized. Spraying because there is not a non-mechanized means of easily applying liquid pesticides. Threshing because it represents a peak period of hard work when labor is frequently short, and the equipment can do a more complete job. Both operations can use power units separate from the tractor. The spraying is usually done by any of a multitude of pack-back units. This includes those operated with small high revolution engines. Threshers require a medium size power unit which may be supplied by either independent power units or the belt drive of a larger tractor. In double cropping systems, this could result in a conflict with use of the tractors for land preparation as mentioned earlier with reference to Egypt.

If water is available, pumping may be the next most urgent operation to mechanize. It would most likely be a separate power source. This may be followed by mowing. In Egypt, mowing is the current request, but it may be a result of local economic conditions which place a premium value on straw and the need to cut it as low as possible. Transplanting of rice is being encouraged in many areas and succeeding in tropical irrigated areas. It is also being encouraged in Egypt but is doubtful of success. Most rice transplanters require young seedlings. However, in Egypt the transplanter needs 60 days of transplanting each year to be competitive with hand transplanting (Tinsley and Ley, 1983). Cool temperature on either side of the rice growing season make 60 days of transplanting with small seedlings impractical. The late planted seedings will not have time to mature before cool temperatures cause too many sterile grains. Likewise the use of planting drills may be a low priority. Their use will conflict with the simultaneous high demands for land preparation on other farms, as discussed at the beginning.

PROMOTING MECHANIZATION

Encouraging farmers to accept some types of mechanization may require having a good understanding of some of the subtleties of the farming system. It may require promoting the equipment for reasons other than the designers primary intention. This may be the case of introducing threshers in the Philippines. In the Philippines, the turnaround period between rice crops was a uniform 60 days throughout the islands, with no replanting being done until all fields were harvested and threshed. This was because labor for harvesting and threshing were paid in-kind at 20% of the crop. Payment is made immediately at the end of the day. With the advent of high yielding varieties, the in-kind wages for harvesting and threshing greatly exceeded those for planting or other activities. Threshers could easily expedite the harvesting activity, allow earlier second crop planting, and higher yields; but only after a sizable amount of the area was mechanically threshed. Since the entire community had to finish threshing before replanting, one or two farmers buying threshers to expedite replanting would not have a significant impact. Threshers were successfully introduced on a large scale, but the initial reason for acceptance was because it did a cleaner job. The labor agreement was then modified to give the workers 15% and the thresher owner 5% of the yield.

FARMERS INNOVATIONS

Sometimes the interest of the farmers in mechanization can be seen from the innovations farmers develop themselves. An example would be Victor Quiban in Pangasanan, Philippines. He is a small farmer who manages 1.5 hectares of rice land. He developed a thresher made almost exclusively from bicycle parts. His thresher is lighter, just as durable and much easier to repair than some trudle threshers commercially available. However, when mechanization engineers examined his thresher, they were not interested in promoting it. It was too simple for commercial production. Victor also made a well point which he and 5 neighbors used to punch through about 4 meters of clay. Below this was a sand and gravel aquifer from which they could pump enough water to irrigate vegetables during the dry season. The wells were never "developed" or lined, but a piece of bamboo placed in the opening to show the location. Once, when his pump broke he simply took his hand pump from his domestic well, put it in his irrigating well and ran two hoses to his crops. At the end of the day he would connect his pump motor to a generator so he and his neighbors could relax and watch TV. It only takes one farmer like this to keep a community dynamic and working at the limits their resources will allow.

SUMMARY

In planning and promoting successful mechanization programs that will support national development objectives, careful attention must be given not only to "appropriate" type but also to how the machinery will fit into the system. Included in this are government policies that will encourage mechanization. Such policies may include:

- Pricing as it affects equipment density,
- Size of holdings that would provide sufficient returns to afford mechanization,
- Credit that encourages the desired people to buy machines,
- Importation of 2-wheel vs 4-wheel tractors, and
- The order in which operations may be mechanized.

Another thing that needs to be considered is how the different types of machines are to be successfully promoted. This may well depend on observing innovations that farmers develop for themselves.

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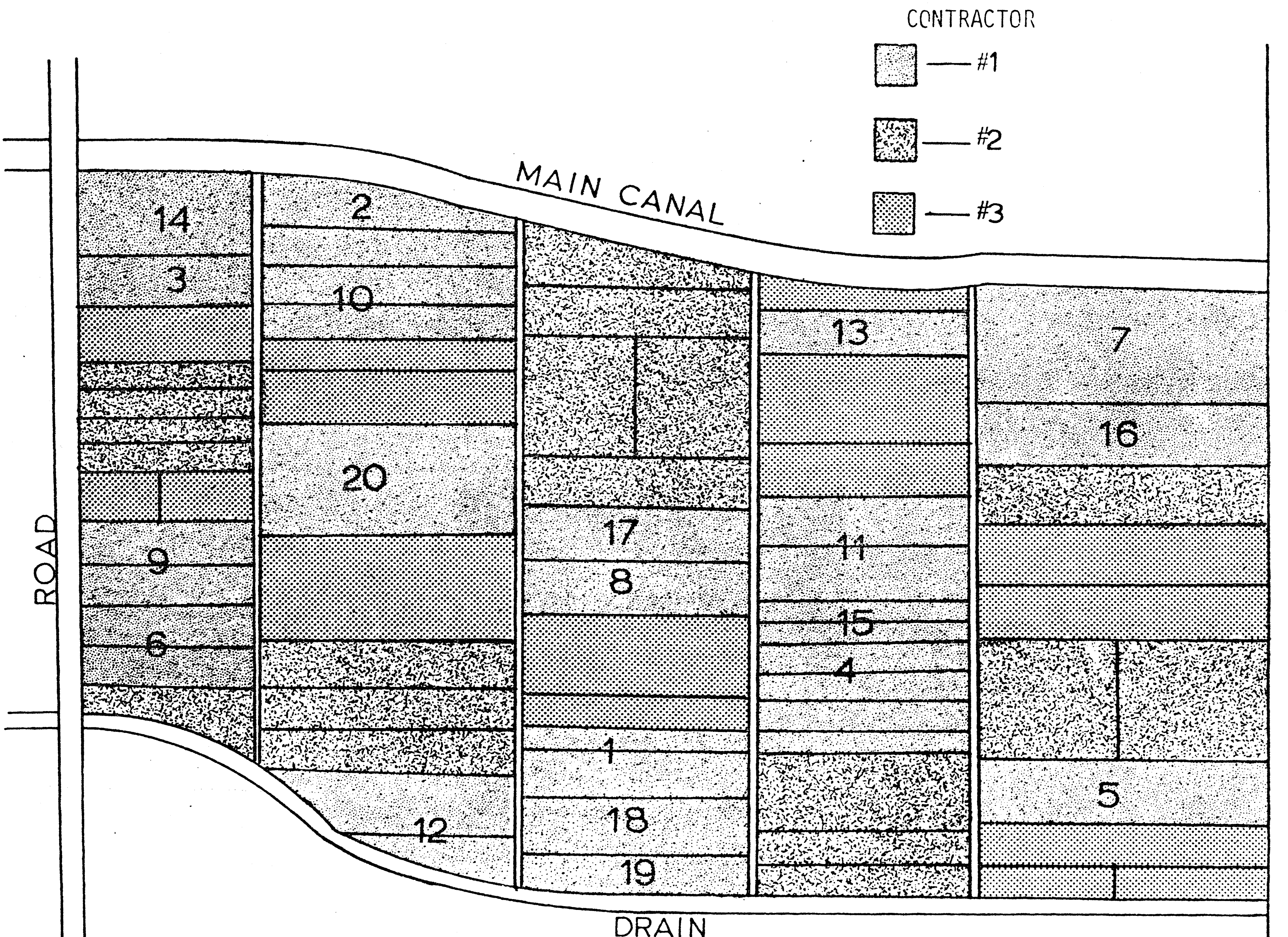


Figure 1. Hypothetical Farm Situation

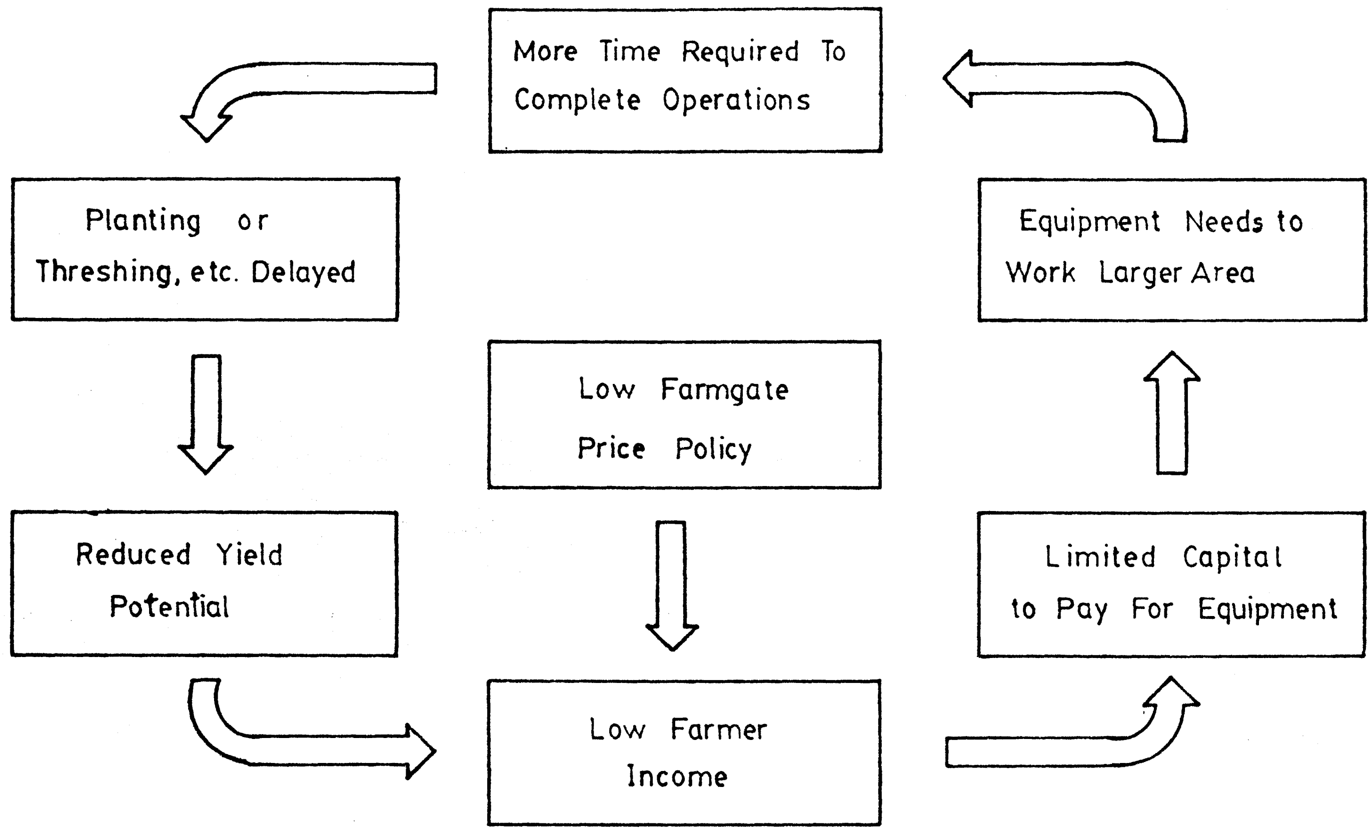


Figure 2. Possible Impact of Price Policy on Mechanization and Yields.

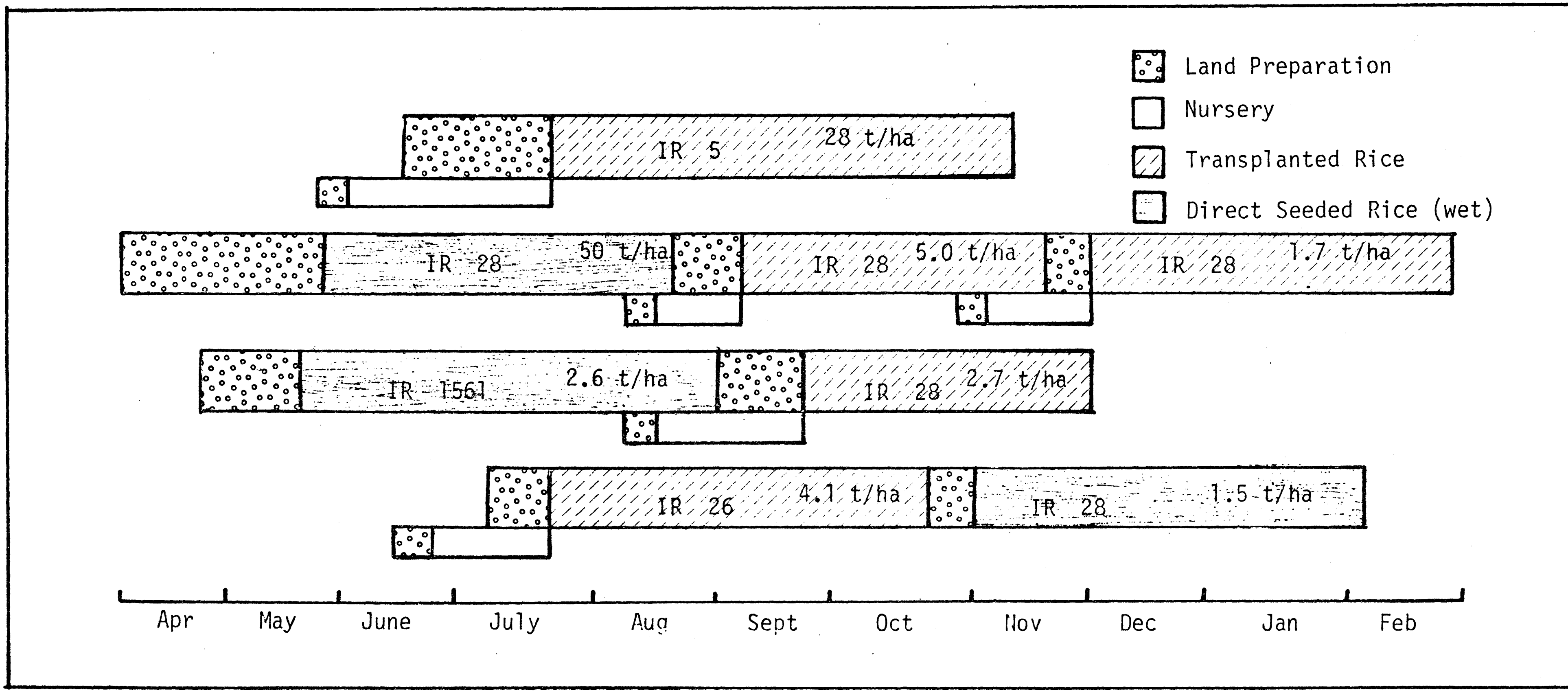


Figure 3 The land use of L. Tiquison on his four parcels of land during 1975.
Adopted from IRRI 1975 Annual Report.

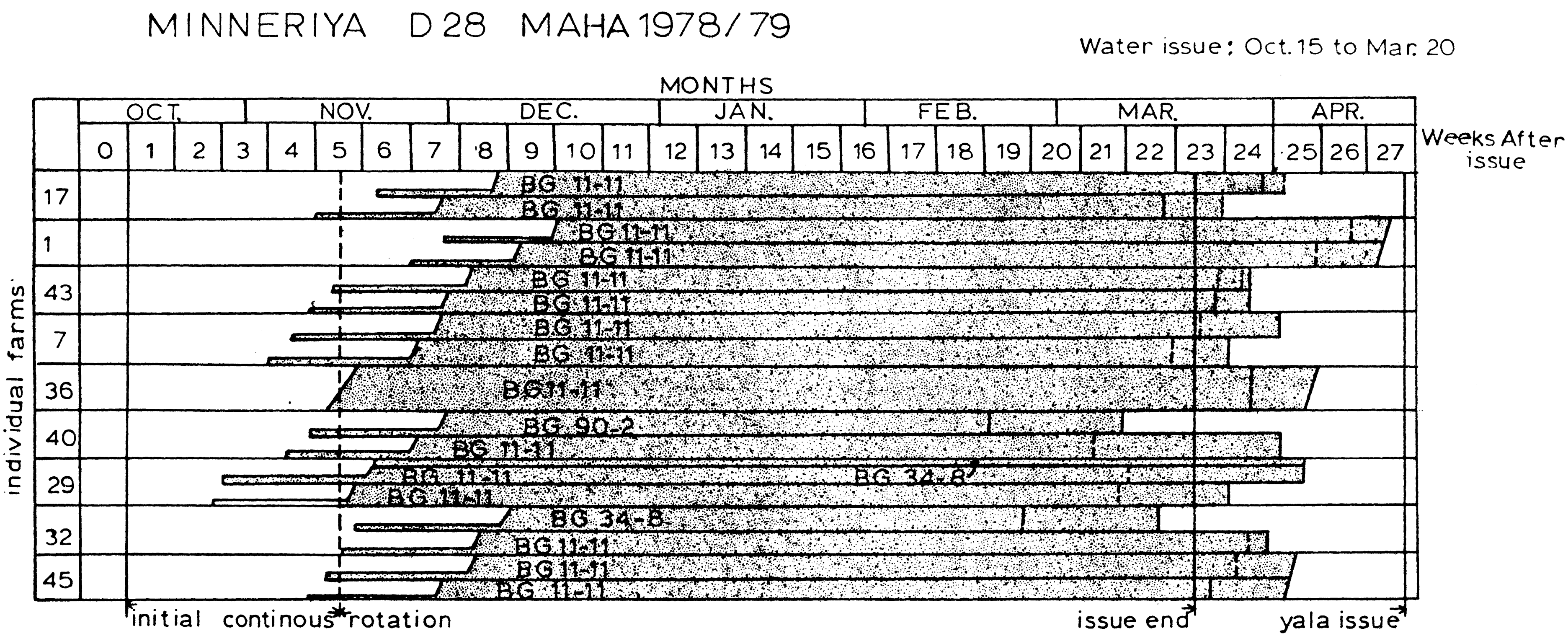
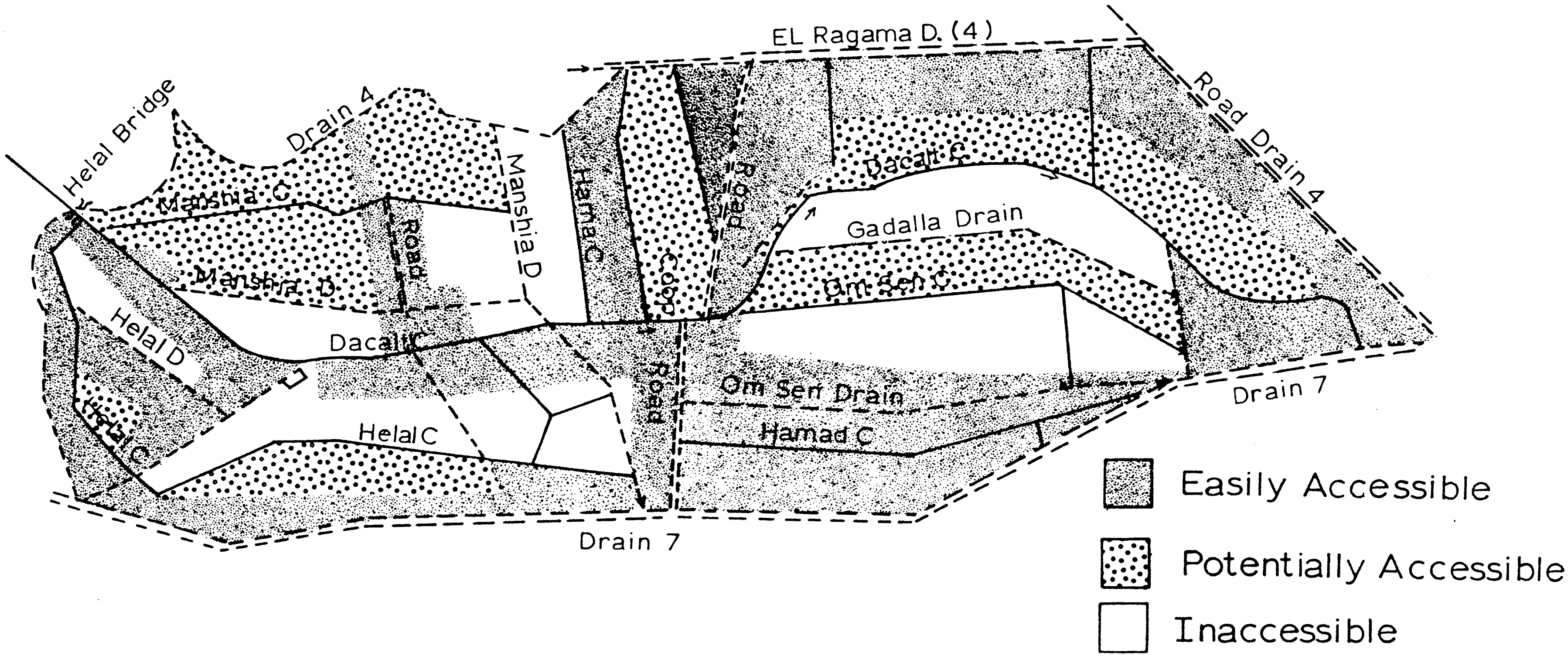


Fig. 4 Land preparation calendar for the Mahawali area of Sri Lanka.

Fig. 5   Tractor Access to Farmlands in ABO RAIA, Egypt



MONITORING

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ECONOMIC ANALYSIS WITHIN THE FARMING SYSTEM RESEARCH AND TECHNOLOGY DEVELOPMENT METHODOLOGY: AN EMPIRICAL APPLICATION IN CENTRAL AMERICA

German Escobar

INTRODUCTION

The Tropical Agricultural Research and Training Center (CATIE) has been working on programs that are on-farm-oriented and which attempt to integrate an understanding of the farmer's production systems and their economic rationale, since 1974 with small farmers in the mandate region: Central America, Panama and recently, the Dominican Republic. The research approach, often called Farming Systems Research (FSR), has been complemented with narrowly focused Technology Development (TD) activities. In cooperation with different national and international organizations, CATIE has established several working groups in areas representing the dominant ecological conditions of the region.

The objective of this paper is to discuss the role and contributions of applied economic analysis to the FSR/TD general methodology as practiced by CATIE. Our working methodology is under constant adjustment as the empirical results from different areas are incorporated into all phases of our methodology.

This paper summarizes our experience with the application of economic analysis to our FSR/TD methodology focusing on a specific technological problem in the humid lowlands of the Atlantic region of Costa Rica. The first section describes the general methodologies approach of FSR/TD as established by CATIE. The second part describes the application and contribution of economic analysis to each phase of the FSR/TD methodology. Empirical results illustrate the second section, including estimates of adoption by farmers.

METHODOLOGICAL FRAMEWORK

The general FSR/TD methodology that CATIE has assembled is based upon field work with small farmers; analysis and further conceptualization are built on that empirical analysis. Nevertheless, due to the great variability on both ecological and socioeconomic environments within CATIE's mandate region, our methodology must be presented in general terms, leaving details of the adaptation to the area's implementation team (Escobar and Moreno, 1984; Moreno, 1984). Thus, it has been essential for us to formalize a general theoretical construct to use as a guide for our field teams.

Figure 1 gives a static representation of the major components of CATIE's working methodology. Both the FSR and TD activities are contained implicity in this overview. FSR emphasizes the physical unit of production organized in a hierarchical manner (region, farm agroecosystem, and crop systems levels) as well as a dynamic record keeping program, while TD emphasizes technology design, on-farm trials, basic supporting biological research, and the validation phase. The diffusion phase is the application of the previous effort and depends on the appropriateness of the technological alternative. This phase includes specific extension and communication techniques to be supplied by specialists within the multidisciplinary implementation teams.

The target systems level is the farm (production unit) which includes specific cropping, animal or mixed production subsystems. The objective is to develop improved production technologies tailored to the farmers's specific circumstances. This implies that technological alternatives must be effective with respect to the physical, biological, and socioeconomic characteristics at both the regional and the farm level.

The area selection is completed by combining a set of selected indicators to assign priorities according to both technical and socioeconomic circumstances. A revision of secondary source data is usually performed for selecting the working area, and specific criteria is defined with national agricultural authorities, as well as researchers and extensionists with experience in the potential working areas.

The characterization phase is intended to provide a fairly detailed information of the farm as the target system for research and technology development. In order to better understand the farm system, a hierarchical order which includes the area and the agroecosystem is established for characterization of the main technical, ecological, social, and economical relationships. Direct data collection is usually required subsequently to determine such characteristics.

The process of alternative technology design begins with the theoretical construction of production alternative technologies, such as changing the chronological or space cropping arrangements of a given production system, adding or subtracting new species, or changing production inputs. Further on-farm experimental trials enriched with the knowledge obtained from the supporting biological research and the dynamic record keeping activities test such designs establishing a cycle which repeats itself up to the moment in which an agroeconomic viable alternative to farmer's cropping systems is sustained in the field.

Promising technological alternatives go to the validation, which tests these alternatives with a larger number of producers under the farmer's own management at a semi-commercial level. Successful alternatives (as compared to the levels of production achieved by the existing technology of the region's own farmers) are subject to a continuous monitoring of selected farmers in order to generate further data for evaluating the adoption of improved technologies. Technologies that appear successful by the above criteria according to our validation phase are selected for massive diffusion to the small farmers. Technological alternatives with inferior production or economic results, are subject to additional tuning through research efforts, and should successfully complete the validation phase before massive diffusion.

Economic analysis is used at every phase of the FSD/TD methodology. The functions of this analysis are twofold: assessing the farmer's own economic rationale for allocating production factors within his own production constraints; and evaluating TD to ensure that technological alternatives provide farmers with higher production and/or productivity levels than the traditional technology while conforming to regional and farm limitations, as well as the farmer's objectives. Such analyses include farm management and production economics applied to the farm and the agroecosystem levels, cost effectiveness, budget, and microeconomic analysis focused on evaluation of the appropriateness of the new technological alternatives to the farmer's production limitations.

The role of economic analysis is not familiar to most agricultural scientists who tend to be oriented toward more specific technical problems. For this reason, the implementation of the FSR/TD methodology requires multidisciplinary teams that bring scientists, economists, and extensionists together. In the same sense, the economic analysis must be simple because the methodology must be reproducible at the field level by various national institutions who generally work under limitations of time, money, and technical expertise. Moreover, it has been demonstrated that the simple microeconomic evaluation procedures applied to cropping systems research yield the same essentail results as more sophisticated quantitative oriented economic analysis (CATIE, 1979).

EMPIRICAL APPLICATION

The case that we use to illustrate the role and contribution of the economic analysis within the FSR/TD methodology deals with the development of a technological alternative for weed control and land preparation applied to a maize production system. This case involved technical expertise and support from both CATIE and the International Plant Protection Center (IPPC) of Oregon State University (Figure 1).

Area Selection

The North Atlantic Zone of Costa Rica was identified in conjunction with the Central government of that country as a region with particular agricultural problems. Three main selection criteria were established for final selection: presence and characteristics of small farmers, technological potentiality of the area for improvement, and convenience and concordancy with the national agricultural policy. After separation and qualification of these criteria, the districts of Guacimo and Pococi were selected for the FSR/TD project implementation.

Characterization

Data from both secondary and primary sources were used to characterize, using a hierarchical systems approach, the area, farm, and maize cropping systems (Banta, 1982 and Escobar, 1981). This region has elevations from 40 to 300 masl, and flat topography. The climate is humid, with annual precipitation ranging from 3200 to 5000 mm and temperatures ranging between 25 and 27^{o} C. A major sociological attribute to the region is the existence of an agricultural frontier under expansion, with strong land concentration due to the presence of large banana plantations (Ginni coefficient 0.771). Nevertheless, there exists an important small farmer subsector (65% of farms are smaller than 20 ha) with an average area of 17.4 ha.

Labor for agricultural production appears to be a critical factor limiting regional production due to demand for labor in banana plantations. This issue also was detected at the farm level, and it affects the total land area under production. The intensity of labor use is correlated with the precipitation distribution pattern (Figure 2).

Small farmers devote the most productive land to livestock and annual crops for which a fairly adequate supply of both inputs and credit exists. A market for maize is guaranteed by a government program, but this is not the case for dairy products. At the time this project began, a difficult access road existed, but a new main highway for rapid access to the national capital is under construction.

At the small farm level, approximately 39% of farmland was in fallow, 32% in pasture 17% in annual crops, and 12% in perennial crops. Land in maize represented 77% of the land in annual crops. The average farmer plants 3.6 ha of maize in the first cropping season, and 1.2 ha in the second season for an average area of 2.4 ha per year. Other important agricultural products in addition to livestock and maize are cassava, maize and cassava grown together, and other root crops. Cocoa, peach palm, and plantain are the most common perennial crops (Escobar and Moreno, 1984). Family labor provides about 50% of the total labor used in the farm. The level of technology used by various farmers was highly diverse, perhaps as a result of the relatively recent agricultural development of the region. The farmers are from different places of the country, each with different technologies and agricultural customs developed in a large variety of ecological environments. Farm income is derived basically from livestock and maize-based cropping systems: net maize income represents about 58% of total net farm income, suggesting its economic importance.

Crop losses due to aerial insects are very small, but precipitation levels appeared to be a major constraint with maize production, especially during the second growing season. Credit supply and commercialization channels were not determined to be important constraints to maize production.

Weed control seemed to be the main production problem at the maize cropping systems level. Approximately 45% of total labor is used for weeding, and 40% of cash expenditure goes to herbicides. We defined agroeconomic constraints in terms of our hierarchical characterization: labor supply was short at both the level of region and farm; weed control was the major limitation at the cropping system level. These were constraints that were necessary to take into account when designing any technological alternative.

Alternative Technology Design

The diagnostic from the characterization phase suggested that we concentrate our efforts on vegetation management improvement, with the possibility of deriving new technologies useful in several cropping systems. Weed control techniques practiced by farmers were related to soil preparation patterns. These two aspects were selected to focus technological improvement in the subsequent methodological problems.

The initial design to introduce changes only on vegetation management practices was maintained for four years, but some other production components were incorporated from time to time in response to results from on-farm experimental trials. For example, new maize varieties and fertilization levels were added in several experiments and soil insect control became a permanent component of crop management along with weed control practices. CATIE's agricultural scientists grouped the small farmers according to the predominant type of weeds, and the soil preparation techniques (e.g. mechanized vs non-mechanized, annual weeds vs perennial weeds) for on-farm experimental trials.

Moreover, CATIE in collaboration with other international agencies, decided to develop a more comprehensive set of technological alternatives using vegetation management and soil preparation technology as a part of the more complex alternative. The vegetation management experience is the subject of this analysis in order to keep it simple and more illustrative.

On-Farm Experimental Trials

Immediately after the design phase several experiments were conducted on the farms located throughout the working area. Table 1 is an example of the type of experiments done and the basic economic results obtained.

Results of the experimental trials for each cropping season were analyzed for economic effectiveness in a very straightforward manner, including estimates of: 1) net income; 2) production return to cash and labor invested; and 3) farmer's reactions to experiments they helped to conduct. These simple indicators were compared with similar estimates for the farmer's own existing technologies on their own maize plots, as well as with baseline comparison data obtained during the characterization phase. Data from the dynamic farm record keeping should feed these analyses, but at that time the methodological development did not include this activity.

The technological alternative was approved for the validation/transference phase if the trial results were found to be significantly higher than those for the farmer's own fields, reasonably stable over time, and reproducible at various sites. Economic analysis was applied to help decide which of these treatments yielded the most promising results on actual farms. An example of the application of this analysis is given for the case of technological alternatives for perennial weed control in Figure 3.

We estimated a production function using a two variable regression fit to all comparable experimental results during almost four years of experiments. Cost functions were derived from this data and the optimum production level was estimated, as shown in the bottom part of Figure 3.

We found that five of the experimental treatments gave results that were not significantly different from the theoretical optimum level of 3988 kg/ha within the 95% confidence interval of this, assumed normal, yield distribution. These data are shown in Table 2. Since fertilization levels did not contribute to yields in these particular experiments, treatments 1 and 2 became similar and the cheapest alternatives among the optimum experimental results.

Comparison of several economic indicators demonstrated the advantage and the attractiveness of the selected treatment. As given in Table 3, the least cost optimum alternative (treatment 1 or 2 in Table 2), the average of all optimum treatments, and the lower yield replication of the least cost treatment, compare favorably in every indicator to the most common farmer's technology for the maize cropping systems.

We included in the simple economic analysis an estimate of the cost constrained net cash income maximization, using the local bank maximum maize production loan to cover variable costs which does not include labor costs. We evaluated this hypothetical situation to account for farmers with no working capital and no family labor. In this case, farmer's actual technology appears slightly superior in all indicators by the rate of return to cash costs.

Validation

Following the methodological sequence, we initiated the validation phase in the first cropping season with 35 farmers who planted maize under the technological alternative of weed control and weed control + insect control with plot size of 1000m2 each. At the same time they conserved their own technological pattern in the rest of the land devoted to maize. Data summarizing basic agroeconomic results in the first cropping season are given under columns headed with A in Table 4.

The technological alternatives including insect control and the use of fertilizer, in addition to the weed control, did not yield economic results that appear attractive to small farmers. For this reason, we recommended to continue on-farm experimental trials to tune-up such an alternative. This issue materialized the feedback process between the experimental trials and the validation phase, demonstrating the contribution of both the validation trials and the simple applied economic analysis as a decision-making tool.

Due to the evaluation of participating farmers and the available experimental support, during the second cropping season we submitted to validation trials a technological alternative combining the weed and the soil insect controls, while we kept the weed control and the farmer's technology in the same fashion of the first cropping season. Corresponding data appears in the columns headed with B in Table 4. In general, the overall comparison does not show significant cash income differences among technological alternatives, but the farmer's production strategy for this season is far less expensive than the two proposed alternatives. These findings suggested that not all technological alternatives yielded the expected agroeconomic results obtained during on-farm experimental trials. Based on these data, the weed control alternative was selected as the only promising validated alternative for the first cropping season which happens to be the major maize season of the year.

Further analysis of the validation trials included the separation of results in Table 4. We learned that the weed control alternative presented differences according to the predominance of annual or perennial types of weeds in each farm: perennial weed control requires a higher cash expenditure and returns to input costs are lower than those obtained in annual weed control (Escobar and Shenk, 1981).

The former differences became evident when the promising alternative is compared with the farmer's own technological pattern. As presented in Table 5, a partial budget analysis for the proposed alternative shows a negative additional return in farms with predominant perennial weeds, while the rate of return on additional costs is about 60% in farms where annual weeds are predominant.

From the previous analysis, we concluded that as far as the cropping production systems is concerned, the only technological alternative feasible for farmer's implementation is the weed control alternative for farms in which annual weeds predominate. All other alternatives examined in the validation trials as well as the perennial weed control, must return to the design-field research process. Another validation round will be needed before these alternatives could be released for massive diffusion to farmers.

Dynamic Farm Records

This activity was completed during the validation phase although it is designed to feed all TD phases. In the case of the Costa Rica Atlantic zone, the methodological development was not completed as presented in Figure 1, by the time of the on-farm trials implementation.

The farm record consists of an input-output set of data recorded through weekly visits during the two validation cycles, and sparce visits to participating farmers in the following cropping year for monitoring adoption of weed control practices.

Two basic products are obtained from these farm records: a) the technical coefficients of every farm production system; and b) the evaluation of farmers who have totally or partially adopted the weed control techniques to which they were exposed during the validation phase. The technical coefficients permit the evaluation of the technological alternative within the entire farm system context as implied by the selection of the target system for the FSR/TD activities. The record of adoption of the technological alternative allows the orientation and planning of the technology diffusion by the corresponding national extension institution.

The role of economic analysis is more active in evaluating the appropriateness of the validated technological alternative at the farm system level. However, the selection of an evaluation method simple enough to be repeated by field teams is very important. Economists could approach such an evaluation from different perspectives utilizing fairly sophisticated analytical tools. For this specific case we decided to follow the simplified programming method due to its simplicity and the actual reliability, since there is no major reason to expect very different results by using other linear analytical methods.

The results of the programming presented in Table 6 include the technological alternative for maize production in plots where annual weeds are predominant. It must be mentioned that the evaluation at the entire farm level as shown in Table 6 did not allow variations in perennial crops; we assumed, for simplicity, that decision and investment in perennial crops are not likely to be changed in the short run, due to the nature of the production activity. Nevertheless, accounting for all annual crops and livestock, the optimal farm plan includes the weed control maize production system for the first production cycle, but kept the farmer's traditional technology for the second cycle; these results are consistent with the economic evaluation of the results obtained from the validation phase.

The reliability of this programming technique was checked by a linear programming algorithm with the same basic results in terms of the activities included with optional farm plan solution. (Escobar and Moreno, 1984). From the applied economic analysis viewpoint, this is a meaningful result since the simplicity of the manual programming brings about the capacity of replication of the analysis, keeping in mind the restriction and limitation of the linear models.

The other major concentration of the farm record keeping is the monitoring activity which is intended to evaluate the adoption of specific production techniques by those farmers who were exposed to the technological alternative during the validation phase. Data recorded during the following cropping year allowed the classification of farmers into four adoption groups, as shown by the bars in Figure 4. This classification goes from a group of non-adopters of any of the recommended practices (Group 1), to a group of full adopters (Group 4). The separation between the second and third group depends upon the use of a handmade herbicide application shield which was provided to farmers during the validation phase.

The partial and total adoption groups in Figure 4 (Groups 3 and 4) represent about 62% of the expected population of adopters. However, the difference between groups 3 and 4 is given by the rate of chemicals used by farmers in relation to the recommended levels. This aspect could be very important for farmers to attain economic optimum due to the cost of chemicals and the labor use involved in the weed control.

Some site and economic characteristics were analysed in association with the adoption behavior. An illustration with lines appears in Figure 4, besides the bars representing the adoption groups. There seems to be a direct relation between the degree of technology adoption and the labor use maximization, judging by the increment in the returns to total farm labor and family labor devoted to maize with the adoption groups. These findings are consistent with the seasonal labor constraint determined during the characterization phase which could induce farmers to maximize the use of this production factor. On the contrary, we found that other indicators like the return to farm cash cost does not follow the same path since it decreases for groups 2 and 3 in comparison with the non-adopters group. For the full adopter group, however, we found the higher returns to both labor and cash production costs.

Several options exist to pursue the analysis of the adoption of the technical alternative which could be helpful for the phase of massive diffusion through extension techniques. We have used a linearized discriminant function to obtain classification coefficients to predict the adoption behavior of a farmer, based upon a set of twelve variables including farm site, factor utilization, and personal characteristics (Escobar and Moreno, 1984). However, we feel the need for developing a less sophisticated analytical tool that could be applied by a field technical team. A method using the accumulated knowledge available to researchers and extensionists should be explored before the application of standard multivaried statistical techniques.

Final Remarks

The application of economic analysis to the FSR/TD activities demonstrates, in our view, three main issues. First, economic analysis is a continuous activity during the entire process. This means that an economist or a biologist with training in applied economics should integrate the multidisciplinary team from the beginning of the FSR/TD. Second, results of the economic analysis must be interpreted according to the agronomic and biological results. This means that economic results constitute actual support information for decision-making but cannot replace biologists' results and farmers' reactions to real on-farm applications. Third, in order to make a contribution to the field team, the economic analysis must be farm applied and very simple. During the FSR the focus of the analysis is the farm system within the hierarchical order, and during the TD activities, the concentration of the economic analysis is on the technology generation and its evaluation. In both cases, the use of simple analytical tools is mandatory since every member of the multidisciplinary team has to interpret these results.

Several implications can be derived from the above considerations to link technology generation and extension. First, the extensionist who is a member of the FSR/TD team for a specific area is aware of agro-economic characteristics of the technological alternatives he/she is to diffuse; as a corallary, such a field team must be formed by researchers (biologists, social scientists, extensionists, and farmers). Second, the validation phase and the monitoring activity in which adoption behavior and some farm characteristics are analysed, improve the extension planning and programming capacity. Farmer's adoption strata could be identified by quantitative characteristics, and target farmer groups for the short and long run could be separated for diffusion purposes. Third, a continuous monitoring during the diffusion phase in conjunction with the simple economic analysis would allow for the determination of the final structural changes in the farm system strata. This would be very useful in improving the application of the FSR approach.

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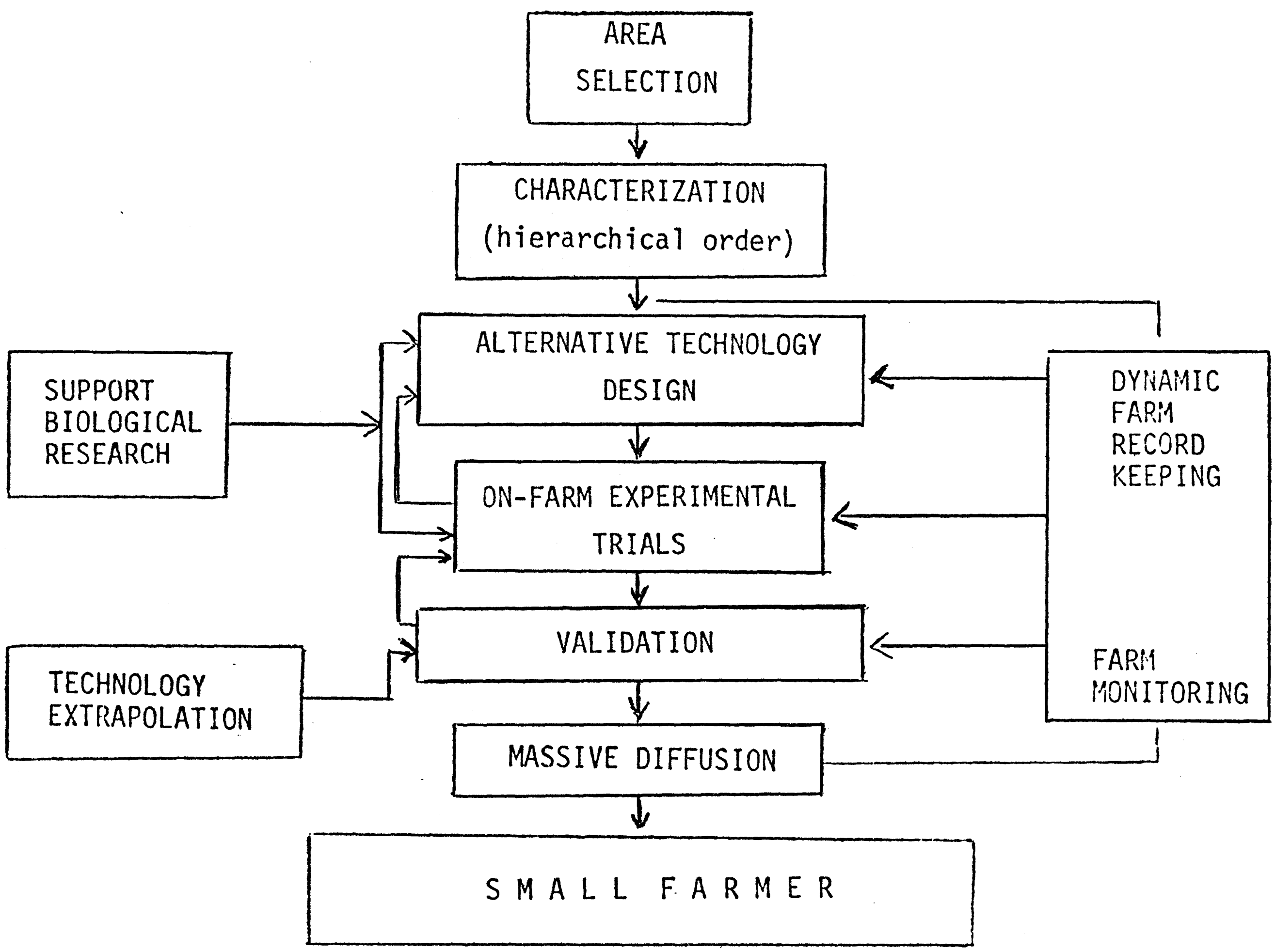
Figure 1. Phases of the CATIE's Farming Systems Research and Technology Development Methodology.



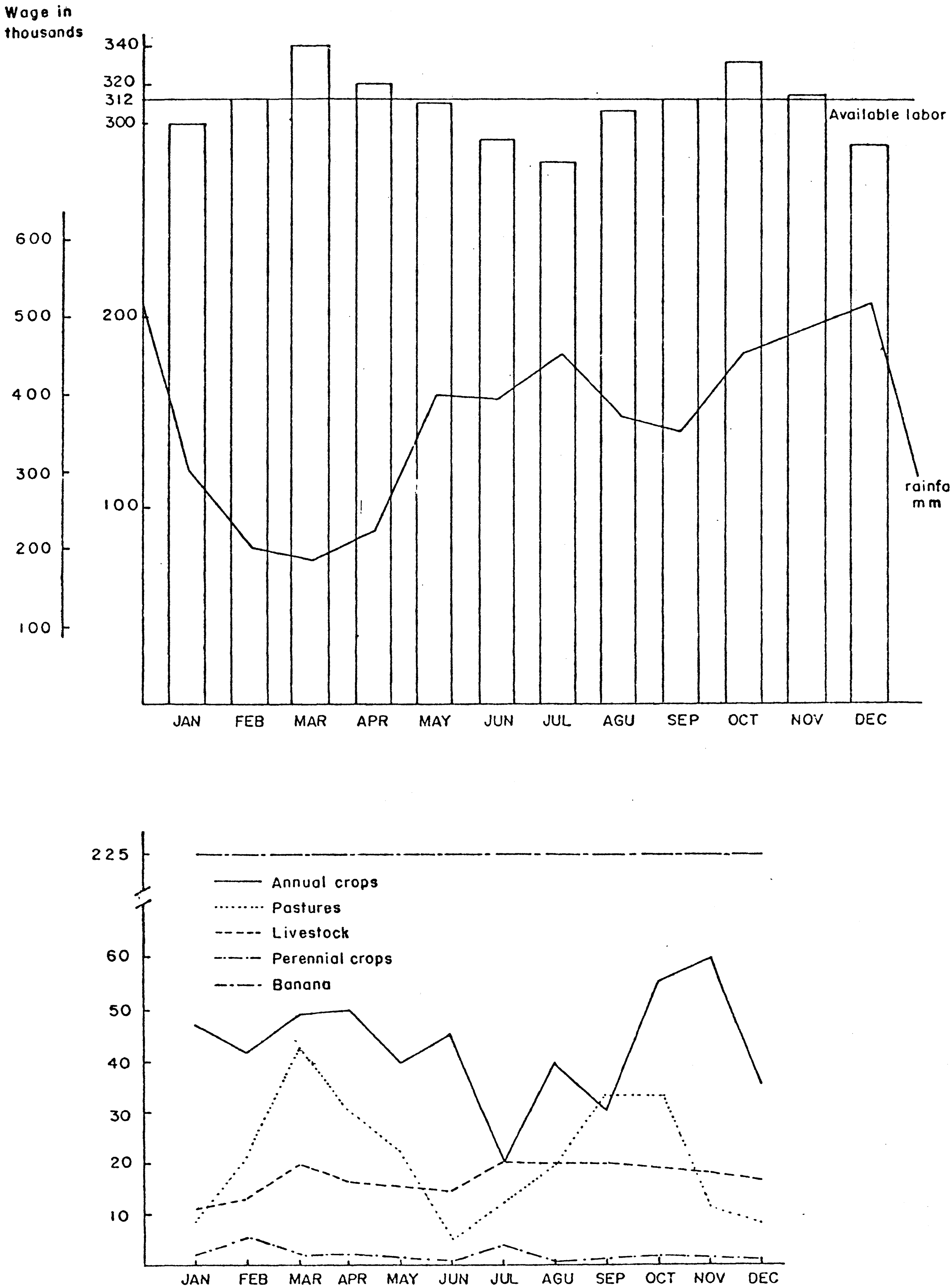
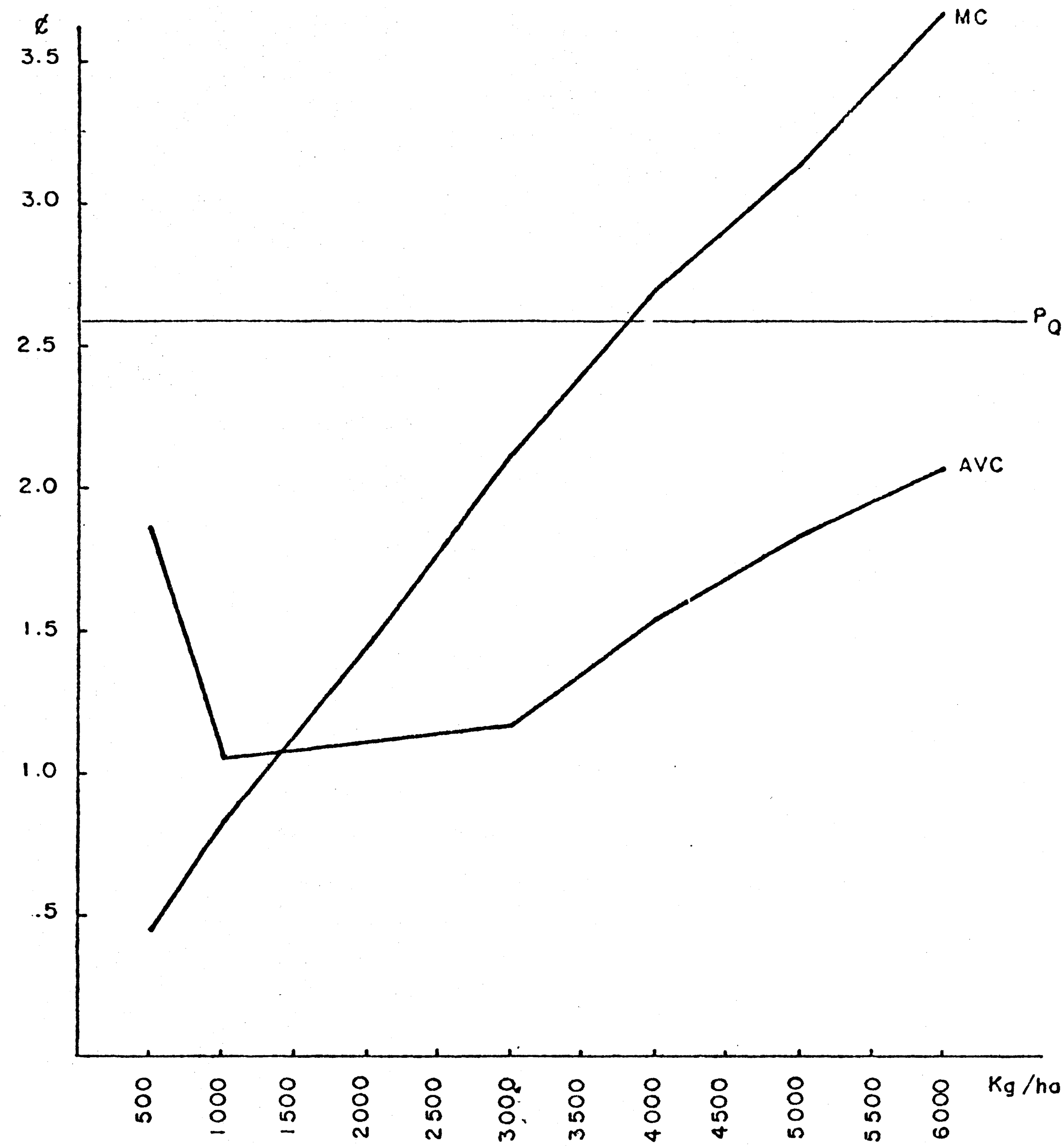


FIGURE 2. Labor distribution at the area level (upper) and by farm activities (lowers)

FIGURE 3. AVERAGE VARIABLE COST AND MARGINAL COST CURVES FOR MAIZE PRODUCTION. PERENNIAL WEEDS. MAY 1980 PRICES.

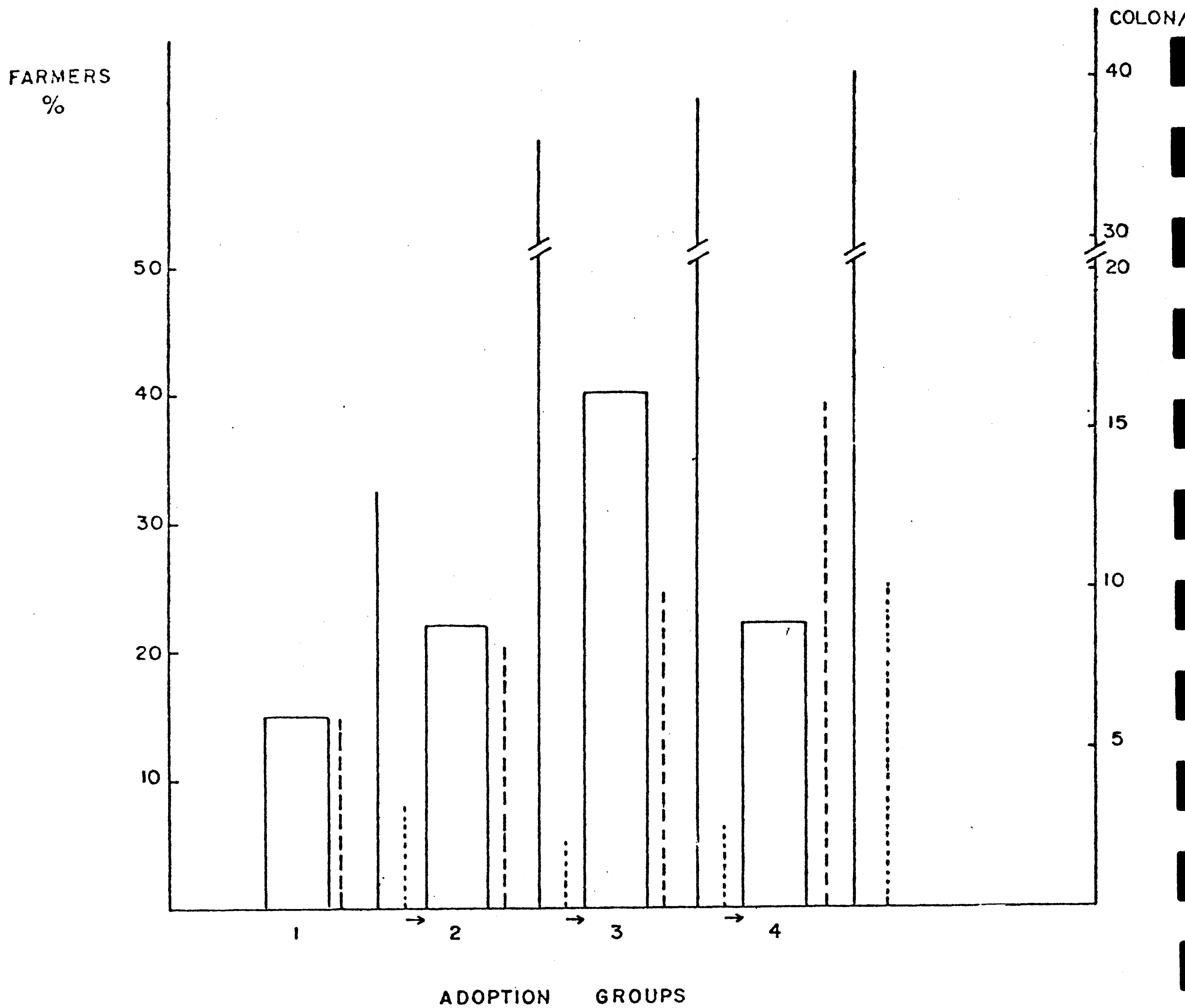


$Q = 250.996\ L^{.445}\ K^{.004}\quad R^2 = .637$

$C = 600 + .0016\ Q^{1.82}$

MC = P_Q at 3987.5 Kg/ha

FIGURE 4. DISTRIBUTION OF MONITORED FARMERS BY ADOPTION GROUPS. NORTH ATLANTIC COST A COSTA RICA. 1.983



------ RETURN TO TOTAL FARM LABOR (¢/HOUR)

——— RETURN TO FAMILY LABOR INTO MAIZE PRODUCTION (¢/HOUR)

.... RETURN TO FARM CASH COST

Table 1. Maize yield, weed control cost expressed both as Colons/ha and as percentage of the cost of existing technology for farms with predominant annual weeds. Cariari, Costa Rica. August 1977 and January 1978.

Systems[1/]	Maize yield (kg/ha) 1977	Maize yield (kg/ha) 1978	% Improvement 1977	% Improvement 1978	Weed control cost (₡ ha)[2/]	Cost as a % of the cost of farmer's existing technology
Plow + manual weeding 25 DAP	2277	4280	66	15	770	107
Plow + atrazina pre (2.0 kg/ha)	2414	--	76	--	729	101
Plow + paraquat 25 DAP (0.5 kg/ha)	2626	4431	92	19	719	100
Mulch + manual weeding 25 DAP	2613	4302	91	16	630	88
Glyphosate 8 DBP (1.3 kg/ha)	3177	4769	132	29	645	90
Paraquat 8 DBP (0.75 kg/ha)	2487	4381	82	18	342	48
MSMA 8 DBP (5.0 kg/ha)	1831	4117	34	11	378	53
Paraquat 8 DBP and 25 DAP (0.5. kg/ha each)	--	4563	--	23	561	78
CV%	19.0	10.0				
MSD (.05) (kg)	702	n.s.				

1/ DAP = days after planting
DBP = days before planting
Pre = preemergence

2/ US&1= 8.54 ₡

Source: Shenk, M.D. et al (12)

Table 2. Experimental yields that are not significantly different from the estimated oprimum production level for farms with predominant perennial weeds, May 1980 prices.

Treatments	kg/ha	Cash[1/] Costs	Cash cost without[2/] fertilizer
Glyphosate (1.3 kg/ha) 8 DBP + Paraquat (.2 kg/ha) 45 DAP 40-28-9	4090	5062.2	3920.9
Glyphosate (1.3 kg/ha) 8 DBP + Paraquat (2. Kg/ha) 45 DAP 0-0-0	4180	3895.9	3895.9
Glyphosate (1.3 kg/ha) 8 DBP + Paraquat (.2 kg/ha) 45 DAP 40-0-0	4250	4821.1	3965.9
Glyphosate (1.3 kg/ha) 8 DBP + Paraquat (.2 kg/ha) 45 DAP 40-0-0 + Carbofuran (.5kg/ha9	4350	5437.3	4582.1
Glyphosate (1.3 kg/ha) 8 DBP + Paraquat (.2 kg/ha) 45 DAP 40-28-9 + Carbofuran (.5 kg/ ha)	4280	5678.4	4537.1
x all treatments	4230	4974.9	4285.4

1/ Includes imputed value to family labor accroding to the current wage rate in the area.

2/ Fertilizer costs are not taken into account due to the statistical analysis showing no significant difference in yield attributable to fertlization levels.

Table 3. Cash net income and return to production factors in maize. Promissing technological alternatives, least experimental yields, farmer's technology and constrained cost output maximization. May 1981 prices/ha.

Indicators	Least cost optimum treatment	Average of all optimum treatments	Farmer's technology	Level yield of least cost treatment	Cost constraint optimum treatment (VC = ₡2500)
Input cash costs	2076	2350	1959	2076	1184
Labor (man-days)	40	43	33	40	32
Total variable costs[1/]	3876	4285	3444	3876	3242
Gross income	10634	10998	6804	8840	5642
Net cash income	8558	8647	4845	6764	4458
Return to land	4475	4127	1885	2680	1697
Return to cash cost	6158	6113	2760	4364	2400
Rate of return to cash cost (%)	297	260	141	210	203
Return to total labor	7750	7813	4051	5956	3740
Return to man-day	194	182	123	149	115

Table 4. Agroeconomic results of two technological alternatives for the maize production system, cropping seasons (A & B) and prices of 1981 (standard deviations in parenthesis).

Alternatives	N		Kg/ha 1/		(Colons/ha)		(hours/ha)		Net Cash Income 2/	
	A	B	A	B	A	B	A	B	A	B
Weed control	32	22	3075^{a} (764)	2386^{ce} (561)	2819^{f} (1283)	1286^{i} (843)	197^{k} (91)	244^{l} (67)	3698.5	2827.6
Weed control ' soil insect control ' fertilization	32	--	3272^{a} (909)	--	4985^{g} (710)	--	235^{k} (70)	--	2659.7	--
Weed control ' soild insect control	--	27	--	2248^{de} (762)	--	964^{i} (689)	--	273^{l} (57)	--	2833.3
Farmer's actual technology	34	33	2617^{b} (770)	2032^{d} (438)	1959^{h} (1001)	548^{j} (379)	198^{k} (81)	255^{l} (84)	3360.2	2822.7

1/ Different letters are significantly different at $\alpha = 0.05$. or less, ordered by columns.

2/ Total labor was priced at 1981 wage rates for net cash income estimation.

Table 5. Partial budget analysis for the weed control alternatives for maize production, separated by predominant type of weeds. 1981 prices.

	PERENNIAL WEEDS		ANNUAL WEEDS	
Additional Costs				
Insectice	1049.8		141.5	
Fertilizer	684.5		437.6	
Herbicide	1310.3		253.4	
Labor	106.4		---	
Land preparation	---		252.6	
TOTAL ADDITIONAL COSTS		3151.0		1067.1
Reduced Costs				
Land preparation	145.8		---	
Herbicide	---		158.9	
TOTAL REDUCED COSTS		145.8		158.9
Net Additional Costs		3005.2		908.2
Additional Receipts				
Value product	1167.9		1445.7	
TOTAL ADDITIONAL RECEIPTS		1167.9		1445.7
Addition receipts - net additional costs		-1837.3		536.5
Return on net additional cost (%)		---		59.2

Table 6. Optimal farm plan including annual weed control technological alternative. Simplified programming solution prices 1984. (Colons).

RESOURCES / ACTIVITIES	LAND (has)		LABOR		CAPITAL		System Net Income
	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	
Maize cycle I.Technologial alternatives	3.8	-	111.7	-	8449	-	27009.4
Main cycle II.Farmer's technology	-	3.8	-	115.3	-	3785	5943.6
Livestock (10 cows and 7 calfs)	-	-	24	24	1529	1529	29977.8
Pasture	5.5	5.5	25	17	413.6	279.5	-
Peach Palm	.38	.38	21.2	10.1	592.9	148.4	2024.5
Cocoa	1.4	1.4	25.8	25.8	438.7	438.7	653.4
Land in bushes	6.5	6.5	-	-	-	-	-
Unused Resources	-	-	50.5	36.6	44.2	.23	-
Total Net Income							65608.7

AN ECONOMIC EVALUATION OF SELECTED AGRICULTURAL TECHNOLOGIES WITH IMPLICATIONS FOR DEVELOPMENT STRATEGIES IN BURKINA-FASO

Michael Roth
John H Sanders

The USDA reported in 1981 that Sub-Saharan Africa is the only region in the world where per capita food production has declined over the past two decades. The drought of the early seventies in the Sahel has resulted in very large increases in food aid and in developmental assistance to countries in this region (Eicher, 1983). Imports of food staples into Sub-Saharan Africa have been increasing by 7% annually (Delgado and Mellor, 1984). Farming Systems Research (FSR) has been emphasized as one of the panaceas for quickly making technology more relevant to the needs of small farmers. However, the process of developing and evaluating technology is a long term, gradual, institutional evolution. It requires the development of capacity to work with experiment station scientists to put together the component parts of the new technology, the agronomic expertise to set up farm trials, and collaboration between agronomists and economists to evaluate the results of farm level testing.

Here the results of farm level trials in Burkina-Faso on tied ridges and fertilization are combined with baseline survey data to compare alternative agricultural development strategies. The tied ridges and fertilization are land substituting strategies, which increase yields and labor utilization. Chemical fertilizer requires increased cash expenditures and hence higher risks. Tied ridges enable improved water conservation, thus reducing the risk from fertilization. Animal traction allows a substitution for labor[1] but requires a large initial investment plus the availability of pasture land or another low cost feed source.

Areas with higher population pressure would be expected to have a higher return to the land substituting technologies. In spite of large scale out-migration to other countries and to the more fertile, higher rainfall areas to the east, south and west, the highest population concentrations are still on the Central (Mossi) Plateau. The traditional system of long fallow periods and shifting of household sites has been breaking down with the higher population pressures. Hence, the implicit value of land has been rising. With the breakdown of the fallow system has been a decrease in organic material in the soil and more surface crusting. This has decreased the soil water absorbtion capacity and lowered soil fertility. Yields of all crops and particularly the basic cereals, sorghum and millet, are low and are apparently declining due to deteriorating soil quality and lower rainfall in recent years

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[1]In some cases animal traction can have a yield effect. Two well-known cases are through better water retention with improved land preparation or more timely weeding. See Footnote 13 for some experiment station results on the yield effects of mechanization.

(Ruthenberg, 1976; and W. Morris, personal conversation). In the east, there is less population pressure, and soil fertility is higher. Crop yields are superior to those on the Central Plateau and there is greater potential for area expansion.

In this paper the evaluation technique is whole farm modeling with mathematical programming. The first section will briefly describe the farming systems in the two regions. The second section will explain the methodology employed. The third through fifth sections will report the results for animal traction, fertilization, and then the combination of animal traction, fertilization, and tied ridges. The final section compares results from the different development strategies in the two regions and draws implications for future research.

DESCRIPTION OF FARMING SYSTEMS ON THE CENTRAL PLATEAU AND IN THE EASTERN REGION OF BURKINA-FASO[2]

Approximately 60% of the population of Burkina-Faso is concentrated on the Mossi Plateau.[3] The high population pressure has led to a breakdown of the traditional fallow system and to declining soil fertility and cereal yields. Some organic fertilizer is used principally in the compound areas near the household for corn production, but to only a limited extent on principal cereal fields (Bonkian, 1980). Moreover, use of chemical fertilizer to maintain soil quality is rare and when applied is less than 50 kg/ha (ICRISAT, 1980; Lassiter, 1981; Singh, et al., 1983). Use of organic matter and fertilizers in the Eastern region is also limited but lower population densities have permitted more land fallowing and thus better maintenance of soil fertility. The practice of fallowing combined with better soils inherent to the region produce higher crop yields than on the Central Plateau. Total rainfall in both regions averages 600-900 mm per year and is concentrated in a 3-4 month rainy season (June to September).

Under the traditional agricultural practices followed in Burkina-Faso, land and labor are the primary inputs into the production process. Hand labor represents the principal power source for tillage operations, though use of animal traction is gaining more widespread

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[2]For a more elaborate description of crop enterprises as they pertain to risk management by farmers on the Central Plateau see Lang and Roth, 1984.

[3]In spite of large scale emigration out of the country, the World Bank estimates man-land ratios of 30 people/km^2 in the Central Plateau compared with 8 people/km^2 in the Eastern region and 12 people/km^2 for the country as a whole. An estimated 0.7 million Burkinabe presently live outside the country, constituting roughly 25% of the labor force.

acceptance.[4] Most labor used on the farm is provided directly by family members. Very little hired labor is used in farm operations (generally less than 10% of total labor requirements). Farms in general are small, around 4-8 ha. in size, but differences in area cultivated exist between the two regions. Family size and total area cultivated tend to be larger on the Central Plateau, but land/labor ratios tend to be smaller.[5]

The principal crops cultivated are red and white sorghum and millet.[6] These crops are grown on the household's main cereal fields and are frequently intercropped with cowpeas (Singh, et al., 1983). Small areas of corn are planted on the highly manured plots immediately surrounding the household compound. Some rice, peanuts, bambara nuts, cotton, and fonio are also cultivated. The red sorghum is primarily grown for beer production, though it is used for animal feed and human consumption as well.[7] Peanuts are grown as a cash crop to help pay taxes and meet household expenses. The corn is harvested early to meet family consumption needs during the hungry season (i.e., "soudure"). This period corresponds to the month prior to harvest of the main sorghum and/or millet fields when grain stocks can be depleted. Most of the millet and white sorghum (80-95%) are stored at harvest for consumption during the year. White sorghum is usually preferred in this regard because of its superior storing quality (2 to 3 times as long as millet according to farmers).

Land quality and availability of labor are the major determinants of cropping patterns. Sorghums and millets are cultivated on village and bush fields, but distinct differences in soil quality exist. Farmers explain that they plant sorghum on the better quality soils, because it is more responsive to higher soil fertility than millet. Millet is planted on the poorest soils, where its greater drought and low fertility resistance give it a comparative advantage. Under traditional "hoe" practices, the area devoted to sorghum is determined by the quantity of good land the farmer has available. The area of millet is primarily determined by the amount of labor available at the critical bottleneck periods[8] (See SAFGRAD-FSU, 1983). The better soils in the East thus permit more sorghum in the crop mix than what is grown in the central region.

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[4]Donkey traction is more common on the Central Plateau and the East while oxen traction is more prevalent in the West and Southwest areas of Burkina-Faso. Roughly 21,000 oxen teams, 3,000 horse teams, and 24,000 donkey teams were being used in Burkina-Faso in 1978 (Ministry of Rural Development, various O.R.D. Annual Reports).

[5]The ratio of area cultivated per worker has been estimated to be 0.94 for hand tillage farms in the village of Nedogo on the Central Plateau (Jaeger, 1984) and 1.21 for the aggregate of 13 villages in Eastern region (Barrett, et al., 1982).

[6]Over 90% of crop area on both the Central Plateau and in the Eastern region are in sorghum and millet.

[7]Red sorghum is not generally cultivated in the Eastern region.

[8]The area devoted to millet is usually expanded until labor bottlenecks at planting and/or weeding are faced.

Absolute yield levels for the basic cereals are low and declining on the Central Plateau. Millet yields are 300 to 500 kg/ha., sorghum 400 to 700 kg/ha., and corn yields 900 to 1200 kg/ha. on the more fertile compound soils. To meet the minimum consumption needs of Burkina-Faso's growing population, higher yields especially of sorghum and millet will be required.

High yielding cereal varieties have been available on the experiment station in Burkina-Faso for some time. ICRISAT'S E-35-1 sorghum has yielded 3.5 to 4 t/ha. under experimental conditions, while IRAT's corn varieties have obtained yields of 3 t/ha. Cowpeas yielding 1.5 to 2 t/ha. have been obtained by IITA under experimental monoculture conditions (Singh, et al., 1983; and World Bank, 1982).

Unfortunately, these new varieties have had little impact at the farm level (Stoop, et al., 1982). The farming systems project of SAFGRAD-FSU has taken new varieties and other improved technologies and put them into trials on farmers' fields. In these agronomist managed trials, yields of 1-1.5 t/ha of sorghum and 1.5-2.5 t/ha. of corn have been achieved (Kaylen, 1982; SAFGRAD-FSU, 1983; 1984). Due to less varietal improvement of millet combined with the poorer land quality upon which it is normally grown, millet yields above 1 t/ha. have not yet been attained.

Improving soil fertility is critical to increasing cereal yields. Higher yields can be achieved through increased utilization of inorganic fertilizers, but this requires better water retention in order to reduce the riskiness of the higher cash expenditures on inputs. This is especially important on the Central Plateau where water retention is poor and rainfall highly irregular. The breakdown of the fallow rotation,[9] the failure to return organic material to the soil, and overgrazing all contribute to soil degradation. This often leads to crusting hence increased run-off (Saunders, 1980). Under these conditions improved water retention through land preparatio orn ridging can reduce the erosive effects and lead to higher soil productivity.

When better water retention is obtained, the potential response to inorganic fertilizer will be increased. Combining these two new technologies may be an economic alternative to increase cereal yields. Another proposal to increase farmer incomes, especially in the Eastern Region, is through land area expansion with the introduction of animal power (donkey and oxen) and improved traction equipment.

The role of economic analysis is to take these agronomic results and evaluate their benefits and costs in a whole farm context. This paper uses economic modeling tools to evaluate the potential impact of these

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[9] The soils on the Central Plateau are generally sandy and shallow. On these fragile soils with their tendency for the topsoil to erode away and to form a crust, an adequate fallow could require 10 to 15 years (Hammond, 1966).

new technologies on farming systems in an older settled region (Central Plateau) and a frontier region (East) of Burkina-Faso

METHODOLOGY

Simple budgeting of costs and returns of alternative technologies are generally employed to evaluate the results of field trials. On both the Central Plateau and in the East, significant yield increases and higher returns to various new technologies have been shown. However, the partial budgeting techniques employed in these evaluations are limited in two ways. First, the explicit values of land and labor in Burkina-Faso are unknown and are generally included in an _ad hoc_ manner.[10] Secondly, the budgeting analyses are partial, hence they ignore the substitutability of inputs on the farm and how they are allocated to alternative crop activities based on fixed endowments and implied prices of resources.

New technology needs to be considered in a whole farm context to account for the effects of constraints on availabilities of land, seasonal labor, credit for purchase of modern inputs, and other interactions. The availability of higher quality land is severely limited and possesses higher implied prices than the poorer quality bush lands. Of particular importance are the constraints on the flow of labor. Critical labor bottlenecks arise at planting and first weeding. In these peak labor periods all farmers are working to capacity on their own farms, and hired labor is difficult to obtain. The implied price of labor at these times is much higher than the average wage rates observed at other times of the agriculture season.[11] These implicit prices are an important factor in farmers' decisions concerning the timing of operations, cropping mix, and choice of production technologies.

One advantage of whole-farm modeling is that an implicit value (shadow price) is derived for all on-farm and off-farm resources available in restricted supply. An estimate of the marginal returns associated with labor is especially important, since certain new technologies are labor intensive. Tied ridging, for example, requires a very large investment of labor resources to perform the ridging operations, unless this operation is mechanized.

Representative farm models were constructed for each region, using mathematical programming, to assess the impact of prospective new

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[10]In the context of farming practices in Burkina-Faso, major problems arise in valuing traditional inputs. Land is primarily allocated by tribal customs whereas labor is almost entirely provided by family members. In either case, little exchange takes place in markets where an implicit price is determined.

[11]Shadow prices of labor at peak times are up to five times higher than wage rates observed at other times of the agricultural season. When these is no agricultural work, as during the off-season, the shadow price of labor nears zero.

technologies. Linear programming techniques were used to simulate producer behavior based on profit maximization paradigm and a constraint on minimum maize production. Details on the construction of these models, their assumptions, and data utilized are available in Roth, et al. (forthcoming).

Briefly, the farm models developed for each region have the option of performing farm tillage operations under one of three types of tillage practices. Within each model, farmers possess four types of resources: land of various qualities, family labor, animal traction, and modern inputs. Land is disaggregated into four types, including high quality fields encircling the family compound, village fields, and higher and lower quality bush fields. Bush fields on the Central Plateau are permanently cultivated whereas land fallow is practiced on these soils in the Eastern region. Each farmer has a fixed quantity of each of the first three land types but has an unlimited quantity of bush land at his disposal. Stocks and flows of labor are disaggregated into weekly time periods to capture the critical labor constraints at planting and first weeding. A constraint of the minimum area of maize is included to ensure that the family has sufficient grain for the hungry season.

Crop activities included in each representative farm were selected from cropping patterns observed in each region. A summary of crop activities, land types, and yield levels under traditional management practices are given in Appendix 1. The remaining sections analyze the response of the representative farms to new technologies.

ANIMAL TRACTION TECHNOLOGY

Animal traction has been promoted, in development schemes across West Africa, as a technology appropriate for small "hoe" farms. Under the traditional hand tillage practices followed throughout most of West Africa, serious labor bottlenecks arise at times of planting and first weeding of major cereal. Use of animal traction with appropriate equipment can reduce the severity of these bottlenecks by increasing the productivity of human labor (decreasing the amount of labor time spent on an operation per unit of area).[12] Besides the area extensification effects this can promote, animal traction also offers the potential to intensify production per unit of area. With deeper preplant plowing and incorporation of crop residue better soil aeration and water absorption

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[12] On station trials in Mali by the Institut de Recherches d'Agronomie (in Sargent, et al., 1981), for example, have shown animal traction to decrease total labor requirements by 43%. The higher labor productivity that ensues oftentimes expansion of cultivated area.

can be achieved.[13] Manure from draft animals can improve soil structure and fertility while the technology's labor-saving effects permit more timely operations.

In the context of draft power use in the two regions studied here, benefits realized in practice have fallen short of the technology's potential. On the Central Plateau, animal traction is primarily used during weeding operations. Plowing is limited because donkeys, the principal traction animal, are not strong enough for the task while oxen are often left in a weakened state following the long dry season. Farmers also say plowing conflicts with time spent on planting.[14] In the Eastern region, animal traction is used primarily for land preparation.[15] Most farmers are equipped with plows and/or ridgers but weeding equipment is less common. Since farmers customarily perform weeding by hoe, the area increase from animal traction in the Eastern region is less than in the Central Plateau.[16]

On farm studies of performace of animal traction are limited. The few farm management surveys which have been performed show labor savings of 10-35% on weeding of cereals and 10-60% on land preparation maize and peanuts (ICRISAT, 1980; McIntire, 1981; Swanson, 1982; Lassiter, 1981; and Singh, 1983). Area extensification effects (increase in area per worker) range from 2-20%. Large yield increases from animal mechanization have been reported in the literature (Jaeger, 1984), but

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[13]Charreau and Nicou (1977) found that deep plowing increased yields by 19% for groundnuts, 20-30% for cereals, 27% for cotton, and more than 50% for rice on experiment station trials conducted by IRAT in Senegal. Kline, et al. (1969) found yield increases from plowing of more than 40% on millet and peanuts from on-station research in the Gambia.

[14]Farmers start planting immediately with the onset of rains to take full advantage of seasonal rainfall. Fields can be planted for only 2-3 days after rains. Hence plowing of fields and then planting slows considerably the rate of planting. Several common soil preparation activities that are performed are line tracing, used to delineate rows, and soil scarification. These operations loosen the surface crust and facilitates line planting and subsequent weeding with animal traction equipment (ICRISAT, 1980). The area planted to maize and peanuts is frequently plowed. Land preparation for these crops is begun following completion of planting the major cereal fields of sorghum and millet. The soil is softer and plowing combats the weed problems arising on these fields at this time.

[15]Barrett, et al. (1982) report in their Eastern region study that only 14% of cultivated area for oxen farmers and 10% of area for donkey farmers were weeded with animal traction equipment. This contrasts markedly with 59% and 85% of cultivated area plowed by donkeys and oxen in the East.

[16]Indeed, Jaeger (1984) shows area cultivated/worker to increase from 0.94 ha. for hand tillage households to 1.23 ha. for donkey traction households in Nedogo, compared with an increase of only 1.21 ha. to 1.26 ha. for animal traction households, respectively, for the Eastern Region (Barrett, et al., 1982).

appear to be dueto other complementary factors. Animal traction adopters are often better managers with better resource endowments, who employ higher levels of other inputs in the production process.

To incorporate the effect of animal traction into the farm models, four adjustments were made: a) labor reductions of 11-43% for different crops and operations were used to represent the technology's labor saving effects (Table 1); b) yields are increased moderately on areas cultivated with animal traction (Table 2); c) manure from draft animals is used to expand the area of high quality land available;[18] and d) the number of active workers/household is increased to reflect the observed larger family size of households possessing animal traction.

One of the most difficult aspects of the modeling effort was the comparison of different types of traction households. The cross sectional analyses, which are commonly used to evaluate animal traction, are weak in describing the dynamic processes involved in the shift to adoption of the technology. Also, by comparing households possessing animal traction with those that do not, the problems of varying resource levels and management skills between groups are introduced. Here, it was only possible to make inferences about the adjustment processes from the limited cross-sectional observations which were available. A more complete analysis of animal traction adoption would include the longitudinal adjustment of households over time to introduction of the improved traction system.

The effects of animal traction on demographic characteristics of the household, area cultivated and cropping patterns are shown in Tables 3 and 4. Animal traction is shown to be associated with larger farm size and a larger number of workers per household in both regions. Donkey and oxen households cultivate an area approximately 55 and 70% larger respectively than hand tillage households. The main determinant of this area expansion, however, is large number of workers. On the Central Plateau the number of active workers increases from 5 to 7 in moving from manual to oxen traction households.[19] In the East the increase is from 3.5 to 6 active workers. Once number of workers is adjusted for, the area extensification effect is greatly reduced. Area cultivated per worker on the Central plateau is shown to increase from .96 ha. for hand

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[18]A donkey producing a recoverable 0.75 mt of manure is estimated to increase the quantity of high quality of high quality sorghum land by approximately 0.1 ha. Ownership of an ox roughly doubles the area enlarged. Manure increases the quantity of compound land or high quality sorghum land depending on where economic returns are the highest. Information on recoverable manure and field applications rates was taken from Bonkian, 1980; Nourrissat, 1965; martin and Leonard, 1967 and Delgado, 1978.

[19]There is a debate over whether only larger families adopt animal traction or whether animal traction by increasing capital investment per worker and alleviating seasonal labor constraints thereby encourages larger family size. This is an empirical problem requiring more field research.

tillage households to 1.12 ha. for donkey households to 1.16 ha. for oxen households, representing area increases to 17-21%. These gain are much smaller but consistent with Jaeger's results for Nedogo and with other studies (Sargent, et al., 1981). No area increase was observed for the Eastern region, reflecting the lack of weeding equipment mentioned earlier.

A summary of the impact of animal traction on cereal production and net farm income is shown in Table 5 (also see Appendix 2). The higher productivity of the Eastern region is apparent. Compared with the minimum consumption standard of 180 kg/capita/yr. used by the government of Burkina-Faso, a large surplus is produced. Animal traction substantially increases total household production and farm income. However, the gains are less dramatic when computed on a per worker or per resident basis (Table 5). On the Central Plateau, donkey traction increases farm revenue/worker by 4% and oxen traction by 14%.

Several implications can be drawn from the analysis. First, returns to animal traction which appear to be large, are greatly diminished when computed at a per-capita level. In cases where large returns are reported in the literature, questions arise as to whether the effects of management ability, resource endowment, or higher input use of farmers has been appropriately accounted for. Second, area extensification pushes cultivation onto poorer soils where with disappearing land fallow and lack of soil improving inputs, declining soil fertility occurs. With low and declining levels of soil fertility, the economic evaluation of land substituting inputs becomes especially important. In the next two sections the representative farm models are used to evaluate the impact of fertilization and tied ridging.

CHEMICAL FERTILIZERS

Over 90% of the fertilizer sold in the country is a general purpose cotton fertilizer (14-25-15). In 1982, the FAO Upper Volta fertilizer project estimated the real farm gate costs of cotton complex fertilizer at 127 CFA/kg., compared with 65 CFA/kg. charged to farmers by the regional extension agencies (ORDs). This represents a fertilizer subsidy of 49%. Recently, Burkina-Faso has been asked to phase out the subsidy and bring fertilizer prices more in line with world prices.

The yield response of various crops to chemical fertilizer were estimated from on-farm trials conducted in the two regions (Table 6). The physical response is lowest on poor quality bush soils and highest on lower slope soils and areas close to the compound. Response rates in the Eastern Region are estimated to be higher than on the Central Plateau, especially on the outlying soils which receive the benefits of the fallow rotation.

The results of evaluating the impact of the fertilizer technology on various measures of productivity are shown in Tables 7 and 8. The fertilizer technology is evaluated at both subsidized and unsubsidized fertilizer prices. In both regions, fertilizer increases cereal production and net farm income. However, the elimination of the fertilizer subsidy substantially reduces returns. The model results indicate that as subsidies are reduced, the area fertilized is cut back starting with the poorer soils where fertilizer response rates are lowest. Even at unsubsidized prices, however, some of the better soils continue to be fertilized.

When viewed in the whole-farm context, the potential impacts of fertilizer technology lead to fairly pessimistic results. At unsubsidized fertilizer prices, farm income per capita increases only 5 to 9% depending upon the type of tillage used. These returns to fertilization are very low even without considering other constraints such as cash requirements, risk, and the necessary marketing infrastructure.[20]

Even though physical gains to fertilizer are larger in the Eastern region, returns per worker are not greatly different than on the Central Plateau. The reason for this is that while fertilizer prices are constant across both regions, commodity prices are much lower in the East, thus contributing to a higher real cost of fertilizer in the region.[21]

Chemical fertilization is a risky input in a semi-arid area because a successful response requires the availability of adequate water at the critical stages of plant development. The most critical input in a semi-arid area appears to be a technology to provide or to conserve a more assured water supply. With improved availability of water, the probability of a profitable response to fertilization is increased. In the next section an economic evaluation is made of the water conservation technique of tied ridges combined with chemical fertilization and animal traction.

TIED RIDGING

One of the promising new agricultural technologies in Burkina-Faso is tied ridging. This technology consists of constructing mounds of dirt between ridges in the field, at distances of approximately one meter, to

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[20]The potential profitability of chemical fertilizer will depend upon the availability of cash or credit to the farmer and an input delivery system. The process of agricultural development implies the need for the private and public sector to facilitate these changes. The objective here is only to measure the potential farm level profitability once this process occurs. Since yields are declining in the Central Plateau, the provision of inorganic fertilizer will become increasingly necessary over time.

[21]The price of sorghum in the East was 46 FCFA/kg. compared to 58 FCFA/kg. on the Central Plateau.

facilitate entrapment of rainfall and promote water infiltration.[22] This technology reduces soil erosion and increases available soil moisture. The yield response of cereals to a more ample supply of water has been shown to be significant (see Table 9, where a 40% increase in yields is reported), but usually constrained by low levels of soil fertility especially on the Central Plateau. When tied ridging is combined with improvements in soil fertility, dramatic increases in cereal yields are possible. The results of on-farm trials in Table 9 show a doubling of yields for the combination of tied ridges and moderate fertilization.

Tied ridging can be performed at various periods of the agricultural season. The maximum yield effect would be expected at planting, but farmers have said this conflicts with their planting strategies (i.e., getting their principal millet and sorghum fields planted as early as possible). Tied ridging performed later at first weeding confronts the high implicit price of labor from labor bottlenecks existing at this time. The tied ridging practiced by farmers in the field and followed in this paper is to construct the ridges using animal traction at first weeding, but performing the labor intensive tying of ridges by hand in slack periods immediately following.

The tied ridging technologies used here (Table 10) are for maize and sorghum and based upon experimental results reported by ICRISAT (1982), IRAT (1983), and SAFGRAD-FSU (1983 and 1984). The fertilizer rates of 100 kg. of cotton fertilizer (14-25-15 NPK) and 50 kg. of urea are moderate levels and are costed at the unsubsidized prices.

Tables 11 and 12 show the impact of the tied ridging plus fertilization plus animal traction technology in contrast with hand tillage farming systems in the two regions. On the Central Plateau, donkey traction farmers are estimated to cultivate 0.75 ha. and oxen farmers 1.0 ha. using the new technology. Tied ridging is implemented on the better soils, starting first on compound soils then onto further outlying soils. Returns to the technology are substantial. On the Central Plateau income per worker increased by 11% (donkey) and 24% (oxen), respectively. Results for the Eastern Region are less dramatic. Areas planted using the new technology are smaller and the impact less pronounced. This reflects both the poor efficiency of animal traction and higher fertilizer to output prices relative to the Central Plateau. Both of these effects offset the slightly higher yield in the Eastern region.

The potential benefits of the new technology appear to be considerable. Tied ridges on both the Central Plateau and Eastern region are implemented on only 10% of total crop area yet a significant increase in household income is achieved. The technology, however, appears to be economically viable on only the better quality soils. On the poorer bush

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[22]The construction of tied ridges can vary considerably, from that of small depressions dug in the ground, which require little labor, to tall ridges formed in a "lattice" type manner which can require considerable labor to construct.

soils customarily planted in millet, an economic response to tied ridges and fertilization has not yet been found. Once the physical and economic factors responsible for this lack of response in millet can be identified and resolved,[23] the potential impact of tied ridges will be greater.

Figure 2 illustrates the sensitivity of the tied ridge results to yields and labor requirements for their construction.[24] The level of net income/household is shown to be very sensitive to yields obtained under the technology and to the amount of additional hand labor required per hectare for the tying of ridges. The research focus now is to further refine the technologies to achieve higher yields and reduce labor requirements.

Both improved varieties and more cost effective fertilization would shift upward the curves in Figure 2. In the new environment created by the improved water retention capacity of the soil due to the tied ridges and the increased nutrient availability from the chemical fertilizers, a large payoff to the introduction of new varieties should exist (Lang, et al., 1984). The SAFGRAD-FSU farm trials of 1984 have incorporated two new Framida parent sorghum varieties combined with the tied ridges and fertilization. Preliminary observations show them to have superior yield response with less lodging than the traditional varieties.

With the development of animal traction equipment, it should be possible to decrease the labor requirements for constructing the tied ridges. A prototype implement fitting an animal traction plough with a ridger is currently being tested in the field and appears to be producing good results. If labor times can be reduced through improved animal traction equipment, economic returns to the new technology will be further improved.

By putting all the component technology pieces together dramatic icreases in household income would be possible. The combined effects of water retention, inorganic fertilizer, and animal traction are all necessary. Introducing these agronomic innovations creates an improved environment, which promotes a high return to improved varieties.

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[23]Due to lower fertility, poorer water retention capacity, lack of organic materials and lack of crop residues being returned to these poorer soils in Burkinabe farming systems, improving millet yields is not a trivial problem. ICRISAT has substantially increased the number of scientists working on millet in its Niger operations.

[24]Yield level Y_1 corresponds to the response rates given in Table 10. Yield level Y_2 represents a 25% increase in the yield response rates, increasing total yields by about 10%. The figures 75-175 represent the range of labor rates observed in the literature for time requirements to do the tied ridging. The large variance in labor times is attributable to the newness of the operation, variation in farmer adaptation of the technique and measurement error.

INTENSIVE VS. EXTENSIVE TECHNOLOGICAL CHANGE

In the previous sections, three different types of technological change were considered. These results are summarized in Tables 13 and 14 to enable a simpler comparison. Animal traction households are shown to have substantially higher incomes than hand tillage households reflecting principally the impact of a larger number of workers. When measured on a per worker basis, the increase in area cultivated per worker and in total labor productivity (income/worker) are smaller especially on the Central Plateau. Land productivity (income/hectare) is shown to decline slightly with the expansion of total area cultivated. In the East, the income increase per household from animal traction is not as large as on the Central Plateau. There is less area expansion and less increase in area cultivated per worker. This is apparently due to the failure to introduce appropriate cultivation equipment.

Moving across the tables to the more intensive, land substituting technologies of fertilization and tied ridges, the effect on household income and land and labor productivity is larger on the Central Plateau than in the Eastern region. Since soil fertility is lower and declining more rapidly there, it is not surprising that land substituting inputs should have a high payoff. Another important factor is that areas closer to the nation's capital receive a higher product price. The close proximity of the major market of Ouagadougou to the Central Plateau appears to offset the higher physical yield response of the frontier region.

An important result is that while tied ridges and/or fertilization have a significant impact on household incomes and on land and labor productivities, the technologies remain viable on only the better quality soils. As yet the technology has not been produced to extend these intensive practices onto the poorer quality millet soils where millet is normally cultivated. This will be a major challenge first for agronomists and later for plant breeders.

In the East the promotion of appropriate animal traction equipment and improvement of roads and market information, to obtain higher product prices, may have higher short run returns than the introduction of land substituting inputs. This is discouraging, because the on-farm trials of tied ridging, fertilization, and new sorghum and maize varieties have shown good physical results in the East (SAFGRAD-FSU, forthcoming). Investments in marketing infrastructure may be a necessary component to make new agricultural technologies economically viable.

In summary, significant returns are possible from the introduction of animal traction with appropriate cultivation equipment in both regions of the country. However, in the future as soil fertility continues to decline on the Central Plateau, the focus of research efforts there should be more directed to the land substituting technologies -- i.e., fertilization and tied ridges. These investments would include the development of an animal ridger, experimentation on different levels and types of inorganic fertilizer, and the continued development of improved varieties of sorghum and maize.

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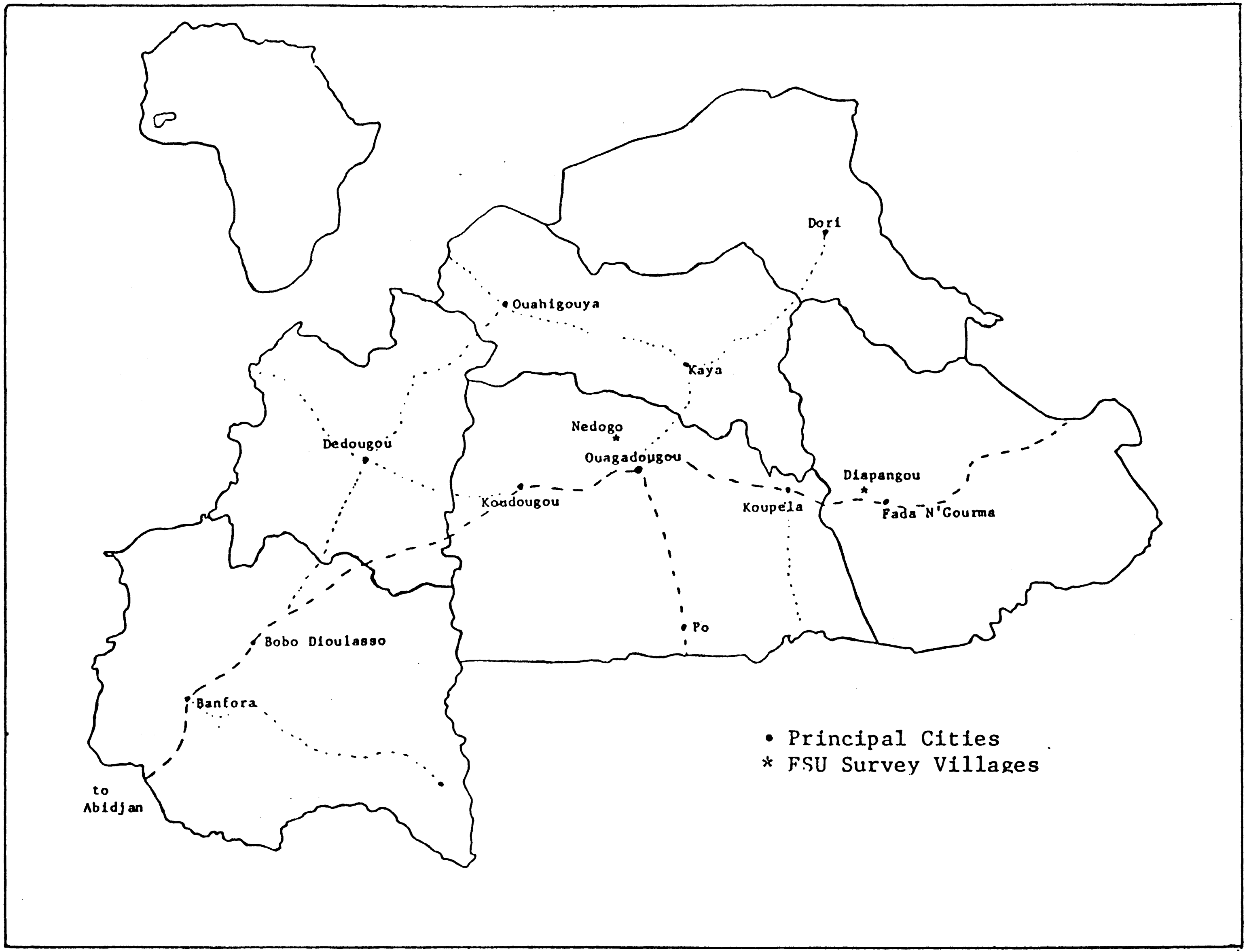

Figure 1: Map of Burkina Faso

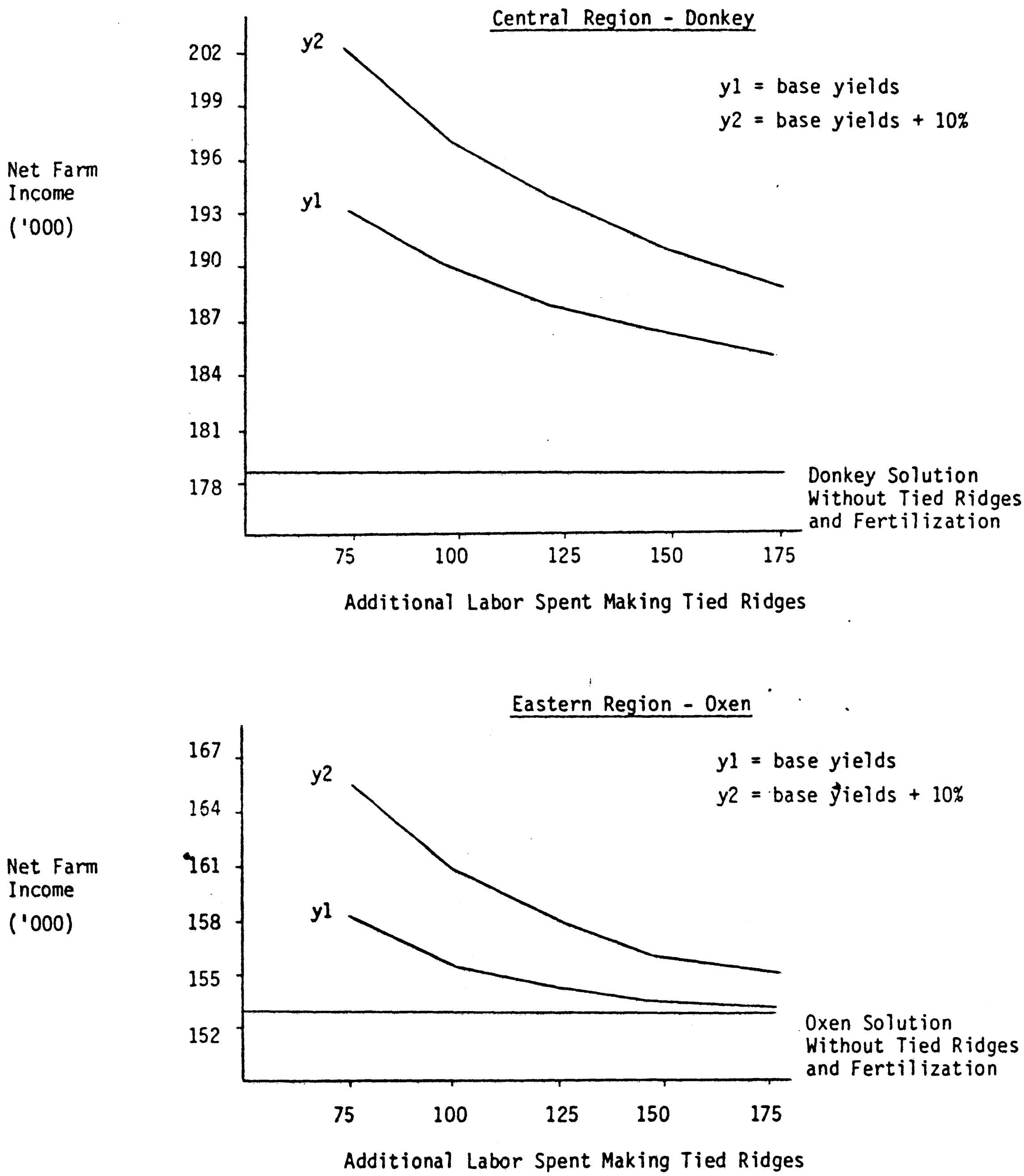

Figure 2: Effect of Various Yields and Labor Spent Tied Ridging On Total Net Revenue of the Farm.

Table 1. Estimated Reduction in Labor Times in the Shift From Hand to Animal Power[a] (percentages)

		Sorghum/ Millet	Maize	Peanuts	Rice
Central Plateau	Land Preparation	+16(+13)	-40(-47)	-40(-47)	-26(-36)
	First weeding	-30(-43)	-20(-27)	-11(-15)	
	Second weeding	-30(-43)			
Eastern Region	Land Preparation		-43(-50)	-43(-50)	-26(-36)
	First weeding	-23(-30)	-38(-43)	-11(-18)	
	Second weeding	-15(-22)	-25(-35)		

Note: The coefficients represent the percentage reduction in human labor time by crop and type of operation due to use of donkey traction. Figures in parenthesis are percentage reduction for oxen traction.

[a] These figures represent average rates of reduction. In reality, the percentage labor savings were varied according to different land types employed. Labor savings were synthesized from studies performed in both regions of Burkina Faso.

Table 2. Percentage Yield Increases Estimated for Animal Traction Adoption [a]

	Sorghum/ Millet	Maize	Peanuts	Rice
Swamp Land				9(18)
Highly Manured Compound Soils	6(12)	9(18)		
Village Soils	5(10)	7(14)		
Higher Quality Bush Soils	5(10)	7(14)	-9(-9)	
Lower Quality Bush Soils	3(6)		-9(-9)	

Note: Coefficients in the table represent the percentage yield increases from employing donkey traction technology. Figures in parenthesis refer to yield gains for oxen traction. Yield increases were synthesized from studies performed in both regions of Burkina Faso.

[a] The same estimated percentage increases in yields from animal traction were utilized for both the Central Plateau and Eastern Region.

Table 3. Demographic Characteristics, Area Cultivated, Land Use Patterns and Land-Labor Ratios Under Alternative Traction Scenarios, Central Mossi Plateau

(Per Farm Results)

	Representative Farm[a] Central Mossi Plateau			Jaeger-Nedogo[b] (1983)	
Variable	Hand Tillage	Donkey Tillage	Oxen Tillage	Hand Tillage	Donkey Tillage
Demographic Characteristics					
Residents	10.0	14.0	15.0	-	-
Active Workers	5.0	6.5	7.0	4.71	6.64
Total Area Cultivated (Ha)	4.8	7.3	8.13	4.41	8.18
Cropping Proportions (%)					
Millet	65.6	68.9	68.1	62.0	63.0
White Sorghum	16.6	11.0	9.8	15.4	18.5
Red Sorghum	12.5	4.8	1.7	12.7	8.6
Maize	3.1	6.2	8.5	2.0	2.4
Peanuts	1.7	8.8	11.6	5.4	5.5
Bambara Nuts	-	-	-	1.8	1.2
Rice	0.5	0.3	0.3	0.5	0.1
Land - Labor Ratios:					
Area Cultivated/Worker	0.96	1.12	1.16	0.94	1.23
Area Cultivated/Resident	0.48	0.52	0.54		

a/ Representative Farm refers to a farming system which has been developed from farm data collected by ICRISAT, IRAT, Purdue SAFGRAD/FSU, etc. The information was incorporated in a mathematical farm model which produced the results shown here.

b/ Nedogo is a Purdue SAFGRAD survey village located about 30 kms from Ouagadougou on the Central Mossi Plateau. Results for the Central Plateau are compared with Jaeger's (1984) study of hand tillage and donkey traction households compared in the village of Nedogo to help validate the representative farm forecasts.

Table 4. Demographic Characteristics, Area Cultivated, Land Use Patterns and Land-Labor Ratios Under Alternative Traction Scenarios, Eastern Region

(Per Farm Results)

	Representative Farm[a] Eastern Region			Michigan State University - BEAP Study[b]	
Variable	Hand Tillage	Donkey Tillage	Oxen Tillage	Hand Tillage	Animal Traction
Demographic Characteristics					
Residents	7.3	11.7	14.3	7.34	11.72
Active Workers	3.5	5.0	6.0	3.47	5.07
Total Area Cultivated (Ha)	4.1	6.39	7.1	4.21	6.40
Cropping Proportions (%)					
Sorghum	18.8	17.5	19.6	31.7	25.7
Sorghum/Millet(75:25)	18.8	12.1	10.8		
Millet	18.5	16.4	18.7	19.4	27.7
Millet/Sorghum(75:25)	33.2	43.2	41.5	32.2	21.7
Maize	3.9	2.5	2.5	4.2	3.4
Rice	1.2	0.8	0.7	1.3	3.3
Peanuts	5.6	7.4	5.9	6.4	9.0
Bambara Nuts	-	-	-	0.8	0.5
Soybeans	-	-	-	0.4	4.1
Cotton	-	-	-	0.7	1.6
Other	-	-	-	2.9	2.8
Land-Labor Ratios:					
Area Cultivated/Worker	1.17	1.28	1.18	1.21	1.26
Area Cultivated/Resident	.56	.55	.50	.57	.55

a/ Representative farm refers to a farming system which has been developed from farm data collected by Michigan State University, in the Eastern O.R.D. (Organismes Regionaux de Developpement de L'Est), Purdue/SAFGRAD Farming Systems Project and others. The information was incorporated into a mathematical farm model which produced the results shown here.

b/ This was a farm study conducted by the Bureau of Economic Analysis and Planning of the Eastern O.R.D. and Michigan State University. The study encompassed 25 villages in 12 agro-climatic zones. The figures are overall results across all villages and act as a benchmark for validating the representative farm model.

Table 5: Returns to Animal Traction Per Household, Per Worker and Per Resident

	Hand Tillage	Donkey Tillage	Oxen Tillage
Central Plateau			
Cereal Production/worker	397	426	444
Cereal Production/resident	199	198	207
Income Per Household ('000 FCFA)	131.8	178.4	211.4
Net Farm Income/worker ('000 FCFA)	26.4	27.5	30.2
Eastern Region			
Cereal Production/worker	560	585	567
Cereal Production/resident	269	250	238
Income Per Household ('000 FCFA)	103.9	135.8	152.9
Net Farm Income/worker ('000 FCFA)	30.0	27.4	25.8

Note: The numbers of workers and residents per household in each region were reported in Tables 3 and 4.

Household characteristics utilized in the representative farm modeling were obtained from the literature review. The yields and prices utilized to determine production and income can be found in appendices 1 and 2.

Table 6: Yield Response of Various Crops by Type of Land for the Central Plateau and Eastern Region [a]

(kg./ha.)

Region		Sorghums/ Millets	Maize	Peanuts
	Highly Manured Compound Soils		450(45)	
Central [b] Plateau	Village Soils	450(70)	500(80)	
	High Quality Bush Soils	240(55)		
	Lower Quality Bush Soils	110(34)		275(57)
Eastern [b] Region	Highly Manured Compound Soils		475(40)	
	Village Soils	500(70)	550(69)	
	High Quality Bush Soils	360(62)		
	Lower Quality Bush Soils	180(44)		175(58)

Note: Figures in parentheses are the percentage increases over yields achieved under traditional management practices.

a) These responses represent a summary of yield increases obtained from farm level experiments. The response figures given here are for applications of 50 kg of urea and 100 kg of cotton fertilizer (14-25-15) per hectare. Different yield responses were used for millet and sorghum. For example, yield responses of millet and sorghum on low quality soils on the Central Plateau were estimated at 95 and 125 kg/ha, respectively.

b) These soils on the Central Plateau are permanently cultivated. In the Eastern Region a fallow rotation system is practiced.

Sources: This information was synthesized from farmer managed trials conducted by ICRISAT (1980, 1981, and 1982) and SAFGRAD FSU (1983, 1984).

Table 7: Productivity Measures for Alternative Fertilizer Prices and Power Sources, Central Plateau

			Subsidized Fertilizer Prices	Unsubsidized Fertilizer Prices
	Price Urea	No Modern Inputs	62	120
	Price Compound Fertilizer		65	125
Hand Tillage Household	% Total Area Fertilized	0	34	17
	Cereals Production:(kgs)			
	Per Household	1,987	2,505	2,301
	Per Resident	199	251	230
	Oilseeds Production (kgs)			
	Per Household	219	282	279
	Net Farm Income ('000FCFA)			
	Per Household	131.8	152.4	140.3
	Per Worker	26.4	30.5 (15.5)	28.1 (6.4)
Donkey Traction Household	% Total Area Fertilized	0	36	25
	Cereals Production: (kgs)			
	Per Household	2,766	3,126	2,946
	Per Resident	198	223	210
	Oilseeds Production (kgs)			
	Per Household	465	886	874
	Net Farm Income ('000FCFA)			
	Per Household	178.4	212.8	192.7
	Per Worker	27.5 (4.2)	32.7 (23.9)	29.6 (12.1)
Oxen Traction Household	% Total Area Fertilized	0	25	15
	Cereals Production:(kgs)			
	Per Household	3,106	3,285	3,106
	Per Resident	207	219	207
	Oilseeds Production (kgs)			
	Per Household	594	1,311	1,299
	Net Farm Income ('000FCFA)			
	Per Household	211.4	254.4	228.1
	Per Worker	30.2 (14.4)	36.3 (37.5)	32.6 (23.5)

Figures in parenthesis are the increase over net farm income per worker, hand tillage households with no modern inputs.

Table 8: Productivity Measures for Alternative Fertilizer Prices and Power Sources, Eastern Region

			Subsidized Fertilizer Prices	Unsubsidized Fertilizer Prices
	Price Urea	No Modern Inputs	62	120
	Price Compound Fertilizer		65	125
Hand Tillage Household	% Total Area Fertilized	0	70	50
	Cereal Production (kgs):			
	Per Household	1,962	2,616	2,326
	Per Resident	269	358	319
	Oilseeds Production (kgs)			
	Per Household	269	379	308
	Net Farm Income ('000FCFA)			
	Per Household	102.3	120.4	108.2
	Per Worker	29.3	34.4	30.9
			(17.4)	(5.5)
Donkey Traction Household	% Total Area Fertilized:	0	32	21
	Cereals Production (kgs):			
	Per Household	2,924	3,515	3,496
	Per Resident	250	300	299
	Oilseeds Production (kgs)			
	Per Household	456	593	508
	Net Farm Income ('000FCFA)			
	Per Household	134.9	153.6	140.1
	Per Worker	27.0	30.7	28.0
		(7.8)	(4.8)	(-4.4)
Oxen Traction Household	% Total Area Fertilized:	0	44	22
	Cereals Production (kgs):			
	Per Household	3,400	4,182	4,080
	Per Resident	238	292	285
	Oilseeds Production (kgs):			
	Per Household	500	652	566
	Net Farm Income ('000FCFA)			
	Per Household	152.1	174.8	159.2
	Per Worker	25.3	29.1	26.5
		(-13.7)	(-0.6)	(-9.6)

Figures in parenthesis are the increase over Net Farm income per worker, hand tillage households.

Table 9a. Results of Tied Ridging Experiments on Sorghum Fields, Nedogo, Upper Volta, 1983.

Donkey Traction Technology

	I	II	III	IV
Mean Yields (Kg/Ha.)	444	624	604	962
Revenue (CFA/Ha.) [a]	25,752	36,192	35,032	55,796
Cash Inputs:				
100 Kg. Cotton Fertilizer			6,200	6,200
50 Kg. Urea			3,000	3,000
Labor Input (hrs.):				
Base	390	390	390	390
Fertilizer			20	20
Tied Ridges		120		120
Animal and Equipment Depreciation, Maint., & Feed (CFA/Ha.)	3,000	4,000	3,000	4,000
Net Revenue/Ha.	22,752	32,192	22,832	48,596
Revenue/Hr.	58.3	63.1	55.7	80.4

Source: Adapted from 1983 Purdue SAFGRAD/FSU Field Trial Results, Upper Volta.

I = Traditional
II = Tied Ridges Made 30 Days After Seeding
III = 100 Kg/Ha. Cotton Fertilizer + 50 Kg/Ha. Urea
IV = Tied Ridges + 100 Kg/Ha. Cotton Fertilizer + 50 Kg/Ha. Urea

[a] Yields times Crop Price of 58 CFA/Kg.

Table 9b: Results of Tied Ridging Experiments on Sorghum Fields, Diapangou, Burkina Faso

Oxen Traction Technology

	I	II	III	IV
Mean Yields (kg/ha)	526	578	857	991
Revenue (CFA/ha)[a/]	24,196	26,588	39,422	45,586
Cash Inputs:				
100 Kg. Cotton Fertilizer			6,200	6,200
50 Kg. Urea			3,000	3,000
Labor Input (hrs):				
Base	425	425	425	425
Fertilizer			20	20
Tied Ridges		120		120
Animal and Equipment Depreciation, Maintenance and Feed (CFA/ha)	3,000	4,000	3,000	4,000
Net Revenue/ha	21,196	22,588	27,222	32,386
Revenue/Hr.	49.9	41.4	61.2	57.3

Source: Adapted from 1983 Purdue SAFGRAD/FSU Field Trial Results, Burkina Faso

I = Traditional
II = Tied Ridges made 30 days after seeding
III = 100 kg/ha Cotton Fertilizer + 50 kg/ha Urea
IV = Tied Ridges + 100 kg/ha Cotton Fertilizer + 50 kg/ha Urea

a/ Yield Times Crop Price of 46 CFA/kg

Table 10: Yield Response to Tied Ridging Plus Fertilizer Technology Used in the Whole Farm Analysis

Region	Land Type	Maize a/	Sorghums
Central Plateau	Highly Manured Compound Soils	650 (60)	
	High Quality Village Soils	600 (90)	550 (80)
	High Quality Permanently Cultivated Bush Soils		425 (90)
	Low Quality Permanently Cultivated Bush Soils		325 (100)
Eastern Region	Highly Manured Compound Soils	700 (55)	
	High Quality Village Soils	650 (75)	610 (80)
	Higher Quality-Fallowed Bush Soils		520 (90)
	Lower Quality-Fallowed Bush Soils		420 (100)

a/ Figures are yields achieved under donkey traction technology; yields for oxen were estimated to be 10 percent higher. Figures in parenthesis are the percentage increase over yields estimated for donkey traction alone (i.e. without tied ridging or fertilization treatments).

Table 11: Effect of Tied Ridging Technology Plus Animal Traction on Area Cultivated, Production and Net Farm Income Estimates, Central Plateau

		Traditional Management	Tied-Ridging [a] Technology	
Variable:		Hand Tillage Only	With Donkey Traction	With Oxen Traction
Total Area Cultivated (hectares):		4.8	6.96	7.67
Maize:	Traditional	.15		
	with Tied Ridges		.20	.20
Red Sorghum:	Traditional	.60	.07	
	with Tied Ridges		.53	.60
White Sorghum:	Traditional	.80	.80	.65
	with Tied Ridges			.15
Millet		3.15	4.39	4.61
Rice		.03	.03	.03
Peanuts		.07	.94	1.43
Fertilizer Used: (kg./farm)	Urea		37	49
	Cotton Fertilizer		73	98
Total Cereals Production (kgs):				
	Per Household	1987	2975	3381
	Per Resident	199	213	225
Total Oilseeds Production (kgs)		219	618	835
Net Farm Income ('000 FCFA)				
	Per Household	131.8	189.8	229.3
	Per Worker	26.4	29.2	32.8
No. of Workers Per Household		5.0	6.5	7.0

[a] Based on 50 kg Urea and 100 kg/ha Cotton Fertilizer; labor time of 100 hours per hectare and yield estimates given in Table 10.

Table 12: Effect of Tied Ridging Technology Plus Animal Traction on Area Cultivated, Production and Net Farm Income Estimates, Eastern Region

		Traditional Management	Tied-Ridging [a] Technology	
Variable		Hand Tillage Only	With Donkey Traction	With Oxen Traction
Total Area Cultivated (hectares):		4.10	6.14	6.78
Maize:	Traditional	.16	.16	.02
	with Tied Ridges			.14
Sorghum	Traditional	.77	.66	.83
	with Tied Ridges		.43	.54
Sorghum/Millet	(75:25)	.77	.77	.77
Millet		.77	.61	.77
Millet/Sorghum	(75:25)	1.36	3.16	3.46
Rice		.05	.05	.05
Peanuts		.23	.29	.20
Fertilizer Used:	Urea		21.7	28.2
	Cotton Fertilizer		43.3	56.5
Total Cereals Production (kgs):				
Per Household		1961	3153	3733
Per Resident		269	269	261
Total Oilseeds Production: (kgs)		269	422	456
Net Farm Income ('000FCFA)				
Per Household		103.9	136.4	155.4
Per Worker		29.7	27.3	26.0
No. of Workers per Household		3.5	5.0	6.0

[a] Based on applications of 50 kg Urea and 100 kg cotton fertilizer per hectare, labor time of 100 hours and yield estimates given in Table 10.

Table 13: Summary of Various Productivity Measures Estimated From Sole and Combined Impacts of Animal Traction, Fertilization and Tied Ridging Technologies, Central Plateau

Alternative Power Sources	Traditional Technologies:	Land Substituting Technologies: Fertilization a/	Tied Ridges a/ Plus Fertilization
Hand Tillage:			
Total Area Cultivated (hectares)	4.82	4.82	b/
Active Workers/Household	5.0	5.0	
Area Cultivated/Worker	0.96	0.96	
Income Per Household ('000 FCFA)	131.8	140.3	
Income Per Hectare	27.5	29.1	
Income Per Worker	26.4	28.1	
Donkey Households:			
Total Area Cultivated	7.29	7.29	6.96
Active Workers/Household	6.5	6.5	6.5
Area Cultivated/Worker	1.12	1.12	1.07
Income Per Household	178.4	192.7	189.8
Income Per Hectare	24.4	26.4	27.3
Income Per Worker	27.5	29.6	29.2
Oxen Households:			
Total Area Cultivated	8.13	8.13	7.67
Active Workers/Household	7	7	7
Area Cultivated/Worker	1.16	1.16	1.10
Income Per Household	211.3	228.1	229.3
Income Per Hectare	26.0	28.1	29.9
Income Per Worker	30.2	32.6	32.8

a/ The unsubsidized price of fertilizer was utilized: 122 CFA/kg Urea and 125 CFA/kg cotton fertilizer.

b/ Since the tied ridging is a very labor intensive operation, it was assumed that animal traction would be necessary to assist in the construction of the ridges.

Table 14: Summary of Various Productivity Measures Estimated From Sole and Combined Impacts of Animal Traction, Fertilization and Tied Ridging Technologies, Eastern Region

Alternative Power Sources	Traditional Technologies	Land Substituting Technologies: Fertilization[a]	Land Substituting Technologies: Tied Ridges Plus Fertilization
Hand Tillage:			
Total Area Cultivated (hectares)	4.10	4.10	[b]
Active Workers/Household	3.5	3.5	
Area Cultivated/Worker	1.17	1.17	
Income Per Household ('000FCFA)	103.9	108.2	
Income Per Hectare	25.3	26.4	
Income Per Worker	29.7	30.9	
Donkey Households:			
Total Area Cultivated (hectares)	6.39	6.39	6.14
Active Workers/Household	5.0	5.0	5.0
Area Cultivated/Worker	1.28	1.28	1.23
Income Per Household ('000 FCFA)	135.8	140.1	136.4
Income Per Hectare	21.3	21.9	22.2
Income Per Worker	27.2	28.0	27.3
Oxen Households:			
Total Area Cultivated (hectares)	7.10	7.10	6.78
Active Workers/Household	6.0	6.0	6.0
Area Cultivated/Worker	1.18	1.18	1.13
Income Per Household ('000 FCFA)	152.9	159.2	155.4
Income Per Hectare	21.5	22.4	22.9
Income Per Worker	25.5	26.5	26.0

a/ The unsubsidized price of fertilizer was utilized: 122 CFA/kg Urea and 125 CFA/kg Cotton Fertilizer

b/ Since the tied ridging is a very labor intensive operation, it was assumed that animal traction would be necessary to assist in the construction of the ridges

Appendix 1A: Yield Levels for Sole Crops and Crop Mixtures by Type of Land and Traction Technology Assumed for the Central Plateau Representative Farm

Type of Land	Crop Mixture	Hand Tillage
Swamp Land	Rice	850
Compound Land	R. Sorghum	850
	W. Sorghum	770
	R. Sorghum/W. Sorghum	638/185
	Maize	1000
Red Sorghum Land	R. Sorghum	640
	R. Sorghum/Cowpeas	640/55
	W. Sorghum	590
	W. Sorghum/Cowpeas	590/55
	Maize	625
White Sorghum Land	R. Sorghum	430
	R. Sorghum/Cowpeas	430/45
	W. Sorghum	450
	W. Sorghum/Cowpeas	450/45
	Millet	420
	Millet/Cowpeas	420/45
	W. Sorghum/R. Sorghum	340/105
	Millet/W.Sorghum	315/115
	Maize	350
	Peanuts	520
Millet Land	W. Sorghum	310
	W. Sorghum/Cowpeas	310/35
	Millet	340
	Millet/Cowpeas	340/35
	Millet/W. Sorghum	255/78
	Peanuts	480

Appendix 1B: Yield Levels of Sole Crops and Crop Mixtures by Type of Land and Traction Technology Assumed for the Eastern Region Representative Farm

Type of Land	Crop Activity	Hand Tillage
Swampy Land	Rice	820
Compound Land	Maize	1200
	Sorghum	900
	Maize/Sorghum	840/270
Permanently Cultivated Village Fields	Sorghum	710
	Sorghum/Cowpeas	710/85
	Sorghum/Millet	500/185
	Sorghum/Millet/Cowpeas	500/185/85
	Millet/Sorghum/Cowpeas	305/355/85
	Maize	800
Higher Quality Bush Field Soils	NL - Sorghum/Cowpeas	620/65
	NL - Groundnuts	425
	Sorghum/Millet	395/155
(NL-New Land)	Sorghum/Millet/Cowpeas	395/155/65
	Millet/Sorghum/Cowpeas	255/280/65
	Sorghum/Maize	395/150
	Soybeans	375
	Groundnuts	350
Lower Quality Bush Field Soils	NL - Sorghum/Cowpeas	450/55
	NL - Groundnuts	325
	Millet/Cowpeas	410/45
(NL-New Land)	Millet/Sorghum	287/114
	Millet/Sorghum/Cowpeas	287/114/45
	Sorghum/Millet/Cowpeas	190/205/45
	Groundnuts	285
	Soybeans	300
	Cotton	250
Continuously Cultivated (Exhausted) Bush Fields	Millet/Cowpeas	320/35
	Groundnuts	195
	Cotton	175

Appendix 2: Measures of Production and Income Per Household, Resident and Active Worker Under Three Alternative Traction Scenarios, Central Plateau and Eastern Region Representative Farms

	Representative Farm Central Mossi Plateau			Representative Farm Eastern Region		
	Hand Tillage	Donkey Tillage	Oxen Tillage	Hand Tillage	Donkey Tillage	Oxen Tillage
Production:						
Production per Farm (Kg)						
Sorghum				908	1,291	1,537
White Sorghum	360	378	396			
Red Sorghum	387	238	99			
Millet	1,072	1,750	1,983	821	1,379	1,575
Maize	147	377	603	192	209	240
Rice	21	23	25	41	45	48
Peanuts	40	281	409	70	145	134
Cowpeas	179	184	185	199	311	366
Total Cereals Production	1,987	2,766	3,106	1,962	2,924	3,400
Total Oilseeds Production	219	465	594	269	456	500
Cereal Production/worker	397	426	444	560	585	567
Cereal Production/resident	199	198	207	269	250	238
Percent change in Cereal Prod/worker		7.3	11.8		4.5	1.3
Farm Income: ('000 FCFA)						
Total Farm Income [a/] [b/]	131.8	178.4	211.4	103.9 [d/]	135.8 [d/]	152.9 [d/]
Income per worker [a/] [b/]	36.4 [c/]	27.5 [c/]	30.2 [c/]	29.7	27.2	25.5

a/ Comparisons of income figures across regions should be avoided. Because of different supply and demand conditions within each region and high marketing costs between regions, output prices on the Central Mossi Plateau are higher than in the eastern region. For example prices used for the Central Plateau (Eastern Region) are 59 (46) FCFA for white sorghum 55 FCFA for red sorghum, 58 (46) FCFA for millet, 60 (40) FCFA for maize, 92 (69) FCFA for peanuts, 117 (73) FCFA for rawpeas and 80 (90) FCFA for rice.

b/ Income is total value of all crops produced, valued at market prices, minus cost of seed, hand tools, repairs and depreciation and costs of animal traction. Hired labor was not included to its relative unimportance in total labor budgets in these two regions. Use of modern inputs was excluded from these as well, because of low use by farmers.

c/ Jaeger reports total revenue/worker as FCFA 24,422 for hand tillage households, FCFA 28,418 for donkey households and FCFA 31,862 for donkey and oxen households.

d/ The total farm income figures reported here are higher than the income figures reported in the Michigan State U-BEAP study (i.e. net revenue from crop production was reported to be between 75-79,000 FCFA for hoe households, FCFA 71,099 for donkey households and FCFA 146,220 for oxen households). The difference is the higher yield levels used for peanuts and cowpeas assumed for the representative farm.

ON-FARM TRIALS

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A CASE STUDY OF NEW TECHNOLOGY IN FARMERS' FIELDS WITH EMPHASIS ON PLANT DRILLS FOR WHEAT IN 1982-83

E. El-Gamassy, R. Deuson, A. Gomaa, R. Abo-Elenine

PREFACE

This paper is an abstracted version of a research report written by Drs. E. El Gamassy, Robert Deuson, A. Gomaa, and R. Abo-Elenine (EMCIP publication No. 71, December 1983). In the interest of time the original report cannot be presented here but it can be obtained from the Consortium for International Development, 5151 E. Broadway, Suite 1500, Tucson, Arizona 85711.

At all times and in all details the research report supersedes this presentation.

The purpose of this presentation is to propose a methodolgy for testing the statistical significance of differences in yield and net returns between a traditional technology and a proposed new technology as an aid to making recommendations to farmers. This paper focuses on demonstrating the joint use of analysis of variance and of dominance analysis in analysing the results of on-farm trials. The focus of the paper is <u>not</u> to discuss the groundwork that leads to this particular choice of on-farm trials. The FSR/E concept pertaining to communication with farmers which eventually resulted in the choosing and testing of the new technology is not discussed here. This groundwork was done according to the FSR/E concept and information on it may be obtained by writing to the authors at the above address. Information concerning land consolidation practices in Egypt and technical information about the technology itself (types of drills, field efficiencies, operator skills, and costs of operations) may be obtained likewise. In the interest of time and space, the paper stresses the testing methodology.

Finally, it should be pointed out that the authors do not claim that their testing procedure is the only rule for making the decision on whether or not to recommend the new technology to all farmers. However, it is their view that Egyptian farmers heavily weigh economic factors in making the decision to reject or adopt a new technology. Learning from them, the authors have attempted here to formalize the farmers' decision making process.

INTRODUCTION

Beginning with the 1980/81 wheat crop, The Egyptian Major Cereals Improvement Project (EMCIP) crop and extension program leaders have jointly conducted production demonstration programs under which farmers consolidate their plots into fields of 50-100 feddans and agree to follow a package of recommendations growing out of many years of research under the ARC/EMCIP crop research programs. A number of changes were introduced for harvested crops in 1983. For wheat, these included a 3-way comparison between (a) farmers who plant drill seed in a consolidated plot and follow EMCIP recommendations; (b) those who broadcast seed in a consolidated plot and follow EMCIP recommendations; and (c) traditional farmers who do not follow EMCIP recommendations, do not consolidate their fields and do not plant by machine. This aspect was conducted only in two Districts of Gharbiya Governorate, namely El Santa and Zefta.

In the study under review here, 10 farmers were sampled in each of the two Districts from each of the following groups:

- Those in the demonstration program who also took part in the mechanization phase
- Those in nearby areas in the demonstration program who did not take part in the mechanization phase
- Other farmers in nearby areas who did not consolidate their plots and did not take part in the demonstration program.

Thus 30 farmers were selected in each District, for a total of 60 farmers for the study.

The study is designed to answer the following questions:

- Do EMCIP wheat recommendations significantly improve the net economic returns of participation farmers when compared with those of traditional farmers?
- Do EMCIP recommendations, along with drill planting, significantly improve the net economic returns of participating farmers when compared with those of farmers who followed EMCIP recommendations but broadcast seed?
- Do EMCIP wheat recommendations, along with drill planting, significantly improve the net economic returns of participating farmers when compared with those of traditional farmers?

During the last several years, wages of labor in the agricultural sector rose significantly. Due in large part to migration to cities and nearby countries, Egypt faces a problem in obtaining sufficient agricultural labor during busy periods to meet total demand. Increased mechanization is a possible solution to this seasonal agricultural labor shortage; drill planting could be useful for this purpose at planting time. However, most of the potential benefits of planting by drill would need to come from other sources because labor savings, if any, are small.

RESEARCH PROCEDURES

El Santa and Zefta districts were chosen by Wheat/Barley Program staff because of their geographic proximity to the Gemmeiza Research/Extension (R/E) Center and hence the ease of supervision of the experiment by Center personnel and use of the Center drill. One 25-feddan field was chosen from the wheat area under the rotation system in that year. Farmers who participated had to consolidate their wheat plots into this one field and agree to use EMCIP recommendations. Other farmers in the demonstration program consolidated their wheat on one or more 5-feddan fields in specified villages and agreed to follow EMCIP recommendations. They followed the traditional practice of broadcasting their seed.

The Sample

The sample size is 60. Thirty farmers were chosen in El Santa District and 30 farmers in Zefta District, both within Garbiya Governorate. Within each District, 3 groups of 10 farmers were assembled as follows:

Group 1: Farmers who agreed to follow EMCIP recommendations and to plant by drill.
Group 2: Farmers in nearby areas who agreed to follow EMCIP recommendations but broadcast seed.
Group 3: Traditional farmers in nearby areas who do not follow EMCIP recommendations and broadcast seed.

Within each District, farmers in the first group were randomly sampled from among all farmers in the group. For the second and third groups, one or two villages were chosen that were a part of or adjacent to the village in which the 25-feddan field was located. Farmers were randomly sampled from among all farmers within each group in those villages.

Survey Instrument

The questionnaire is built in a matrix form: column headings cover economic variables while row headings represent agronomic practices based on EMCIP recommendations and as they occur most often on traditional farms. Agronomic practices are grouped in five categories: land preparation, planting, growing, pest control, and harvesting operations. Economic variables cover family labor, hired labor, animal work and feed record, equipment and supplies, fertilizer and manure, seed, herbicides and pesticides. The costs of these items are summed in the last column as total variable cost. Separate pages are provided to calculate net field yields and gross and net returns. The questionnaire also includes general information on type of soil planted to wheat, a plot-use chart, a summary of equipment used on the farms, whether owned or rented, and some information on the household. Questionnaire headings appear in both Arabic and English.

Data Collection

Data were collected by direct observation of all major field operations in all three groups, supplemented with surveys whenever direct observation was not possible because of logistics. Surveys, however, always took place within a week of the field operation which had not been observed directly. The short lapse of time between the operation and the survey guarded against recollection error.

STATISTICAL ANALYSIS

In their flow chart (Figure 1) for new technology evaluation in farm trials, Sanders and Lynam indicate that significant increases in farm yields with the new technology must be identified with the use of ANOVA prior to testing (through budgeting) whether the new technology is more profitable than farmers' practices. In fact, Harrington suggests that recommendations to farmers should be made only when yields are higher to a statistically significant extent for the recommended over the traditional technology.

Looking back at the study objectives, we recall that a major interest is to evaluate whether farmers who plant by drill, while following EMCIP recommendations, receive higher net returns than farmers who follow EMCIP recommendations but broadcast seed, and whether the latter group enjoys higher net returns than traditional farmers. Also, we would like to know whether any benefits found are domain-specific, i.e. whether they apply to El Santa and to Zefta Districts or to only one of them. If they apply in the same way to both Districts, then they may apply to the whole Governorate. If the response in the two Districts varies, then we must attempt to see why. This then should assist in establishing the nature of the domains to which each response applies.

In ANOVA terms, we refer to the type of technology (EMCIP recommendations and plant-drill, EMCIP recommendations and broadcast, or traditional) as a factor, and the three possible forms of this factor as the number of levels. Similarly, we refer to the type of recommendation domain as another factor which potentially has two levels (El Santa and Zefta Districts). A particular combination of one level from each factor determines a treatment. Thus we have an experiment with two factors, one with 2 levels and the other with 3 levels. This is called a 2 x 3 factorial experiment.

One way to display the possible factor combinations is to array them in a matrix form as shown in Table 1.

In total, we have 6 treatments, each with 10 replicates (10 farmers in each group per District). This experiment is a complete factorial experiment since each combination of factor levels (or treatments) is used the same number of times. The statistical significance of the difference between treatment means for each factor can be tested by its F-ratio in an ANOVA. Furthermore, if there exists an important[1] observed F-value for the interaction between the type of technology and the recommendation domain, we should study the 2-way table of treatment means to determine which of the mean values are significantly different. To do this, we use a mean separation method, such as the least square difference (LSD). Testing treatment differences by LSD is in effect making a t-test for each difference and leads to the same basic statistical inference as a F-test of the same differences as a composite

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[1]Snedecor and Cochran (1967, p. 348) argue that a table of treatment means should be consulted whenever the involved interaction F excedes unity, regardless of whether it is statistically significant. This practice is adopted here. The word "important" is used to designate an interaction F that exceeds unity.

group[2]. ANOVA and LSD analyses, when appropriate, in this case are run on each of 5 variables: grain yield, straw yield, gross returns, total variable costs, and net returns. Each of these variables in turn are considered in the sections that follow.

STATISTICAL RESULTS

The related ANOVA table is shown in Table 2. The observed F-values show statistically significant differences in grain yield between (a) Districts [D] and (b) technologies [T]. Given the important (above unity) observed F-value for the D x T interaction term, LSD is used to determine which of the means are significantly different within the D x T 2-way table.

Table 3 shows the 2-way D x T table of means, with each entry being an average over the 10 involved farmers. In Figure 2, two segmented lines trace grain yield means for three levels of technology: one for each recommendation domain (District). These two lines are not parallel, verifying that there is an interaction between recommendation domains and levels of technology. We note that in El Santa District, each higher level of technology results in approximately the same increase in yield of grain. However, in Zefta District, yields are nearly the same for drilling versus broadcasting of seed when farmers follow the overall EMCIP recommendations. A need thus exists to try to find a reason for these differing responses.

We now move forward to use LSD to determine which differences are statistically significant. In computing LSD, two levels of statistical significance, $p = 0.05$ and $p = 0.10$, were used to reflect possible levels of risk preference among farmers.

For analytical purposes, it is convenient to break Table 3 into two parts. This is done in Tables 4 and 5. The first two columns of Table 4 repeat the data in Table 3 in a different direction. Mean differences in relation to specified LSD's are shown in the last 3 columns of Table 4 and in the 3 columns of Table 5. In each, two levels for LSD are shown. The higher figure is the LSD at $p = 0.10$. It is shown when the mean differences are not statistically significant at $p = 0.05$. An NS in the last column implies lack of statistical significance at $p = 0.10$.

It should be noted that Sakha 61 was used for the mechanized plot in

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[2]That is, if the main-effect F is statistically significant, then at least one of the sample mean differences will be statistically significant when tested by LSD. However, if sample means are ranked in order, an LSD test between the largest and smallest may be statistically significant when the related F-test is not significant. Thus, LSD should not be used in that way. It should be used instead to spot which means among small groups differ significantly when the F-test has demonstrated that at least one pair has this attribute. If large groups of means are involved, other tests are more appropriate.

Zefta District, whereas Giza 157 was used elsewhere. Based on the assumption that variety within this framework does not significantly affect yield, conclusions are that broadcasting is as good as drilling in Zefta District. But in El Santa District, grain yields can be expected to be higher when a drill is used. Since yields were nearly the same in the two Districts when a drill was used, the difference between Districts appears to be mainly due to the adverse effects of broadcasting in El Santa. In both Districts, grain yields are significantly larger when EMCIP recommendations are used.

Straw Yield

Exactly the same procedure is used as in the preceding section. Hence, only the results and their interpretation are covered. Table 6 shows the involved ANOVA.

The observed F-value shows a statistically significant difference in straw yields between technologies [T]. However, the difference between Districts [D] is not significant at $p = 0.10$. Given the important (above unity) observed F-value for the D x T interaction term, LSD is used to determine which of the means are significantly different within the D x T 2-way table.

Table 7 shows the 2-way D x T table of means with each entry being an average of the straw yields obtained by the 10 farmers involved in each group. The mean straw yields are then plotted by technology level for each District in the middle section of Figure 2. The segmented lines representing each recommendation domain (District) intersect, verifying that there is an interaction between recommendation domains and levels of technology. We note that for both Districts the lines are upward sloping, indicating that straw yields increase with each higher level of technology. As before, we now use LSD to determine which differences are statistically significant. Since the F between Districts was non-significant, we bypass the equivalent of Table 4 for grain yields. Table 8 shows for straw the equivalent of Table 5 for grain yields.

Table 9 shows the following:

- The observed F-value for variation in gross returns between Districts is less than the F required at $p = 0.10$. Thus the variation is not statistically significant.
- The observed F-value for variation in gross returns between technologies is highly significant.
- The observed F-value for the interaction term exceeds unity. Thus, we must study the 2-way table of means by use of LSD.

Table 10 shows the 2-way D x T table of means with each entry being an average of gross returns, in L.E., obtained by the 10 farmers involved in each group. The mean gross returns are plotted by technology level for each District in the last section of Figure 2. Again we note that the two segmented lines are not parallel, verifying an interaction effect. Prices per unit for straw were 14% higher in El Santa District than in Zefta District. Although yields of both grain and straw were less in El Santa than in Zefta for the first two technologies, gross returns are nearly the same. Returns are nearly identical in Zefta for the two technologies using EMCIP recommendations.

Since the F-values between Districts is not statistically significant, these means are not analyzed by LSD. Table 11 presents the analysis between technologies. The last column is identical to those in the corresponding tables for grain yield and straw yield.

Total Variable Cost

The ANOVA is given in Table 12. The observed F-values show a statistically significant difference in total variable costs between Districts at the $p = 0.10$ level but not the $p = 0.05$ level. Differences between technologies are statistically significant at $p = 0.05$. Given the important (above unity) observed F-value for the D x T interaction term, LSD is used to determine which of the mean values are significantly different within the D x T 2-way table.

Table 13 shows the 2-way D x T table of means with each entry being an average of the total variable costs incurred by the 10 farmers involved in each group. The mean total variable costs are then plotted by technology level for each District in the upper section of Figure 3. We note that costs are much higher for traditional farmers in El Santa than in Zefta but, for the two groups of demonstration farmers, costs are about the same within each technology. For demonstration farmers, variable costs are lower based on use of a drill than when seed is broadcast. Reasons are discussed in the research report. These results are verified by the LSD analyses shown in Tables 14 and 15. Between Districts, only the difference for traditional farmers is statistically significant. In both Districts, costs with a drill are significantly less than when seed is broadcast provided that EMCIP recommendations are followed. Comparisons with traditional practices are mixed because of the difference in cost in the two Districts when traditional practices are used.

Net Returns

Net returns are defined as the difference between gross returns and total variable costs which include all labor. The ANOVA is given in Table 16.

The observed F-values show a statistically non-significant difference in net returns between Districts at $p = 0.10$. Differences between technologies are significant at $p = 0.05$. Given the important (above unity) observed F-value for the D x T interaction term, LSD is used to determine which of the mean values are significantly different within the D x T 2-way table.

Table 17 shows the 2-way table of means, with each entry being an average for the 10 involved farmers in each group. The mean net returns are plotted by technology level for each District in the lower section of Figure 3. An important interaction effect is shown by the intersection of the two segmented lines.

Since differences between Districts were not statistically significant, the equivalent of Table 14 is omitted. Differences between levels of technology within Districts are shown in Table 18. For El Santa District, net returns increase for each higher level of technology and the increase in each case is statistically significant at $p = 0.05$. For Zefta, the difference between net returns when seed is broadcast is not statistically significant under traditional practices versus EMCIP recommendations. Plant drill, however, gives net returns that are significantly higher over either broadcast technology.

Summary, With Emphasis on Aspects That Relate to the Economic Analysis

The following highlight findings from the statistical analyses:

- Levels of technology have statistically significant effects on each of the five variables considered.
- Differences between Districts were statistically significant only for grain yield and variable costs per feddan. However, all interaction F's between Districts and technologies excede unity. Hence, 2-way tables of means were analyzed by use of LSD to determine which treatment within Districts were contributing to the statistically-significant F's for technologies.
- For Zefta District, higher net returns from plant drill versus broadcast within demonstration plots reflects lower costs rather than increased yields.
- For El Santa District, similar higher net returns reflect both lower costs and increased yields.
- For traditional farmers, total variable costs are higher and grain yields are lower in El Santa than in Zefta Districts. Factors involved are discussed in detail in the text.
- For demonstration farmers, costs between the two Districts within technologies do not differ to a statistically significant extent.
- In El Santa District, each higher level of technology gives higher net returns, and the differences in each case are statistically significant.
- In terms of averages, this is true also in Zefta District. However, when seed is broadcast, net returns based on use of EMCIP recommendations do not differ to a statistically significant extent from those based on traditional practices.
- Within each District, grain yield, straw yield, and gross return per feddan are higher to a statistically significant extent when EMCIP recommendations are followed than when grown based on traditional practices.

ECONOMIC ANALYSIS

Given the above statistical results, we proceed to the economic analysis. For each District, we perform the following tasks:

- Draw a partial budget for each of the 3 groups of farmers studied;

- Array treatments from high to low net returns and show their corresponding total variable costs;
- Plot net returns against variable costs for each treatment and draw the dominance curves (really segmented lines);
- Eliminate dominated treatments;
- Calculate marginal rates of return for alternative pairs of non-dominated technologies that raised yield or reduced cost to a statistically significant extent;
- Recommend any technology that offers the highest net return and an acceptable marginal rate of return;
- Check the suitability of that recommendation from the point of view of price and/or yield variability.

Partial Budgets

A partial budget is prepared for each of the three groups of 10 farmers for each District. These partial budgets are given in Appendix table A-1, supplemented by tables A-2 to A-7, in the original research report.

Dominance Analysis

This is a methodology discussed in detail in Perrin et al. (1976). It can best be understood by the simultaneous use of Table 19 and Figure 4. In Table 19, technologies within each District first are ordered by net returns, from highest to lowest, as shown in the middle column of the table. Corresponding variable costs are given in the last column. The first column of the table shows the cell identification numbers which are used in Figure 4. We now plot these date in Figure 4, with net returns on the vertical scale and total variable costs on the horizontal scale. The upper section shows the dominance curves with the plant-drill technology and the lower section shows these when all seed is broadcast. Note that each point shows its cell identification number. Non-dominated technologies when the plant drill technology is available, are those that lie on the segmented line drawn through the points (1,1) and (1,3) for Zefta District and the segmented line drawn through the point (2,3) for El Santa District. Note how the vertical and horizontal lines are drawn. Dominated technologies which lie below and to the right of the segmented lines are (1,2), (2,1), and (2,2).

If the plant drill technology were not available, only the points (1,1), (1,2), (2,1), and (2,2) would be considered. These are shown in the lower section of Figure 4. Under these ciricumstances, non-dominated technologies are those that lie on the segmented line drawn through the points (1,1) and (1,2) for Zefta District and the point (2,2) for El Santa District. Dominated technologies now are only (2,1).

Conclusions so far, stated in words, are as follows:
- In Zefta District, the plant drill and traditional technologies dominate the broadcast technology. If the plant drill technology is not available, no technology is dominated.
- In El Santa District, the plant drill technology dominates the other two, while the broadcast technology (with EMCIP recommendations) dominates the traditional one.

- Farmers who are interested in maximizing net returns will always prefer technologies lying on the dominance curve to those found under it.

Marginal Analysis

In those cases where at least two technologies are non-dominated marginal analysis is needed to choose between them. Under such circumstances, higher net returns are obtained by use of more resources, i.e. by higher variable costs. Thus, we need to determine the benefit/cost ratio. If more than two technologies are non-dominated, those involved for each segment of the segmented line are analyzed separately as pairs as discussed below.

The purpose of marginal analysis is to reveal just how the net returns resulting from the adoption of an alternative-technology increase as the total variable costs increase. The <u>marginal net return</u> is the increase in net return resulting from the adoption of an alternative technology. The <u>marginal variable cost</u> is the increase in total variable cost incurred as a result of the adoption of an alternative technology. The marginal <u>rate of return</u> is the ratio of marginal net return to marginal variable cost expressed as a percentage. Marginal rates of return are <u>not</u> calculated in two cases: (1) When neither yield increases nor cost decreases differ to a statistically significant extent; and (2) when the alternative technology under consideration is dominated.

The following comparisons are involved:

- For Zefta District (1,3) vs (1,1). Grain yield, straw yield, and gross returns all are higher to a statistically significant extent for (1,3) over (1,1). The marginal rate of return is calculated as follows:

  $$\frac{267 - 193}{212 - 202} \times 100 = 740\%$$

  Thus, for each L.E. invested by the farmer in moving from the traditional technology to a plant drill technology under EMCIP recommendations, the farmer receives L.E. 7.4 in increased returns.
- For Zefta District, (1,2) vs (1,1). This is of interest only when the plant drill is not available. Again, grain yield, straw yield, and gross returns all are higher to a statistically significant extent for (1,2) over (1,1). The marginal rate of return equals:

  $$\frac{227 - 193}{243 - 202} \times 100 = 83\%$$

  Here the farmer received L.E. 0.83 above his investment for each L.E. invested in moving from the traditional technology to EMCIP recommendations when seed is broadcast in both cases. This 83% return on average has to be compared with that from alternative uses for funds after allowing for the risk of an investment in growing wheat. Returns of 200% or more are considered minimal to induce investment in risky areas like farming in many countries.

- For El Santa District, only one technology is dominant in each case. Thus, marginal analysis is not required. If the plant drill is available, it should be used based on EMCIP recommendations. If it is not, EMCIP recommendations should be used when seed is broadcast.

Sensitivity Analysis

In the research report we show how sensitivity analysis may be used to eliminate economies of scale thorough adjustment procedures of variable cost and related net return data for the plant drill technology. Based on such adjustment data, dominance and marginal analyses may yield different conclusions than those above.

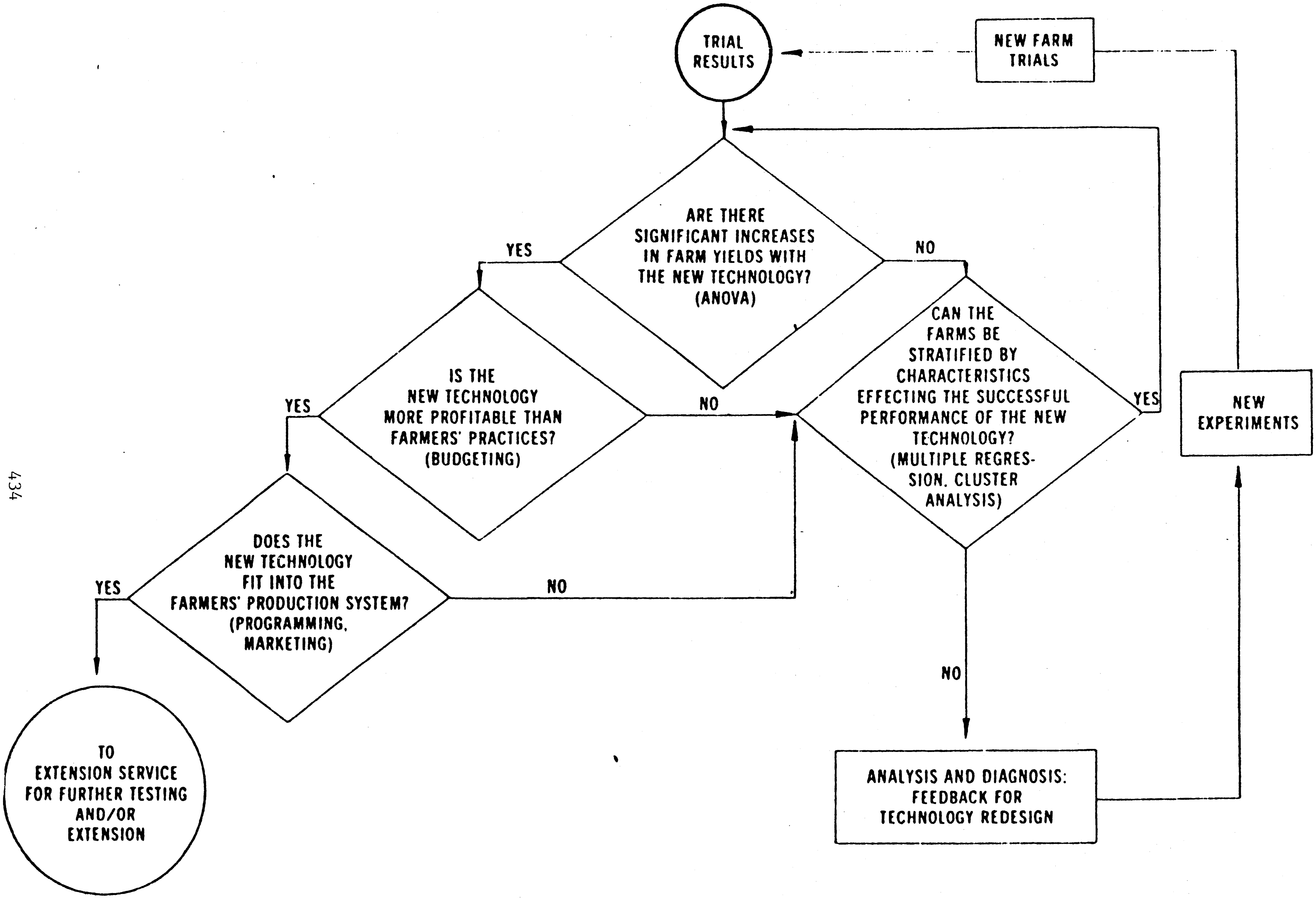

FIG. 1. Flow chart for new technology evaluation in farm trials.

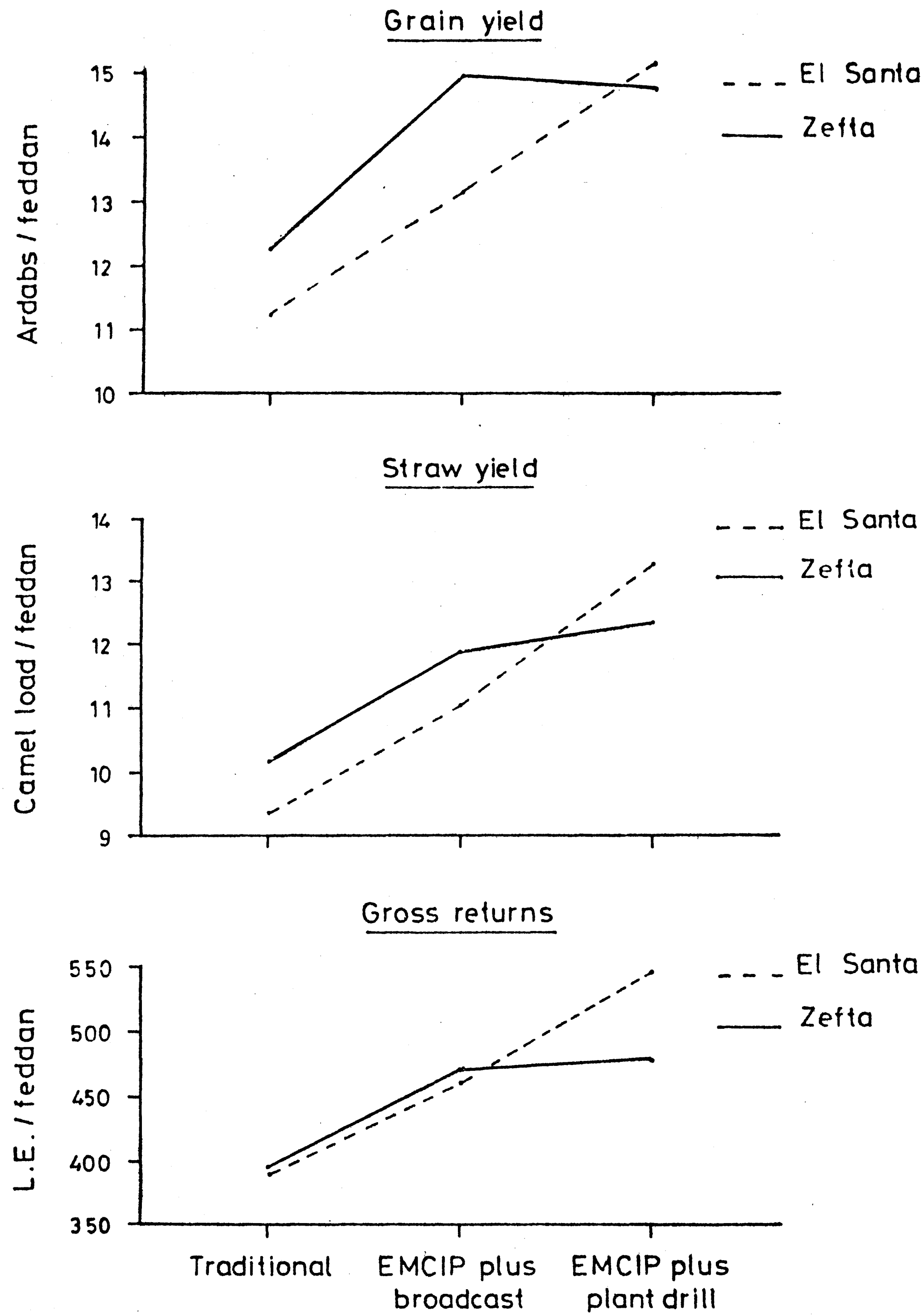

Fig. 2 Grain yield, straw yield and gross returns per feddan: Interaction between Districts and level of technology

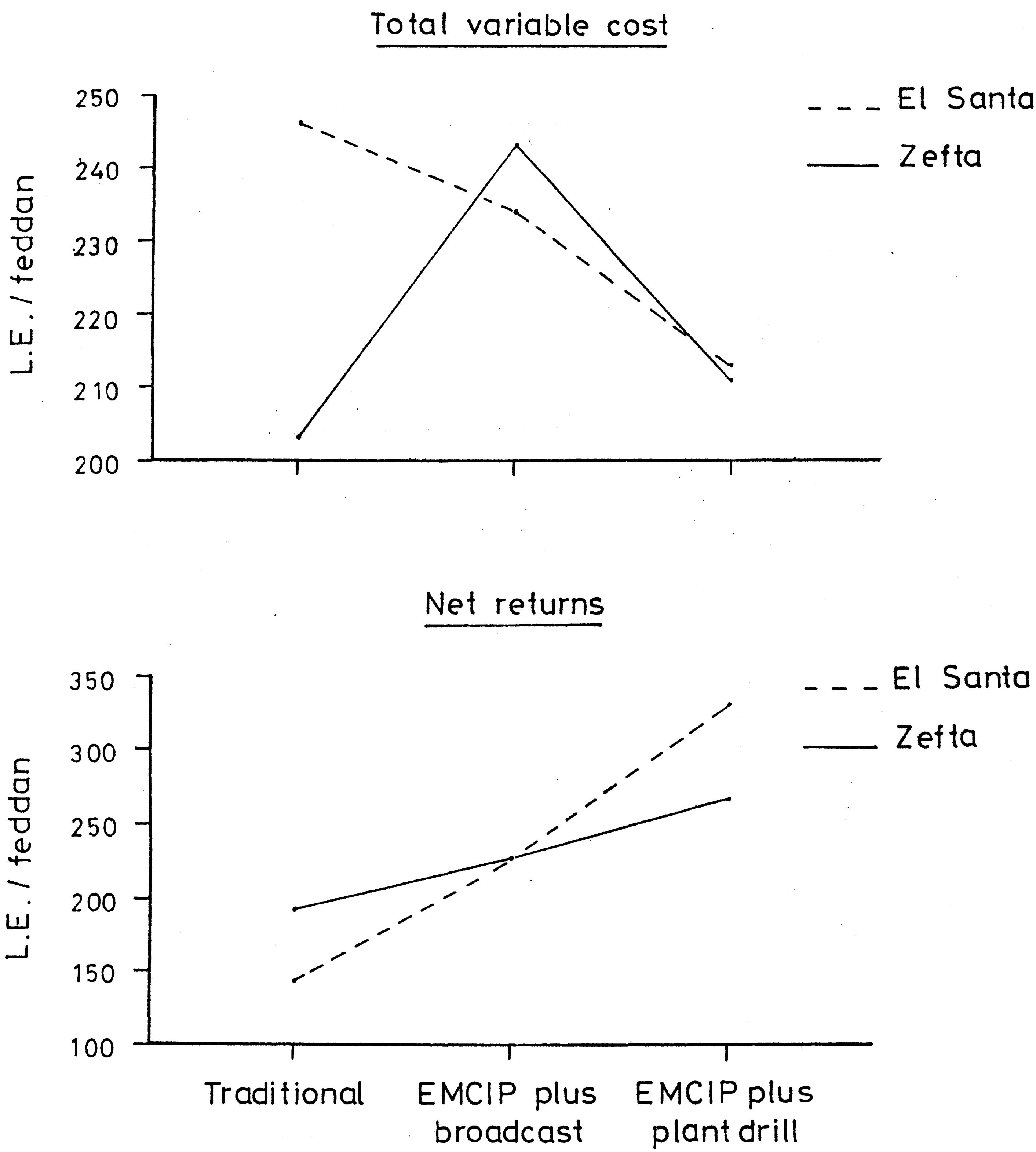

Fig. 3 Total variable cost and net returns: Interaction between Districts and level of technology

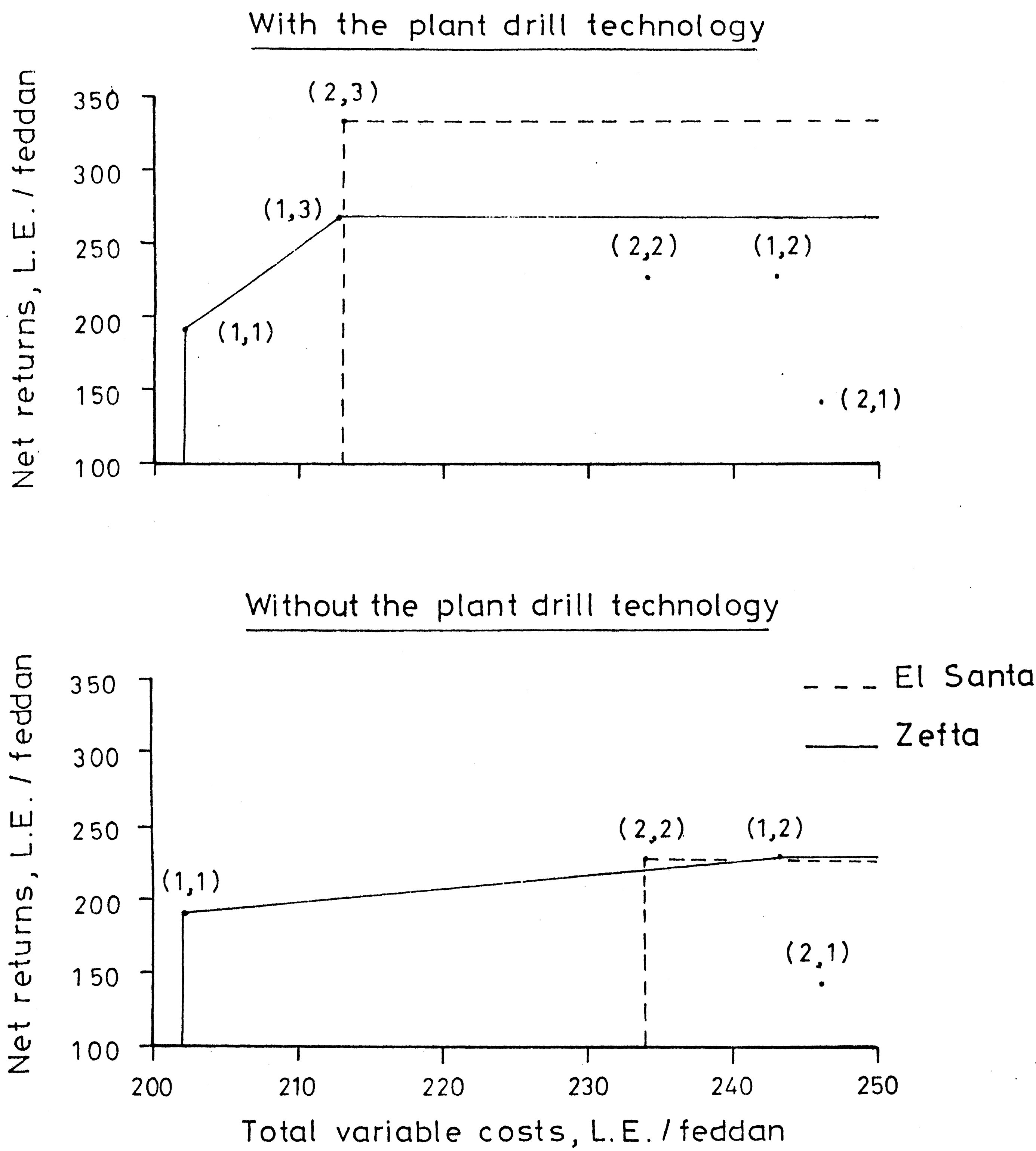

Fig. 4. Dominance curves for the 1982/83 Gharbeya Governorate wheat experiment with & without the plant drill technology based on reported variable costs*

* Numbers in parentheses represent District & levels of technologies, respectively.

Table 1. Matrix configuration of all possible treatments in the 2 x 3 factorial wheat experiment, Gharbiya Governorate, 1982/83

Factor 1: Recommendation domain (District)	Factor 2: Type of technology		
	Traditional (1)	EMCIP recommendations with --	
		Broadcast (2)	Plant-drill (3)
Zefta (1)	(1, 1)	(1, 2)	(1, 3)
El Santa (2)	(2, 1)	(2, 2)	(2, 3)

Table 2. Grain yield: ANOVA in ardabs per feddan

Source of variation	DF	SS	MS	Observed F	F required	
					5%	10%
Between farmers	9	24.42	2.714	-	-	-
Between Districts (D)	1	9.793	9.793	5.51	4.06	2.82
Between technologies (T)	2	112.1	56.07	31.56	3.21	2.43
D x T interaction	2	11.66	5.829	3.28	3.21	2.43
Residual	45	79.93	1.776	-	-	-

Table 3. Grain yield: 2-way table of treatment means per feddan

Factor 1: Recommendation domain (District)	Factor 2: Type of treatment		
	Traditional (1)	EMCIP recommendations with --	
		Broadcast (2)	Plant-drill (3)
		Ardabs	
Zefta (1)	12.27	14.92	14.79
El Santa (2)	11.20	13.19	15.17

Table 4. Grain yield: Mean differences per feddan between Districts and at each level of technology and their level of significance as determined by LSD

Source of difference by technologies	District		Mean difference (1) - (2)	LSD *	Level of significance
	Zefta (1)	El Santa (2)			
			Ardabs		
Traditional	12.27	11.20	1.07	1.00	0.10
EMCIP recommendations:					
Broadcast	14.92	13.19	1.73	1.20	.05
Plant drill	14.79	15.17	-.38	1.00	NS

* The upper figure is at p = 0.05 and the lower one is at p = 0.10. See text.

Table 5. Grain yield: Mean differences per feddan between levels of technology within Districts and their level of significance as determined by LSD

Source of differences by technologies within Districts	Mean difference	LSD*	Level of significance
	Ardabs		
Zefta District:			
EMCIP broadcast versus traditional	2.65	1.20	0.05
EMCIP plant drill versus traditional	2.52	1.20	.05
EMCIP plant drill versus EMCIP broadcast	-.13	1.00	NS
El Santa District:			
EMCIP broadcast versus traditional	1.99	1.20	.05
EMCIP plant drill versus traditional	3.97	1.20	.05
EMCIP plant drill versus EMCIP broadcast	1.98	1.20	.05

* Same as for table 4.

Table 6. Straw yield: ANOVA in camel loads per feddan

Source of variation	DF	SS	MS	Observed F	F required 5%	F required 10%
Between farmers	9	12.66	1.407	-	-	-
Between Districts (D)	1	.9601	.9601	0.74	4.06	2.82
Between technologies (T)	2	96.09	48.04	36.82	3.21	2.43
D x T interaction	2	10.25	5.126	3.93	3.21	2.43
Residual	45	58.72	1.305	-	-	-

Table 7. Straw yield: 2-way table of treatment means per feddan

Factor 1: Recommendation domain (District)	Factor 2: Type of technology: Traditional (1)	EMCIP recommendations with -- Broadcast (2)	EMCIP recommendations with -- Plant drill (3)
		Loads	
Zefta (1)	10.14	11.87	12.37
El Santa (2)	9.32	11.00	13.29

Table 8. Straw yield: Mean differences per feddan between levels of technology within Districts and their level of significance based on LSD

Source of differences by technologies within Districts	Mean difference	LSD*	Level of significance
		Loads	
Zefta District:			
EMCIP broadcast versus traditional	1.73	1.03	0.05
EMCIP plant drill versus traditional	2.23	1.03	.05
EMCIP plant drill versus EMCIP broadcast	.50	.86	NS
El Santa District:			
EMCIP broadcast versus traditional	1.68	1.03	.05
EMCIP plant drill versus traditional	3.97	1.03	.05
EMCIP plant drill versus EMCIP broadcast	2.29	1.03	.05

* Same as for table 4.

Table 9. Gross returns: ANOVA in L.E. per feddan

Source of variation	DF	SS	MS	Observed F	F required 5%	F required 10%
Between farmers	9	22,210	2,468	-	-	-
Between Districts (D)	1	4,234	4,234	2.17	4.06	2.82
Between technologies (T)	2	145,100	72,590	37.16	3.21	2.43
D x T interaction	2	17,770	8,889	4.55	3.21	2.43
Residual	45	87,900	1,953	-	-	-

Table 10. Gross returns: 2-way table of treatment means per feddan

Factor 1: Recommendation domain (District)	Factor 2: Type of technology		
	Traditional (1)	EMCIP recommendations with -- Broadcast (2)	EMCIP recommendations with -- Plant drill (3)
		L.E.	
Zefta (1)	395	470	479
El Santa (2)	390	460	545

Table 11. Gross returns: Mean differences per feddan between levels of technology within Districts and their level of significance based on LSD

Source of differences by technologies within Districts	Mean differences	LSD*	Level of significance
		L.E.	
Zefta District:			
EMCIP broadcast versus traditional	75	40	0.05
EMCIP plant drill versus traditional	84	40	.05
EMCIP plant drill versus EMCIP broadcast	9	33	NS
El Santa District:			
EMCIP broadcast versus traditional	70	40	.05
EMCIP plant drill versus traditional	155	40	.05
EMCIP plant drill versus EMCIP broadcast	85	40	.05

* Same as for table 4.

Table 12. Total variable cost: ANOVA in L.E. per feddan

Source of variation	DF	SS	MS	Observed F	F required 5%	F required 10%
Between farmers	9	7,626	847.3	-	-	-
Between Districts (D)	1	2,042	2,042	3.10	4.06	2.82
Between technologies (T)	2	7,207	3,603	5.46	3.21	2.43
D x T interaction	2	7,540	3,770	5.72	3.21	2.43
Residual	45	29,680	659.7	-	-	-

Table 13. Total variable cost: 2-way table of treatment means per feddan

Factor 1: Recommendation domain (District)	Factor 2: Type of technology		
	Traditional (1)	EMCIP recommendations with -- Broadcast (2)	Plant drill (3)
		L.E.	
Zefta (1)	202	243	212
El Santa (2)	246	234	213

Table 14. Total variable cost: Mean differences per feddan between Districts and at each level of technology and their level of significance as determined by LSD

Source of differences by technologies	District Zefta (1)	District El Santa (2)	Mean difference (1) - (2)	LSD*	Level of significance
			L.E.		
Traditional	202	246	-44	23	0.05
EMCIP recommendations:					
Broadcast	243	234	9	19	NS
Plant drill	211	212	-1	19	NS

* The upper figure is at P = 0.05 and the lower one is at P = 0.10. See text.

Table 15. Total variable cost: Mean differences per feddan between levels of technology within Districts and their level of significance as determined by LSD

Source of differences by technologies within Districts	Mean difference	LSD*	Level of significance
		L.E.	
Zefta District:			
EMCIP broadcast versus traditional	41	23	0.05
EMCIP plant drill versus traditional	10	19	NS
EMCIP plant drill versus EMCIP broadcast	-31	23	.05
El Santa District:			
EMCIP broadcast versus traditional	-12	19	NS
EMCIP plant drill versus traditional	-33	23	.05
EMCIP plant drill versus EMCIP broadcast	-21	19	.10

* Same as for table 14.

Table 16. Net returns: ANOVA in L.E. per feddan

Source of variation	DF	SS	MS	Observed F	F required 5%	F required 10%
Between farmers	9	17,620	1,959	-	-	-
Between Districts (D)	1	49	49	0.02	4.06	2.82
Between technologies (T)	2	188,200	94,110	34.09	3.21	2.43
D x T interaction	2	26,010	13,000	4.71	3.21	2.43
Residual	45	124,200	2,761	-	-	-

Table 17. Net returns: 2-way table of treatment means per feddan

Factor 1: Recommendation domain (District)	Factor 2: Type of technology		
	Traditional (1)	EMCIP recommendations with -- Broadcast (2)	EMCIP recommendations with -- Plant drill (3)
		L.E.	
Zefta (1)	193	227	267
El Santa (2)	144	226	332

Table 18. Net returns: Mean differences per feddan between levels of technology within Districts and their level of significance as determined by LSD

Source of differences by technologies within Districts	Mean difference	LSD*	Level of significance
		L.E.	
Zefta District:			
EMCIP broadcast versus traditional	34	39	NS
EMCIP plant drill versus traditional	74	47	0.05
EMCIP plant drill versus EMCIP broadcast	40	39	.10
El Santa District:			
EMCIP broadcast versus traditional	82	47	.05
EMCIP plant drill versus traditional	188	47	.05
EMCIP plant drill versus EMCIP broadcast	106	47	.05

* The upper figure is at P = 0.05 and the lower one is at P = 0.10. See text.

Table 19. Average net returns and total variable costs per feddan by District and by level of technology

District and level of technology	Cell identification*	Net returns	Total variable costs
		L.E.	L.E.
Zefta District:			
Plant drill	(1,3)	267	212
Broadcast	(1,2)	227	243
Traditional	(1,1)	193	202
El Santa District:			
Plant drill	(2,3)	332	213
Broadcast	(2,2)	226	234
Traditional	(2,1)	144	246

* Numbers between parentheses represent District and level of technology, respectively.

CONDUCTING ON-FARM RESEARCH IN FSR - MAKING A GOOD IDEA WORK

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Over the past decade a widespread interest has developed in Farming Systems Research (FSR) in the International Agricultural Research Centers (IARCs), in the national agricultural research and extension systems of developing countries, and in academic circles in many developed countries. Among practitioners there has been general agreement on the broad philosophical approach. In fact, it has been often stated that FSR is a philosophy rather than a methodology. As a consequence, nearly any research activity that is seen as farmer oriented and interdisciplinary is labeled FSR if for no other reason than to attract donor funding. Wooed by the rhetoric, donor agencies such as the World Bank and USAID have made substantial investment in FSR projects.

Major attempts have been made in the literature to clarify the concepts of FSR. This, for the most part, has led to more acronyms (FSR&D, FSR/E, FSIP, and OFR/FSP to name a few) and more confusion, as various authors have given us their own perceptions. Most recently the World Bank hired Norman Simmonds to tour the world and unravel the mysteries of FSR. Simmonds's report makes an important contribution in that it presents the broad perspective of FSR with great clarity. But, as with most of the literature, the methodological issues are scarcely addressed. With most of the attention devoted to clarifying the philosophy and concepts and a lack of focus on development of methodology, it is not surprising to find a growing concern among the donors and practitioners alike that FSR is not improving the efficiency of our research extension effort. FSR is not leading to more rapid adoption of new technology and significant gains in agricultural production, productivity and farm family welfare. Indeed, many of the problems experienced arise from this lack of focus which in turn explains the weak development of methods that exploit the comparative advantage of FSR. It is the experience of many projects that initial methodological approaches to FSR, both surveys and experiments in farmer's fields, have been for the most part inappropriate.

FSR methodologies are slowly evolving in a number of projects and institutions, which take into account the limited resource endowments and exploit the comparative advantage of national research and extension networks. Our objective in this paper is to identify a set of methods and procedures that allow FSR projects to immediately increase their efficiency in terms of developing technologies that farmers adopt. In doing this we glean from the works of others and our own experiences. This task has been made difficult by the paucity of material submitted to academic journals. Agreed there have been reviews on FSR, notably Shaner et al 1979, Norman 1979, Gilbert, Winch and Norman 1981, and most recently Simmonds 1983; also some IARCs' have produced training manuals, notably Collinson, 1980, Perrin et al 1979, and Zandstra et al 1982. We make no grandios claims for these procedures since we are still at the point of testing them. Unfortunately, like most other practitioners in the field we are more familiar with what does not work than what does work.

UNDERSTANDING THE EXISTING FARMING SYSTEM AND IDENTIFYING PROBLEMS

An important first step in FSR is to select sites in which the research will have a significant impact. The recommendation domain and target group of farmers must be identified and the farming systems described in order to be able to understand and identify the important problems.

Site selection is frequently not accomplished by those who are to carry out the research but rather by those who prepare the project proposals. It normally involves a rather unsystematic mixture of political, socioeconomic, and technical judgement. The governments usually mandate the beneficiaries of research in broad general terms such as "subsistence farmers," "small farmers" or "resource poor farmers." The task of characterizing and selecting research participants should begin with site selection. It should involve the systematic use of secondary data including soil maps and census data to consider in both geographic and demographic terms the potential beneficiaries based on site selection. In short, at the very conception of the project an effort should be made to define in general terms the recommendation domains and target beneficiaries.

In many farming systems (and cropping systems) projects, the site selection has been followed by detailed in-depth benchmark and/or multiple visit surveys to obtain the necessary information to fully describe the farming system. Eicher and Baker (1982) have the following comment on the efficiency of this approach: "Moreover, it often requires 6-12 months to plan a cost route study, a year to carry it out, and sometimes 2-3 years to analyze and publish the results. Concern with the cost of cost route surveys and the need to generate rapid results has led to a search for survey methodologies which can produce results in a few months rather than 2-3 years."

The failure of the large survey approach led to the development of shorter and more informal survey procedures, of which CIMMYT's exploratory surveys and ICTA's sondeo are perhaps the most popular. These procedures come under the heading of a class of activities known as "rapid rural appraisal" and frequently earn the additional title "quick and dirty." The problem suggested by this latter title is that these approaches do not provide adequate information on which to design appropriate research activities. The problems are identified at too general a level, i.e., soil fertility, soil erosion, or livestock nutrition.

Much more must be known about the current range of farmer knowledge and experience and resource potentials and constraints. Here, we propose a diagnostic procedure which combines the quick survey approach with a much more detailed monitoring and measurement in specific problem areas or areas that appear to offer potential for research. These two levels of investigation are described in the sections that follow.

Level one is the sondeo or exploratory survey activity. The sondeo is a survey conducted by an interdisciplinary group without the use of a formal survey lasting a period of several days. The details of this procedure are fully described by Hildebrand (1979). The purpose is to more clearly define the recommendation and target group of farmers and to identify the major problems and potentially researchable issues. While the sondeo team normally represents several disciplines, even more important than the disciplinary composition is the choice of individuals. Two types of people are needed: those who are capable of identifying research problems and issues and those who know the region. While the latter group is likely to be composed entirely of the FSR team the former group may include people outside the project with on-farm research experience. Many of these experienced individuals are busy with other work but are able to commit a few days to participate in a sondeo.

We should emphasize the fact that the success with which the sondeo can identify key problem areas depends a great deal on the quality and experience of the team. The usual project situation is one of doing the sondeo with a fresh group of people who spend as much of their time trying to work together as they do learning about the system.

How do we know that from the sondeo that we have identified the right problem areas? At the end of the sondeo when the report has been completed, a dialogue must be held with farmers, probably on a group basis, to discuss the sondeo team findings. It is very important at this early stage in the project that the farmers and scientists agree on the problems.

Level two is the diagnostic, monitoring and measurement activities. We have already learned from the failure of the large survey approach that we cannot gather and analyze data in a reasonable time period in all aspects of the farming system. The informal survey work has helped us to identify the major livestock and crop activities and the major problem areas. We must now limit the number of data gathering activities and see that they are clearly focused.

First on the agenda is the need for a survey to describe the target group of farmers in more quantitative terms. This survey should concentrate on about a dozen key variables such as farm size and tenure, family size and occupation, land use including crops grown, and livestock enterprises. While the survey procedures can be standardized across sites, in our view, the formal questionnaire must be kept extremely short and when possible should be analyzed at the site. The advent of the microcomputer unfortunately, once again, has strengthened the notion that the size of the survey can be increased and the data brought to a central location for rapid processing and analysis. A more appropriate alternative is to strengthen the capacity of the site team to conduct their own analyses' using calculators, sorting strip etc. Site researchers need such information quickly, for example, to assist them in selecting farmer co-operators who are representative of the target group.

The survey information provided in the above activities should be adequate to allow the researchers to identify the major problem areas.

It is, however, unrealistic to expect that after only a few short months on location, the research team is prepared to design experiments. The experiments conducted in the first year of the project are normally of little value because they do not, or more correctly cannot, address the important issues. More formal monitoring activities are needed. Once the two or three key areas are identified, an in-depth investigation must be undertaken with a view to understanding the farmers' knowledge and experience, the range of environmental variability, and the factors explaining variability in performance among farmers. The specific purpose of this analysis is to quantify the production and management experience across farms and to identify potential areas of research impact. This requires a careful monitoring of both physical and socioeconomic factors.

For example, if improvement in cattle production is identified as a likely area for technical impact, one must examine the existing production system on a sample of farms. Information must be gathered throughout the year on feed supplies and feeding practices, animal health, labor requirements, and purchase of inputs if any. We need to know why some farmers are doing better than others and what researchable topics might lead to significant gains in cattle production.

How is the monitoring to be organized? Approximately 20 farms should be adequate for the task. Monitoring activities might combine occasional surveys to establish labor requirements, livestock inventories, animal health etc. with frequent visits to monitor feeding practices and seasonal variations in feed supplies. It might be necessary to obtain laboratory analyses of indigenous forages to establish their nutritive value. At the end of the monitoring period, a report could be prepared on "potentials for increasing cattle production in the farming system - researchable issues." Knowing that this report is the objective of their efforts will help the site team researchers to focus their work. One could visualize a similar type of monitoring activity for other problem areas such as crop production, erosion control, or soil fertility.

The danger of reducing the monitoring to say a single enterprise such as cattle production is that we may fail to emphasize the linkage of the enterprise to other components of the farming system. We must be careful to guard against this, spelling out clearly the way in which the cattle enterprise competes for feed supplies, labor, and other inputs within the farming system. Alternatively, the failure to sharply focus our monitoring activities also has its price. If we choose to monitor all livestock activities, then it will be difficult or impossible to obtain the depth of understanding we need to identify the researchable issues.

In summary, through the diagnostic analysis, every effort should be made to quantify the parameters to minimize subjectivity in identifying and specifying researchable areas. The site staff have to take an active role in the diagnostic measurements, monitoring, and other forms of data collection. An assessment must be made of those problems which can be solved by carrying out simple experiments conducted on farmers' fields by the site teams in conjunction with farmers, and those problems which require more complicated in-depth investigation. Selecting and designing the innovations for on-farm investigation is the subject of the next section.

SELECTING AND DESIGNING THE INNOVATIONS WORTHY OF ON-FARM INVESTIGATION

In the usual framework of farming systems research, design is recognized as the second stage. The selection of innovations to be tested on farms and their design usually falls to the technical scientists working on the research stations. Typically, the influence of the information gathered during the initial surveys on selection and design is weak. Consequently what ends up being tested are largely the current interests or recommendations of the research institutions. For example, where soil fertility is seen as the problem, researchers will want to run tests on chemical fertilizers even when these cannot be purchased by farmers. This is not to say that these scientists are disinterested in the relevance of work to the farmer, but that they do not have enough detailed information to do the job properly. The point here is that these recommendations are seen to be relevant because any innovation can be said to address the general problem of low production described by the surveys. The cursory nature of this process that is customary in FSR springs also from a confusion about this stage in the overall framework of research.

The stage of design as presented in Norman's four stages of FSR can and has been interpreted in two ways. The original and intended interpretation was that design be a process of refinement of technology packages to fit the farming conditions by on-farm researcher managed experiments. When practiced in the field it did not take long before the stages of design and testing became impossible to distinguish. Now that experience has indicated farmers' disinterest in packages, a second interpretation has emerged, primarily through the work of Collinson. He interprets design to be an intellectual process where all possible technical solutions are screened and 'prioritized' by technical and social scientists. Farmers also should be included in this process.

Five steps are enumerated in the CIMMYT manual for the conduct of design (Byerlee, Collinson, et. al 1980). The first step is identification by technical scientists of the biological problems encountered in the initial surveys. Each problem is then examined to define the possible causes which, for example, may be related to the farmers' objectives or limited resources. In the third step a wide a range of apparent solutions to each problem are generated. Typically a narrow range of direct solutions are entered here when the farmer needs a wide range of direct and indirect (i.e. solutions that exploit system interactions) solutions. These solutions are then screened by technical scientists who pose the questions: Will this biological relationship hold in the farm situation? What are the husbandry requirements for success? Concurrently the economists ask: Are the infrastructural support requirements feasible? Do the farmers have sufficient resources? Will it use resources more profitably?

Step five, prioritizes the technical options in terms of potential impact, ease of adoption, and ease of research effort. When establishing priorities the adoption concern should be the single most important criteria. The importance of this final step cannot be overemphasized because it controls in large measure the successful implementation of experiments, the degree of adoption, and thus the validity of this approach to research. By this token it is essential to involve the farmer in all the steps outlined above and especially the screening process. Here, it may be useful to present a wide range of possible solutions to the farmers so that they can pick those most suited to their circumstances. This will be especially true where researchers have difficulty in answering the questions posed in step four and even more so when assessing step five's ease of adoption.

USING FARMERS TO CONDUCT THE ON-FARM INVESTIGATIONS

The range of on-farm experiments found in FSR programs encompass the most complex replicated factorials to simple two plot demonstrations. This broad range has been divided into three types by the level of researcher and farmer involvement. The most complex trials such as the IRRI component tests or CIMMYT exploratory and levels tests are classified as researcher managed and executed. Intermediate levels such as IRRI's superimposed cropping patterns are classified as researcher managed and farmer executed. The least complex trials often termed demonstrations or by CIMMYT, verification tests are classified as farmer managed and executed. The intention is that technologies move from the most complex type one to the least complex type three which implies that on-station basic research occurs before type one. Thus, type one tests research generated technologies for biological performance in the farm setting. The second type of trial exposes the technologies to farmer levels of management and farmer opinion. Finally, predictable technologies are tested in the type three trials for performance over a wide range of farming conditions. Although this wide range of trials are talked about in practice, most of the research manpower, particularly at the IARCs, is tied up in the complex trials and with intermediate level trials which although simple in design are costly in terms of supervision and management.

FSR recognizes two distinctly different bodies of knowledge - the knowledge which comes from basic scientific research and the knowledge which is acquired through time by farmer experience. This latter body of knowledge is not formalized nor does it appear in the literature. It can only be captured through direct interaction between researchers and farmers. Even though feedback loops are built into the conceptual diagrams of FSR, in practice the ability to draw on the farmers traditional body of knowledge remains weak. This is in large measure because FSR remains very top-down in its methodologies

FSR field workers typically have borrowed designs wholesale from conventional on-station experiments. Most programs expend all their energies on the more complex types of research-managed work because they are very demanding to implement. These conventional experimental methods were primarily developed to determine "site effects" on largely unknown biological parameters. They are largely miniaturized research station experiments having randomized block designs of two or more replicates with four or more treatments which in the case of CIMMYT, levels trials are factorially structured. The analytical procedure is to conduct analysis of variance or response functions analysis and to apply standard statistical tests of significance. Adequate precision in the data are guaranteed by enormous research input into the management and implementation of each experiment; a resource level that IARCs command but that is rarely found in national institutions.

Researchers in the national level programs, despite the great difference in resource endowments, have generally followed the lead of the IARCs adopting the same methodological procedures. While economists have struggled to analyze the benchmark survey, agronomists have borrowed the IARC designs and set out component and cropping pattern trials. The project researchers have been overwhelmed by the sheer magnitude of the problems involved in managing data and controlling experiments. Only a few experiments are conducted at each site on a handful of farms. In the variable farm environments these few observations stand little chance of detecting real effects, even if one were to assume that the experiments have been properly managed, which is normally not the case. These facts notwithstanding, standard statistical tests typically are applied to the data and recorded in the results. The farmers' involvement in these experiments only extends to the lending of land, and perhaps land preparation with some weeding. In the experiments, yield per hectare is taken as the principle criterion of evaluation, and the most commonly used test inputs are variety, chemical fertilizers, and insecticides. Inputs such as seeds and chemicals are supplied by the researchers and for this the farmers are only too willing to cooperate. But, as one project manager observed when asked to write the "success story" of his project, "when we withdrew the farmers withdrew."

The methods and procedures described above are inappropriate for FSR. The primary goal of our research is to enhance adoption of new technology, not to define biological input-output responses at each site. The following on-farm experimental method is presented to illustrate a more appropriate procedure for FSR. Briefly, the experimental method entails the over-laying of treatments onto the appropriate existing crop or soil conditions. The procedure for over-laying treatments onto the farmers own crops is similar to the superimposed trials mentioned by Shaner et al. 1982, Kirkby et al. 1981, and CATIE. For example, to test the benefit of nitrogen top-dressing of maize, an area of healthy maize, that is a crop that farmers would be advised to top-dress, is identified on a participant's farm. The farmer is given the fertilizer with instructions to apply it over half the identified area demarcating the treatment and control plots after implementation. By contrast, a conventional experimenter would select the experimental area prior to land preparation, mark out the plots, and implement the treatments in the appropriate plots.

The simplicity of this experimental method permits farmer implementation. Ideally the innovation, for example, improved seed, or fertilizer is given to the farmers for them to implement the treatments. The researchers' involvement extends to the selection of area, instruction on implementation, and some checking on the accuracy with which the experiments were conducted. Of course, all measurements and data collection are the responsibility of the researchers.

The shift in level of involvement from researcher to the farmer in the over-laid method increases the scope of farmer participation and gives time for the researchers to contact many more farms. Testing in appropriate conditions and the use of many more farms can only increase the rigor and precision with which innovations are assessed. In addition, farmer participation could be deepened by soliciting their reactions to the innovations. The depth of such questioning is likely to be greater when conducted by researchers trained specifically in this area, which also affords greater interaction among the disciplines.

There are important implications of this methodology for quantitative analysis. We have shifted from a few researchers' managed experiments (usually on just four or five farms) to many trials (twenty or thirty) in which the farmer applies the input. Although our treatments are set out in a single recommendation domain, this new procedure introduces the variability in treatment management among farmers. But at the same time, we have increased the rigor of the test and precision of the trial by adding many more replications across the farm. The performance of an innovation across the variety of environmental and management conditions experienced provides important information about the range of outcomes farmers might expect.

Such information is provided by the analysis of the distribution of the observations. This analysis should include the mapping of performance data and the use of scatter diagrams to provide the researcher with a visual image of the data and make it easy to associate the level of performance with the location of the trial. Using simple statistical measures such as mean and standard deviation, the degree of overlap in performance of the two treatments (farmers level and superimposed) can be estimated, and where appropriate significance tests can be employed.

Farmers are also interested in knowing about the likely performance of innovations over a run of years. Some indication of this is provided by the calculation of confidence intervals. Here farmers can learn the range of likely outcomes of a particular new technology. The fact that the trials are run across so many farms with varying conditions strengthens the utility of this analysis. However, caution must be exercised in interpreting these results, since factors causing variability in performance across locations in a given year, and factors explaining variability on a given farm through time may be very different.

As with the socioeconomic surveys, the analysis of the data is at the level of the site teams. Thus, the site teams as well as the farmers are more directly involved in the research process. We have improved the capacity of both groups to access the utility of a new innovation. In the final analysis, the results of our quantitative analysis notwithstanding, farmers will be the judge of appropriateness of the innovation.

In short, the procedure suggested above provides more time for the site team researchers to be engaged in the data collection and analysis. However, greater sensitivity to the analysis and interpretation of data is a product of more education. Researchers must be willing and able to assume a certain freedom from the rigidity of traditional scientific procedures. If the approach we have outlined is to work, it will require developing capabilities at the overall project level and at the site team level that do not normally exist.

CONCLUDING REMARKS

In this paper we have focused on methodological issues associated with farming systems research. We believe that if it is to be effective FSR must be based not only on a philosophy, but also on an efficient methodology. The methodologies used in most projects to date have been borrowed from research stations. They were designed not to enhance the speed of adoption, but to improve our understanding of physical and biological relationships (e.g. fertilizer response). These procedures, while useful in their own right, do not effectively incorporate the experiential knowledge of farmers regarded as essential in FSR.

Given the objectives of FSR, traditional research procedures appear to be inappropriate. Furthermore, the site research teams in the national programs have had neither the trained manpower capacity nor the resources to successfully manage the experiments in farmers' fields. For those who have been involved in national farming systems programs, the problems we have discussed in using existing methodologies and trying to manage experiments in farmers' fields undoubtedly has a familiar ring. We have been struck by the similarity of these problems in locations as far apart and as different environmentally and culturally as Botswana, Ecuador, and the Philippines.

We should be quick to acknowledge that despite these problems much has been learned from FSR to date. Our argument is that it has been learned at a very high cost, a cost higher than developing countries and donor agencies may be willing to pay in the future.

An alternative methodology has been described. To a large extent it is not new. Various components have been described and tested by others who like us have been concerned with the need to develop more appropriate procedures. In the descriptive problem identification phase, we suggest the use of the sondeo coupled with a more indepth diagnostic analysis of the key problem areas identified in the sondeo. In the design we emphasize the need to explore in conjunction with farmers the range of relevant alternatives in order to pick out those to include in the research design. Of critical importance in these early phases is the need for farmer participation. In the testing phase, we suggest that where possible, treatments be superimposed by the farmers themselves, and that 20 to 30 farmers be included in a single trial. The researchers will then be free to concentrate on the collection and analysis of data.

Development of site team research capabilities, of course, will be a major task.

In closing, we stress the need to develop a more efficient FSR methodology. We are, however, in the unfortunate position of knowing what doesn't work. We will need to test the procedures described above in order to determine whether what we have proposed is an appropriate alternative.

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CRITERIA FOR RE-APPRAISAL AND RE-DESIGN: INTRA-HOUSEHOLD AND BETWEEN-HOUSEHOLD ASPECTS OF FSRE IN THREE KENYAN AGROFORESTRY PROJECTS

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INTRODUCTION

Farming systems research methodologies and experience (Chambers, 1981; Collinson, 1981; Hildebrand, 1981; Rhoades, 1981; Zandstra et al. 1981) have served as the basis for system-level methodology development at ICRAF (Raintree, 1983). An interdisciplinary team, led by an anthropologist, adapted the rapid appraisal and technology design procedures to agroforestry applications. Much of the initial development of the method and its further refinement were based on field experience in Kenya in cooperation with Kenyan government institutions[1] and non-governmental organizations (NGO's).[2] Field tests have also been conducted at several sites in Asia, Africa, and Latin America through collaboration with national and regional institutions.

The diagnosis and design (D+D) methodology takes a problem-solving approach with an emphasis on farmers' priorities for fulfillment of basic needs (ICRAF, 1983). The major needs categories are: food, water, fuel, cash, shelter and infrastructure, savings/investment, and social production. Initial rapid appraisal and technology design focussed on the individual farm as the management unit and on individual heads of household as farm managers. Agroforestry designs for prototype farms were intended to serve the needs of the household-as-a-unit within farm boundaries. Recently ICRAF has devoted more attention to the division of labor, difference in interests, differential access to resources, and distribution of benefits within households and within communities.

THE INSTITUTIONAL CONTEXT

The need to look closer within the household and at larger-than-farm community and ecosystem issues surfaced in some of the rapid appraisal exercises for collaborative projects outside Kenya (Costa Rica, India). However, continuous contact with farmers and the surrounding community at two Kenyan sites in Machakos District has provided the stimulus and the opportunity to refine the diagnoses and to re-design technology trials to reflect within-household and community level criteria.

In the case of the Kathama Project, ICRAF was the lead institution

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[1]Kenya Agricultural Research Institute (KARI), Ministry of Agriculture Katumani Station (DFSRS), and Machakos Integrated Development Project (MIDP).

[2]Mazingira Institute, CARE Kenya, and Kenya Energy Non-Gov't. Organizations (KENGO).

and conducted field work in collaboration with Wageningen University within the context of a small methodology development project based on farming system surveys and on-farm trials of agroforestry innovations (Raintree, 1983; Rocheleau and Hoek, 1984; Vonk, 1983). ICRAF is continuing the project (on a limited scale) as a vehicle for testing implementation approaches and variable scale diagnosis and design.

In the second project (Kakuyuni Dryland Agroforestry Project) three Kenyan institutions (KARI, MIDP, NDFSRS) are conducting on-farm and on-station research for a small semi-arid prototype catchment, with technical backstopping from ICRAF (Hoekstra, 1984; arap Sang, 1984). The project began with parallel approaches to watershed management and farm production, and has developed into an integrated treatment of sustainable production throughout the catchment and the larger community that depends on its water yield to the Kakuyuni Dam. Research and extension are linked, as are group and farm level activities.

In both Kathama and Kakuyuni, on-farm trials and group activities have demonstrated the importance of off-farm resources for farm production (varying by farm and family type), the common use of private property, the role of group labor in farm management, the variable effect of individual farm management on the community resource base, and the participation of women in all of the above. The field experience at these sites has changed the researchers' perception of the clients and their farming system, and the lessons from these two sites are being incorporated (and tested) in the planning and early implementation of a third project, the CARE-Kenya Siaya Agroforestry Project. The latter includes a research component within a development context, and combines community nurseries, self-help groups (predominantly women), and farm trials of AF technologies. As such it provides an excellent opportunity for testing/development of variable-scale, participatory research methodology for AF projects. The contrasting physical and social environment and the district level scale of the project also provides an excellent contrast with the Machakos sites, to broaden the scope of case study comparisons.

CASE STUDY RESULTS

The experience from each case is presented separately, in order to demonstrate the empirical and practical basis for the methodological and research policy conclusions which follow. Kathama is treated first, Kakuyuni second, and Siaya third, reflecting chronological order as well as a progression from exploratory research carried out by ICRAF, to testing/application of methodology in a collaborative role, to application/modification of the approach by an independent project with ICRAF as an interested observer/consultant. The sequence of surveys and trials in the Kathama project is treated in greater depth, to set the stage for comparison with the other two cases.

The Kathama Case Study

The case of the Kathama Project illustrates the evolution of the methodology-in-general (Figs 1 and 2) and the self-correction of the project and technology designs in response to social, economic, biological, and physical performance criteria. The experience in this community also illustrates the general importance of social factors in existing production systems, and in the planning, testing, and dissemination of new technologies. In particular, the project has called our attention to the need for designs that transcend farm boundaries, both within and without, according to both social and ecological criteria. Although the case described below deals specifically with agroforestry technologies, many of the methodological and substantive issues apply to farming systems research in general. Moreover, agroforestry technologies _per se_ have relevance to a broad range of farming systems and commodity-based research programs.

Initial Surveys and Trials

Preliminary studies included a descriptive survey of the local farming system(s) (Gielen 1982) and a botanical inventory of local trees and their uses (Fliervoet, 1982). Following these baseline studies ICRAF initiated a two year test of the D + D methodology (Vonk, 1983). The rapid appraisal diagnostic survey identified farm-level potentials and problems that could be addressed by agroforestry interventions (Figs. 3 and 4, Table 1).

The farmers' objectives, basic household needs, current strategies for problem-solving, and available resources guided the design of promising agroforestry technologies (Raintree, 1983). Ten farmers agreed to test these "best-bet" options on their farms (Vonk, 1983). The technology trials included species elimination trials of promising multipurpose (exotic) trees, methods of tree establishment in cropland and grazing lands, hedgerow intercropping of _Leucaena leucocephala_ and _Cassia siamea_ with maize and pigeon pea to improve soil moisture and fertility, and fodder/fuelwood lots to produce high quality fodder at the end of the dry season.

While most species failed to establish with direct seeding under the drought conditions which prevailed during most of the two year study, several species of exotic and indigenous trees and shrubs (Table 2) showed high rates of survival when planted as seedlings. The study incorporated monitoring of labor inputs for establishment and farmer's reactions and suggestions during establishment and early growth. The changes suggested by farmers reduced labor for land preparation and provided a simple low-input alternative for rehabilitation of individual plants in small plots of grazed woodland (Vonk, 1983). A combination of drought and normal time-lag for tree establishment prohibited monitoring of the productive/service roles of the hedgerows and fodder lots within the two year study.

During this same period four additional special studies were carried out by Wageningen graduate students on: nutrient balance in the cropping system (Nijssen, 1983); stickwood increment in the grazing lands (Boer, 1984); potential role of local voluntary organizations in agroforestry activities (Wijngaarden, 1983) and a landscape analysis and design for the surrounding watershed (Hoek, 1983). The first two studies provided quantitative information to refine the farm level diagnosis, while the latter two helped lay the foundation for a sliding scale of AF diagnosis and design. They called attention to the role of women in self-help groups, the role of those groups in farm production and watershed management, and the interaction between watershed degradation, farm production, and management of off-farm resources and public spaces.

Follow-up Study

The project continuation built upon the results of the original farm trials and special studies, with emphasis on farm trial monitoring/implementation and on larger-than-farm D+D and trials. The landscape analysis led into a watershed scale D+D and a follow-up project with self-help groups on AF in soil and water conservation (Rocheleau and Hoek, 1984).

Farm Trials.

As information began to filter back from the continued monitoring of the 10 farm trials, there were strong indications of interaction between on-farm AF technologies and management of the surrounding environment. Three of the participating farmers attempted to propagate their own new seedlings for independent continuation and expansion of species trials, fodder lots, and hedgerow intercropping. Two of the three failed (and others refrained from trying) due to water shortage and difficulty of access to permanent water sources. The one participating farmer who succeeded in growing his own seedlings had prior experience with a home citrus nursery and has a permanent water source on his property. The same is true for the other two farmers in the community who raise fruit and multipurpose tree (MPT) seedlings. For most other families, access to water involves use of public sources.

Water rights in the area range from private ownership and exclusive use of open shallow wells on-farm, to free public access to low-yielding hillside springs and flowing rivers, to temporary shallow wells in dry river beds dug and fenced by small ad hoc groups that may also share water collection and stock-watering trips. Access to water is a major determinant of location preference and is reflected in the location of the largest and/or the most prosperous landholders. The latter are concentrated along the base of the Kanzalu Range (Figs. 5 and 6) where permanent shallow open wells are easy to establish and maintain. These are usually reserved for exclusive use by the owner's household and are considered to be property held and controlled by the head-of-household. Proximity to the Athi River (Figs. 5 and 6) is also advantageous, as is proximity to the springs on the upper slopes of the range. Both of these are considered public domain, with ease of access influenced by location of owned property and means of transport. This implies a need to consider such differences between farms in planning for plant propagation, which may in turn influence AF technology designs and/or choice of species. Alternatively, plant propagation for some or all of the farms might be organized at the group or community level, on either a private or public basis.

Further discussions with farmers also raised the issue of within-household distribution of labor for plant propagation. While men were the main participants in the farm trials, women were required to collect and transport the water for seedlings in the farm nurseries, and the women were unwilling to continue this extra task when water shortage forced them to obtain the domestic water supply from the Athi River (2-5 km distance), carrying water on their backs in containers. This demonstrates the need to involve women as individual beneficiaries/clients, and to consult them about feasibility if they are to play the role of water-bearers for plant propagation.

Other issues of major importance that surface in farm trials included pest control, browsing damage by domestic and wild animals, and the need for protected fodder reserves. All 10 farms experienced problems with termites and/or other insect pests, and all of the trials were affected to some extent by browsing, which varied with the degree of protection at the planting sites. Seedlings placed in grazing lands fared very poorly (up to 100% mortality), while those established in cropland showed higher survival rates (70 to 80% survival) and more vigorous growth during the first six months. The importance of a protected fodder bank was demonstrated by the decision of one farmer to allow controlled dry-season browsing of the <u>Leucaena l</u>. in his mulch hedgerow by his own cattle and goats. He requested help to expand the fodder-tree planting and refused to replace the <u>Leucaena l</u>. with a superior mulch tree. He clearly prefers to use hedgerows in cropland for fodder, rather than to improve soil moisture and/or soil fertility for crop production. Two other participating farmers also requested more seedlings and assistance for establishing fodder trees in marginal cropland. As in the case of water for nurseries, fodder production and animal management involves use of off-farm[3]' resources and the cooperation of other farmers (control of herds and more careful management of gathering). Any interventions of this type would require a closer consideration of land tenure, use rights and terms of access to land, water and plants.

While most of the land in the study site was adjudicated over 10 years ago, exclusive use by one household applies only to cropland (permanent, terraced), home compounds and small grazing plots. Woodlands and large holdings of wooded grazing land are controlled by single households but are perceived as conditionally available to the larger community or to sub-groups thereof (Cantor, 1984). Many smallholders occupy plots that have been reduced to a minimum area required for subsistence food crops, and they depend heavily on this system of discretionary common use of private land. They obtain most or all of their fuel, fodder, timber, thorn-fencing, and minor forest products from off-farm sources. Access is unevenly distributed between households and also varies with seasonal and periodic drought, the latter being an emergency and considered just cause for granting broader privileges than usual. Use of such lands and terms of use vary considerably.

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[3]The term "off-farm", as used here, refers to the use of land outside of a given (consumer) farm, even if it involves sharing or "borrowing" of resources on someone else's farm.

Gathering rights for fuelwood are seldom compensated, although some farmers report buying trees from neighbors for charcoal or fuelwood. More commonly the practice is referred to as "borrowing", but the indebtedness one incurs has to do with social status and deference to the donor. The usual understanding is that "borrowers" take deadwood, small stickwood, and the least desirable species. Some gathering without permission also occurs in the denser, more remote woodlands (Cantor, 1984). While fodder and fuelwood are almost free goods, fencing material, timber and charcoal trees are perceived as commodities to be purchased directly. In some cases charcoal makers may rent access to land for tree harvesting and burning (Hoek, 1983). The favored species for charcoal and timber also produce pods and/or leaf fodder, so these activities impinge strongly on actual carrying capacity of shared lands for domestic animals.

Both cattle and goats are confined in corrals at night, both for protection and for easy collection of manure. During the day, management of grazing and browsing varies from tethering to careful herding to almost free range. Social pressure to control grazing is strongest when grain crops are vulnerable to attack, but "social fences" fade during the dry season. Animals are driven long distances to water holes or to the Athi River. Off-farm fodder sources play an important role during this period. Roadside and gully sites provide grass, shrubs, and high-protein pods to supplement on-farm fodder. Many larger landholders also grant grazing and browsing rights to several other households based on kinship or other social ties or in exchange for cash or services. Changes in animal management for fodder tree protection would necessarily involve the community-at-large. Enrichment planting in public lands and common-use private lands would also require group decisions and maintenance.

<u>Watershed Trials.</u>

The D+D for the community and surrounding watershed identified excessive runoff and soil erosion as major problems (Table 3) limiting individual farm production as well as threatening water supply and road networks throughout the area (Rocheleau and Hoek, 1984). Overharvesting of valuable multipurpose trees (<u>Acacia tortilis</u>, <u>Terminalia brownii</u>) for single-purpose exploitation (charcoal) has also depleted common-use and shared sources of fodder and forest products for the community-at-large. Overgrazing, overstocking, and lack of alternatives for cash earnings and savings/investment also contribute to economic hardship and ecological instability throughout the Kathama sub-location (Table 3).

The drainage network emerged as the predominant structural landscape feature in need of stabilization; it formed the basis for further stratification and detailed study at the Kathama site. A more detailed qualitative analysis, including informal interviews, cartographic analyses, aerial photographic interpretation and detailed field observation, was conducted in three small catchment sub-units (Fig. 5 sites 1, 2 and 3). The detailed landscape analysis identified the major sources of excessive runoff, points of concentration, and sites of sheet and gully erosion (see Hoek, 1983 and Rocheleau and Hoek, 1984 for detailed maps, discussion and technology designs). The grazing lands on the upper slopes of the Kanzalu Range (Fig. 6), and along the slopes to the Athi River were both major sites of prior sheet erosion under annual cropping) and currently major sources of runoff, due to soil compaction and poor infiltration of rainfall. Home compounds also contribute to rapid runoff. The points of concentration included roads and footpaths, drains from grazing lands, home compounds, and bench terraces, often along property lines (Hoek, 1983; Rocheleau and Hoek, 1984).

Residents interviewed cited the following causes of gully erosion on mid-slope to footslope sites: compaction of grazing lands; new construction of upslope homesites, terraces and drains; and re-alignment of farm drainage toward parallel boundaries along the slope (following the pattern of roads laid down by the land survey). Some residents have constructed cut-off drains and check-dams in gullies to prevent or contain gully erosion, and most farmers have terraced their croplands; much of the construction on and off-farm has been carried out by self-help groups. Gully and drainage control structures appear on private, public, and boundary lands, usually at or near the site of damage to roads, paths, homesites, or cropland. In spite of interest and awareness, the overall drainage network is _ad hoc_ and represents the cumulative (and often unanticipated) effect of many separate decisions and actions by groups and individuals upslope on the private and public land and water resources immediately downslope.

Gully reclamation, coupled with more intensive management and increased fuel/fodder production emerged as a priority for exploratory trials, given the existing involvement of self-help groups in gully reclamation, the importance of the disrupted drainage, and the relationship between overgrazing, soil compaction, depletion of woodlands, and apparent decline of favoured species. The watershed level D + D exercise indicated additional needs for multipurpose trees aside from the soil and water conservation aspects. Discussions with individuals and women's groups about fuelwood and fodder availability and management revealed that smallholders rely very heavily on off-farm fuelwood and fodder sources and many consider fuelwood supply a problem. The current role of gully sites as off-farm grazing lands and fuel wood sources for many households, further strengthened the cause for maintaining these productive functions at such sites under a sustainable system.

Other "leverage points" for application of AF or combined AF/soil and water conservation technologies included: the degraded hillslope grazing lands (sources of excessive runoff and sources of fuelwood and fodder for many households); the roadsides and boundaries (often points of concentration and channels for runoff); soil conservation structures on croplands (often unstable and/or unproductive); and home compounds (points of concentration for runoff, convenient for closer management/protection of plants).

The development of AF designs for these niches focused on the Kanzalu range catchments (Fig. 5 Sites 1 and 2) because of the higher activity level of self-help groups, the higher population density and the diversity of problems and potential solutions concentrated in one area. The landscape design emphasized structures along linear features such as gullies and several types of planting on areas and on linear features (see Rocheleau and Hoek 1984). Designs for treatment of grazing lands included enrichment planting (grasses, shrubs, trees) combined with soil and water conservation structures. Designs for improved vegetation on existing structures and features ranged from alley cropping or planting on bench risers in croplands to planting of more productive tree, shrub or grass combinations on boundaries and around home compounds. "Filler" planting along and in gullies was also suggested, as well as live supports for temporary gully structures and productive border plantings on roadsides (especially in/around drains).

The resulting integrated landscape design in cross-section view (Fig. 7) shows the fit of these technologies into a productive sustainable agricultural landscape. The before-and-after oblique view design sketches (Figs. 8 & 9) show the extrapolation to the larger study site along the Kanzalu Range. The current condition and the ideal implementation of the design are juxtaposed to illustrate the scope of the potential effects.

In order to better evaluate the feasibility and probable effects of the proposed design, a parallel ecological and spatial analysis was conducted to quantify some of the existing conditions and potential changes. A representative small watershed was chosen on the Kanzalu Range (Fig. 10) including the Kalama catchment. Results included areas of different land use and land cover categories (Fig. 11, Table 4), the total length and area of various linear landscape features (Table 5), and the relationship of various land cover types (including linear features) to runoff, erosion, and production problems and potentials (Table 6). The analysis also extended to the functional relationships between various structural landscape features, land uses, land tenure, and family composition.

Household surveys (Cantor, 1984) indicated a marked division of labor, control, and interests within and between households, with respect to present and future management of fuel and fodder supplies and the wooded grazing lands in general. Based on qualitative and quantitative analyses of the survey (Rocheleau and Cantor, forthcoming) two major criteria differentiated the households with respect to needs, priorities, and available resources for AF technology development: size and quality of landholdings (eg. land value and productive potential), and family composition (male vs. female-headed, male vs. female-managed, and number of resident family members of working age).

The land size and quality was closely related to the division between "borrowers" and "lenders" of fuelwood and grazing land. There is a general division of interests between the two groups, with the former needing to integrate subsistence production of fuel and fodder into intensified food and cash crop production on their limited smallholdings, and the latter tending toward conversion of lands currently used by borrowers into crop production or private fodder-and-woodlots (all semi-commercial enterprises).

Cutting across this land-based division of interests are three types of households with labor-based differences. Within this watershed 33% of the households are headed by women, 47% are headed by men, and another 20% are managed by women. In the latter case the male head-of-household lives and works away from home, returns at intervals ranging from monthly to annually, and retains varying degrees of decision-making authority in the household. The women are farm managers and make most or all of the day to day operational decisions, but consult or defer to the men in planning decisions (e.g. new cropping systems or land uses). These types of households would usually be designated "male-headed", but have very distinct needs, constraints, and resources compared to households with resident male heads. With few exceptions, woman-headed and woman-managed households have less labor available than those headed by men, have different priorities for allocation of labor (subsistence vs commercial; domestic vs whole-farm; group vs farm), and have different types of labor exchange and other reciprocal arrangements for use of grazing land, fuelwood, and draft power.

Smallholder households headed or managed by very young or very old women present both a challenge and a special opportunity to AF research and extension in this area. These women are extremely limited by labor (often only their own) but even more so by lack of mobility and time. Mothers of very small children, and older infirm women were particularly interested in concentrating fodder and fuel resources (currently gathered off-farm) on croplands, home compounds, small lots, and boundaries. The additional real labor for establishment and management (including fodder lopping) would be more than compensated by the accommodation of their mobility and time constraints for off-farm activities.

These household types are more than academic categories; they imply distinct sets of technology designs and landscape niches at the farm level, and set the context for reconciliation of conflicting interests at the community level in watershed scale designs, land use plans, and project organization. While men-headed largeholder households want timber, cash crop trees, and living fences to better protect their croplands and grazinglands, the smallholder women-headed households want fodder and fuel close to the home and low-input cash crops that can combine with food crops and that can also be consumed on-farm. The first group may well lead the way in grazing land improvement, sylvopastoral technologies, and development of commercial tree crops, while the latter group are the logical choice to pioneer intensive production of fodder and fuel in croplands and on boundaries, and introduction of multi-purpose cash and food crops into subsistence cropping systems. These two contrasting groups with conflicting interests illustrate the potential for design of complementary technologies at the watershed and community scales. Recognizing that the conflicts may not always be easily resolved, and new ones may develop later, the survey information was used for grouping clients, stratifying designs, and integrating research and project management to serve the groups separately, within a larger context of landscape design.

In this landscape, especially given the interest of all groups in boundaries and live fences, linear features can play a major role in production (Table 5) as well as in soil and water conservation. The most prominent linear features are the drainage and transportation networks (Fig. 12). Interpretation of aerial photographs revealed the importance of property and internal plot boundaries as well (Fig. 12). Based on relative area occupied these features have a high potential as production sites; 1.8% of the total area is in gully and stream borders, 0.7% in paths and roadsides, and 2.3% in property and internal boundaries, which places 5% (nearly 5 ha) of the total area in linear features (Table 5). The greater availability of water in gully and stream channels and in roadside or boundary drains also represents a production advantage over many block planting sites, such as grazing lands. Moreover, internal boundaries in croplands and home compounds offer the benefits of existing fences and protection and ease of access for maintenance.

Conservative estimates for fodder and fuelwood production potential for drainage, transport, and boundary features (Table 5) indicate that more than 50% of current fuelwood and almost 40% of fodder needs can be met by planting trees, grass, and shrub combinations along these ribbons and corridors of land. While the same production could be allocated to blocks, hedgerows, or dispersed plantings in grazing and croplands (Table 4), the real or perceived opportunity cost of land utilized may be much higher in croplands, and the real costs of establishment and maintenance would be much higher in grazing lands. The need to protect young fodder trees from browsing may tip the decision in favor of small well-protected fodder lots in grazing plots close to the home compound, depending on available space, species used and proximity to wildlife habitats or cattle and goat trials. In upslope plots the added incentives of reclamation, soil improvement or water harvesting would, however, often weight the decision in favor of some area treatments on strategically located grazing land (Table 6), in combination with carefully chosen placement of road, path, and farm drains planted to productive vegetation.

While the potential benefits were estimated during the first cycle D+D (Table 5), several questions remained as to feasibility, and distribution of costs and benefits, given the existing conditions and practices in Kathama. These questions were left to the second cycle of D+D, on-site trials with self-help groups and selected households (to complement the continuation of the second cycle of the original 10 farm trials).

The team initiated a small pilot project within the Kalama catchment to further explore the research methods, technologies and organizational activities necessary to implement the landscape design within the D+D context. The exercise also provided a practical context in which to test and evaluate the method, the design and the component technologies for application in similar environments in the Machakos District (ranges and hillslopes, Zone 4). The specific objectives of the pilot project were: 1) to develop AF methods suitable for implementation, monitoring, and evaluation of larger-than-farm scale group projects; 2) to build rapport with the groups and assess their organizational and technical capabilities and potential; and 3) to modify AF designs and implementation plans to fit "2".

The implementation consisted of weekly work sessions with five self-help groups at the two sites (Fig. 5, 1 and 2) chosen by the team and the groups respectively. An analysis of the time and labor (Tables 6 and 7) required to implement the original design revealed a vast discrepancy between group capabilities within the public works context, and the demands of the overall plan. However, the entire emphasis on public works was repudiated by the qualitative information from observation of, and participation in, group work sessions.

The groups were found to be small associations of individual households (20-50) engaged in exchange/rotation of services and pooling of resources for the benefit of individual members and their households. While the results of the household survey confirmed the importance of group labor for individual management, they also revealed a *de facto* exclusion of some types of households from participation in group activities and benefits. Women-heads of small households (usually very young or elderly women) who were isolated geographically from relatives and/or the community-at-large, reported being unable to attend group activities due to limited mobility (due to sole responsibility for child care and domestic work, or due to ill health). By contrast, some of the wealthiest and/or largest households found group membership unnecessary. The self-help groups are thus not fully communal in either objectives or in composition. As in other AF studies (Dove, 1983) the difference between communal groups and associations of independent households proved critical to project and technology design.

The groups requested changes in the work schedule, organization and choice of sites, because too much time was being spent on the property of non-members. Even on members' farms the groups cannot spend several consecutive sessions at the same site, but must maintain some semblance of rotation. While they might undertake gully repair at any site that impinges on members' lands or at sites where public roads and schools are threatened, the groups still find continuous long term investment at any one site unacceptable. Moreover, the group leaders insisted that future activities be limited to one or two groups, rather than the combination of five groups as was the arrangement for the first season. They blamed much of the problems in the group trials on inter-group rivalries (Mwendandu, pers. comm. 1983).

During the course of the group work the participants requested seedlings for their own farms and negotiated group soil conservation labor as an exchange for 15 seedlings (sampler package, multiple species) for each member (Table 8). On-farm and group follow-up during the subsequent planting season (no public works at that time) resulted in requests for a switch to nurseries for individual groups (located near water, at a member's home), to supply seedlings for group members' farms. Farm planting results showed that while most people planted all of the trees they were issued, they reserved the cropland sites and special care for fruit and fodder trees. Timber and shade trees planted on the home compound also received special care in some cases.

Trees planted at soil conservation sites were protected, if at all, by property owners, not by the groups as such. Since one of the two sites (Fig. 5, site 2) was badly degraded, poorly protected, and traversed by water collection and cattle paths, most of the planted seedlings died. However, the small water-harvesting structures made by the groups did foster improved growth of the natural vegetation (especially grasses and small *Acacia tortilis* trees). The property owners also managed to protect some of the planted grasses and seedlings located close to the home. At the other site (No. 1) the owner took full responsibility for planting and protection. He converted a small plot just adjacent to the group site into an individual farm trial of AF for fodder and wood production and rehabilitation of a gullied grazing land.

The results from this first cycle of group tree-planting influenced the choice of species and planting sites for the seedlings produced in the group nurseries during the next season. After the focus of the group activities shifted to plant propagation for members' farms, two more self-help groups asked to join the project. While some groups continued to ask for advice on placement and construction of soil conservation works, they gave priority to nursery construction and plant propagation activities (fruit trees and a mixture of fodder, fuelwood and timber trees). Some groups also recruited new members interested specifically in seedlings and grasses for their farms, including one farm trial participant who expanded his fodder lot.

Integration of Group and Farm Trials.

Although it was not originally planned, the farm trials and group activities became closely linked as a result of actions and decisions taken by the individual farmers and the groups themselves. They established complementary domains of group-based and household-based AF activities (tree propagation and planting is a new class of work) and they set limits on the scale of community-level group collaboration (one nursery per group, with some joint training and evaluation activities and occasional joint public works activities with tree-planting and soil conservation). This, in turn, established the social terms of reference for the further development, testing and dissemination of AF technologies in the area.

Farm trials combined with group activities had several advantages. It allowed the farmers (especially women) to speak more freely as part of a majority, when dealing with researchers or with their own families. It also stimulated new ideas and sharing of new technologies suggested by group members.

The nursery activities served to train individual farmers in the full cycle of plant propagation, and at the same time provided a forum for training and discussion re: tree planting, choice of species and sites, and management of AF technologies on-farm. The farm trials, on the other hand, provided a kind of AF "sampler" that allowed farmers (individually and in groups) to observe and discuss results within the realistic context of a neighbor's farm. People were better able to choose species (indigenous and exotic) and to consider alternative planting arrangements and management techniques, once they could see what the new trees and shrubs looked like, and how these and indigenous trees performed in new niches on-farm. The group members also contributed to the farm trials by their honest appraisal and constructive criticism of the trials; they often helped to elicit suggested modifications from the more timid or biased individual farmers.

Out of this consultation and testing came a suggested change of emphasis from alley cropping for mulch to alley cropping for fodder and fruit, with wider spacing between hedgerows. To improve soil fertility most farmers prefer concentrated mulching of cattle pens (pre-composting) with tree biomass from fencerows and dispersed trees in grazing land (a few are still interested in widely spaced hedgerows for mulch). The groups and project team also began a search for indigenous wild fruits and exotic drought-resistant marketable fruit compatible with food cropping systems and/or live fences (on inside of living fences or on internal boundaries). Both groups also initiated a search for tree-based pesticides available in the area, with the help of KENGO foresters and local herbalists. The relationship of these and other research lines to the original D-and-D are outlined in Table 9. Aside from these specific prescriptions for research, several general conclusions can be drawn from this experience.

Lessons From Kathama

Both farm and watershed (group) activities converged on the gap and false dichotomy between treatment of farm and larger-scale units. These themes were common to both activities:

1. the need to mobilize group labor, group skills, group learning and shared access to land and water, to support productive AF technologies on-farm (for the benefit of individual members and households);

2. the need to better integrate women into the initial D+D and farm trials and to better serve their interests in technology design and in organization of group trials/activities;

3. the need to better address questions of shared use and sustainability of farm production and to consider the production benefits to individuals from off-farm, public and shared lands;

4. the need to adjust technology designs for different production objectives and different levels of access (within households and between households) to the means and fruits of production (on and off-farm);[4]

5. the need to plan with farm families and community groups for technology and landscape designs that can adapt to[5] land subdivision,

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[4]One approach would be to design separate AF options for each level of access and domain of control. Another solution would be to integrate complementary resources of different groups, whether at farm or larger-than-farm scale. Feasibility of separate vs. integrated designs will vary, depending on the existing distribution of resources, control over them, and access to them.

[5]In many cases the technology and landscape designs can also help to determine the future of the system by stabilizing development cycles, particularly with respect to land subdivision and land use conversion.

labor pool fluctuations, land use conversions, migration, and other aspects of household and community development cycles.

Extrapolation To Other Cases

Can this type of research and its results make a difference in "real-world" research and development projects conducted by national institutions or non-government organizations (NGO's)? Will those differences matter to the real clients of AF research-for-development? Both the methodological and substantial lessons from the Kathama project are being incorporated (and tested) in the planning and early implementation of the Kakuyuni Dryland Agroforestry Project and the CARE Kenya Siaya Agroforestry Project. The highlights of project experience to date are presented to illustrate the relevance of the general D+D approach, the importance of within-household and between-household criteria for diagnosis, design, and monitoring, and the adaptation of this multiple-scale approach to the objectives and available resources of each project.

Kakuyuni Project

The project definition, technology designs, and research designs were all based on the D+D approach. ICRAF conducted the original diagnostic survey and reconnaissance work, in collaboration with MIDP and NDFSRS (Hoekstra, 1983).

The study area consists of a small watershed (<5 km^2) on the Yatta plateau (agro-ecological zone 5) in Machakos District, and was settled in the 1950's and 60's by Akamba people from the more densely populated (higher potential) areas in the hills and along the slopes of the isolated ranges, including the Kanzulu Range in Kathama. The soils and vegetation are similar to those of the drier plains in Kathama, while the population density and land use intensity are both low relative to the conditions in Kathama[6]. As such the diagnosis (Figs 13 and 14) was quite similar to that for Kathama, with less advanced land pressure and soil degradation. This diagnosis also included separate analyses for large and small farms (e.g. between-household stratification). The group diagnosed two clusters of problems amenable to AF solutions: 1) dry-season fodder shortage leading to land degradation and low cash income from animal sales; and 2) poor soil fertility and soil moisture conditions resulting in low food crop yields, and subsequent food and cash shortages.

This information formed the basis for a specific research project proposal, with research priorities outlined in advance (ICRAF, 1983). The collaborative team of KARI, DFSRS, MIDP, and ICRAF began two sets of field trials during the first year of implementation: 1) on-station

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[6] 65 persons/Km^2; Land cover 22% cropland, 2% fallow, 10% infrastructure, 66% grazed woodland

trials of alley cropping[7] for mulch (for croplands); and 2) on-farm trials of fodder tree establishment and management (for grazing lands), and multipurpose (fodder and fuel) trees for living fences and block planting. Both sets of trials reflected farm and plot-level design criteria.

Toward the end of the first year the project personnel participated directly in a second D-and-D exercise at the site, as part of a training course for a larger group (Zulberti, 1984). The exercise benefited from the field experience of the Kakuyuni team and the diagnosis was refined to reflect the new information.

The same project team has also conducted surveys on the use of trees (Arap-Sang, 1984; Mwendandu, 1984), and has collaborated in household and group surveys on the use of water and forage on and off-farm, and the role of self-help groups in the management of private and shared lands (Caplan, 1984; Janssens, 1984). In some cases the issues arising in Kathama prompted surveys and meetings at Kakuyuni to determine if the same general conditions existed (household composition; role of groups in farm management; role of groups in resource management by women; role of women in use, management, and propagation of trees; common use of private property, and net conversion of grazing land to cropland).

HOUSEHOLD SURVEYS AND DESIGN IMPLICATIONS

Approximately 33% of the households at Kakuyuni are headed or managed by women and 67% are headed by resident men. As at Kathama there are marked differences between households managed by men and women, particularly with respect to labor constraints, mobility, and opportunity costs of time. There is also a difference between women who head large vs small families.

Within households headed by men, men's and women's interests in trees vary primarily with respect to fodder vs fuel. Men tend to be responsible for day-to-day management of the grazing land, and the women for both cropland and domestic work (fuel and water collection, plus child care and food preparations). Men also tend to take more interest in beekeeping, timber, charcoal, and carving-wood sources (all cash-based), whereas women know more about wild foods (fruits and greens), medicines, fibers for handicrafts, and dyes. Both might take responsibility for shade or ornamental trees on the compound, but men would be more concerned with establishment, and women with maintenance, of property line fencing. In the farms managed by women, all of these concerns would be addressed by the head woman but with different priorities, experience, and constraints.

All types of households want, and could readily benefit from, intercropping of fruit trees with food crops. Most households could also engage in some form of tree-leaf mulching, but labor constraints and

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[7]high-risk, least known option, relegated to on-station research for first two years

priority of fodder over mulch would rule out alley-cropping for small labor-limited households. The use of non-fodder tree biomass in boma mulching (corral pre-compost) would be more appropriate because of flexible timing and low opportunity cost of trees and land used. Since live fences are not yet widespread, the mulch would come from dispersed trees and shrubs (eventually from live fences as well). Intercropping of fodder/fuelwood trees with food crops, small fodder/fuelwood lots close to the home, and live fuelwood fences would also be appropriate for small households managed by women.

In larger households labor would probably be allocated first to cash crops and staple food crops, but surplus labor could be used for alley-cropping (or a spatial variant thereof) for high-fertility mulch to improve crop yield. Timber and fuelwood fences and grazing land improvement/intensification would also apply to larger households, especially those managed by men.

<u>Group Surveys and Follow-up.</u>

While land pressure is not as high as at Kathama, "borrowing" is widespread due to the uneven distribution of land. This applies especially to fuelwood and grazing, in some cases to charcoal trees, but not to timber. Labor exchange is also widely practiced, based on self-help groups. Groups weed, fix bench terraces, and make thorn-branch (deadwood) fences for individual members. The latter contrasts with Kathama, where fencing is done individually, and live fencing is more common. Groups also repair gullies and dig cutoff drains, usually as spot treatments and in public places. Given the nature of the project (watershed-based) there was a strong interest in working with groups on soil conservation activities.

The groups were consulted about their own priorities for project-related work, including: farm trials on members' land; community or group nurseries at the Kakuyuni Dam site; the use of vegetation (fodder, fuel, timber) in gully stabilization; and combination of physical structures with vegetation for grazing land rehabilitation on members' land. Group members expressed the most interest in three nurseries, and requested that vegetable plots be allowed at the same site.

Members of three groups worked with project staff to construct the nursery, vegetable beds, and fencing, with separate areas allocated to each group. Many of the women mentioned the possible sale of the seedlings and vegetables as goals of their nursery work. They also planned to establish fruit trees on-farm and to improve family diet with fruits and vegetables. This group activity gave many women access to seeds and other inputs that they would not have had the cash, or permission, to experiment with as individuals. It also provided access to a common water source and training. The management of the plots by groups, rather than individuals, also allowed for rotation of watering and weeding, which minimized the time and travel demands. This, in turn, allowed participation by women with time and mobility constraints (if they were group members). Yields and cash earnings from both seedlings and vegetables were low due to drought and unusual pest infestation ("army worms"), but the prospects are good for expansion of both nursery and vegetable plots, given the performance of the groups under adverse conditions (Mwendandu, 1984).

As at Kathama, AF for gully reclamation received low priority relative to other activities. Gully erosion is less of an immediate threat at Kakuyuni, although there are numerous small (treatable) gullies on private property that could serve as moist planting sites, if treated. Such work, however, is carried out on a short-term rotation basis in spot treatments. Long term treatment of gullied and degraded grazing land will be difficult to accomplish with group labor under the usual arrangement. While most households require weeding, bench repair, and fencing, the need for grazing land reclamation is not evenly distributed, nor is the size of plot or intensity of degradation. Some combination of paid and group labor might be more appropriate, or direct payment of the group by landowners, particularly large holders.

While members approved of group participation in farm trials, the actual involvement of groups in establishment of farm trials was sporadic, and constrained by conflicting commitments of group labor at peak demand period for several concurrent activities: nursery and vegetable bed preparation, bench terrace repair, gully repair, site preparation, and fencing for trials. Also, many farmers were prepared to dig their own planting holes and/or fence the plots. Group involvement could complement individual efforts and should be programmed for those activities which can be completed during "slow" periods for other forms of group and on-farm work. As in gully and grazing land rehabilitation, some form of direct payment or exchange (by owner, to group) may also be appropriate.

The surveys and follow-up provided information for the design of AF trials for grazing land improvement, soil and water conservation, live fences and small nurseries. Further inquiries about subdivision among sons, and future use of plots, will guide the technology design, placement, and species selection for live fences and contour-planting in grazing lands. Self-help groups have been incorporated as sources of information, participants in group nurseries (including vegetable plots at their own request) and participants in AF technology trials on group members' farms (Arap-Sang, 1984; Mwendandu, 1984). The variable response and performance of the groups also indicates which activities and technologies are of general interest, and which are appropriate for group vs individual participation. The explicit study of family and group participation has recently been integrated into all trials at the site (Hoekstra, 1984). The results will help to evaluate distribution of costs and benefits from existing trials, to modify designs of future trials and demonstrations, and to plan expanded research-extension programs.

THE SIAYA PROJECT

The Siaya Project differs substantially from the Kathama and Kakuyuni projects in that it is district-wide (spanning 4 ecological zones), it is an NGO effort in collaboration with government, and it is primarily a development project with a research component. Project staff (Vonk, 1984) and consultants (Buck, 1984; Rocheleau, 1984) have modified the D+D approach to emphasize community scale activities in support of farm-level improvements. Research (on AF technologies and participation) is nested within extension and monitoring activities, except for the rapid appraisal surveys, which form the basis for subsequent technology design and project planning/adjustment.

The project is based on low material inputs and high (national and local) personnel input. The organizational approach is decentralized and relies heavily on extension workers and their constant contact with both clients (groups and farmers) and senior project staff (researchers and managers). Project management (2) and researchers (2-1 social, 1 technical) focus on supervision and documentation, respectively, and both act as trainers/consultants to first level extension staff (6). These in turn train and supervise second-level (local) extension workers (15) who are primarily responsible to consult and assist farmers and groups and to interpret their requests, comments, and suggestions. First level extensionists also collect information for technical and social monitoring and take responsibility for constant readjustment of project action to community needs and practical field constraints (Vonk, 1984).

The extension staff is also actively involved in evaluating and adapting the D+D methodology. During the first year of operation both community and farm level diagnoses have been conducted by first level extension staff, with training and assistance from the manager and consultants (Vonk, 1984; Rocheleau, 1984). Group interviews and meetings (Vonk, 1984) have provided the basis for detailed project planning, survey design, choice of community and farm trial sites. Conflicting interests aired in group interviews called attention to sexual division of labor and implications for planting priorities (fuel vs fodder trees). Further discussions revealed that "men, not women, should plant trees." Subsequent interviews with key informants have influenced the choice of species, planting sites, and terminology, so as to facilitate planting of some trees by women, and women's access to some of the other trees planted by men.

A wide variety of priorities, needs, and resources were identified, demonstrating the need for such exercises at subregional level (using extension-level personnel). Group interests ranged from fuelwood for smoking fish, to dry season fodder, to small timber (poles) for cash, to seedlings-as-cash-crops. Issues common to all groups were the importance of fencerows as a planting niche and as protection for plants in the enclosed area, and the need to resolve related tenure questions (adjudication, grazing rights, shared ownership of fences).

Based on this initial experience in Siaya and prior experience in Kathama (Kyengo, 1984), the form and content of the group interviews has evolved to allow for more reflection and internal discussion by the groups. This has had two effects: 1) to provide a one-week interval for the group, as-a-group, to consider their priority needs re: trees (fuel, food, fodder, shade, erosion control, building material, ornamental, soil fertility improvement/intercropping); 2) to allow the group to consider which species they want to best fill those needs, often resulting in greater emphasis on known indigenous trees vs exotics (Vonk, 1984). A third effect (not documented) might well be that those individuals who are less vocal and influential would have the time and means to make their views known and to include them in the group's reply.

Following the continuing series of D+D exercises the project staff have built up a network of 70 small nurseries in one year (1/3 primary schools, 2/3 self-help groups mostly women), which are primed to produce 500,000 seedlings for the next planting season. As in Kathama and Kakuyuni, the groups are important not only for plant production ends, but also as means to involve and serve women farmers, and poor households.

The major criteria for project participation are: 1) that the group is established and already working (not necessarily on trees); and 2) that group objectives for nursery work place priority on plant production for members' farms, over cash income from sale of seedlings. Participating groups have diverse bases for organization, ranging from clan, neighborhood, occupational or craft groups, and self-help marketing cooperatives, to informal farm labor rotation groups.

The Siaya team has also paid special attention to the character of the groups relative to the larger community (e.g. wealth, influence, educational level, language, special skills, and access to land). Extension staff have tried to assure that wealthy or influential groups do not dominate or exclude other groups re: project activities. Records of nursery activities also require an accounting of distribution of plants and/or cash earnings within groups to assure an equitable share to all working members. Care is also taken to stratify household level D+D exercises within groups, to include different types of farms and farm households in technology design and farm trials.

The application of D+D at both community and farm scales by both first and second level extension workers has had an impact on the quantity and quality of information available for technology design and continued project planning. The inclusion of intra-household and between household concerns into all facets of the project, from D+D to project management, has affected the baseline information as well as the way it is used. Hiring of both women and men in research and extension positions, and hiring of social scientists from the region has affected both the form and substance of the project, from organization and management of farm trials to the design of specific AF interventions (Vonk, 1984).

SUMMARY

All three projects demonstrate the empirical and practical basis for the inclusion of social science theory, methodology and practice in AF research and extension in Machakos and Siaya Districts. The observation and analysis of these projects has raised procedural questions about participation and nested client groups, as well as substantive questions on the adaptation of AF designs (or vice-versa) to tree tenure, tree rights, grazing rights, water rights, gathering rights, and distribution and subdivision of land (within and between households). Some of these issues will be addressed in depth within a special project (Rocheleau, 1984) on AF technologies to replace or enhance use of off-farm lands by women of smallholder farms. This study will also focus on Siaya and Machakos Districts in Kenya, with some comparative discussion of other regions and extrapolation from the Kenyan examples. The objective of this type of research is to help design more appropriate AF technologies and to help define the way in which these are tested, evaluated, modified, and disseminated.

REGIONAL RESEARCH FRONTIERS IN AF/FSRE

The examples cited all refer to mixed farming systems practiced by sedentary populations in areas where land adjudication (by household) is recent, in progress, or imminent. However, the suggested combination of land-use planning with AF research and extension can apply to any tenure situation, provided that there is interaction of public (or group) and private resources in AF production for individuals, farm households, and the community. Such an approach may be even more important in cases where the community, rather than the household, directly manages some aspects of agricultural (or AF) production.

The development of a sliding-scale AF/FSRE approach for the "communal lands" of eastern and southern Africa presents a special challenge to interdisciplinary AF researchers. The mixed pastoral and agricultural systems of the semi-arid and sub-humid zones, and the shifting cultivation and bush-fallow systems of the humid areas are both changing rapidly in response to population pressure, land allocation, national economy, and new technologies. AF technologies for transition to sustainable intensified systems should build on existing local organizations and institutions for management of trees, crops, animals, water, and land.

Farming systems researchers have documented the distinct objectives and conditions of communal farmers for cattle (Avila, 1984; APRU, 1983; Hayward, 1984), crop production (ATIP, 1984; Kean and Chibasa, 1981; ARPT, 1983; Mugabe, 1984; Qasem, 1984) and land and water management (Peters, 1980; Roe and Fortmann, 1982; Silitshena, 1983; Harris, 1981; Castelli-Gattinara, 1984). In addition to the differences in resource base and objectives, the basis of control and ownership (Peters, 1980; Roe and Fortmann, 1982), and the codes of group decision-making in "communal systems" contrast sharply with both large-scale commercial farm management and individual smallholder practices.

Issues of community and intra-household resource management impinge heavily on individual behavior re: management of animals, fodder, fuel and water collection, land preparation and demarcation, and seasonal migration. While the extensive grazing systems are the most widely recognized examples of communal tenure and management, similar issues arise in the management of water-harvesting, small-scale irrigation, contouring, dry season fodder banks, tree crops, and introduction of new annual crops and practices. On-site work in communal systems will require interdisciplinary expertise, and an approach that goes beyond household-based research to treat community and within-household questions of tenure, water rights, and grazing and collecting rights (fuelwood, food, fodder, crop residue, medicine, fibre, dung). The challenge is to integrate such information into self-correcting research and rural development programs that can change to accommodate new information, new questions, and nested sets of clients-as-participants.

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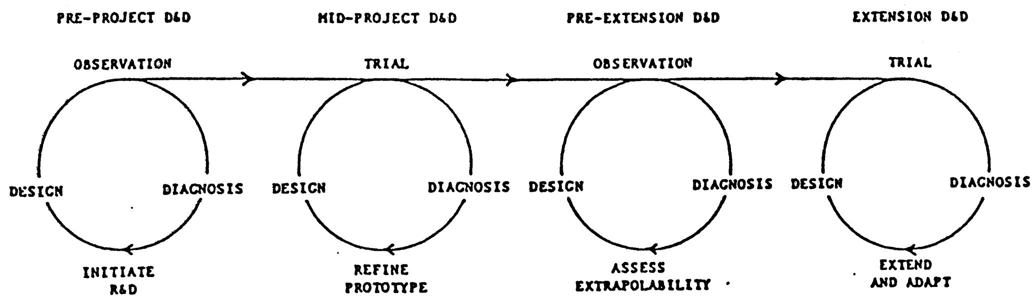


FIG. 1 : D&D AS AN ITERATIVE PROCESS IN THE PROJECT CYCLE
(Source: Raintree, 1983; ICRAF, 1983)

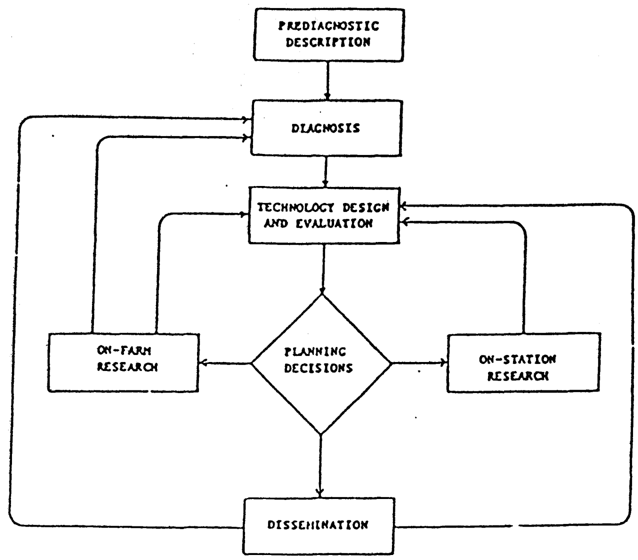


FIG. 2 : DIAGNOSIS AND DESIGN (D&D) PROCESS
(Source: Raintree, 1983; ICRAF, 1983)

D&D is an iterative process which continues throughout the life of a project as part of its internal guidance system. Note feedback linkages.

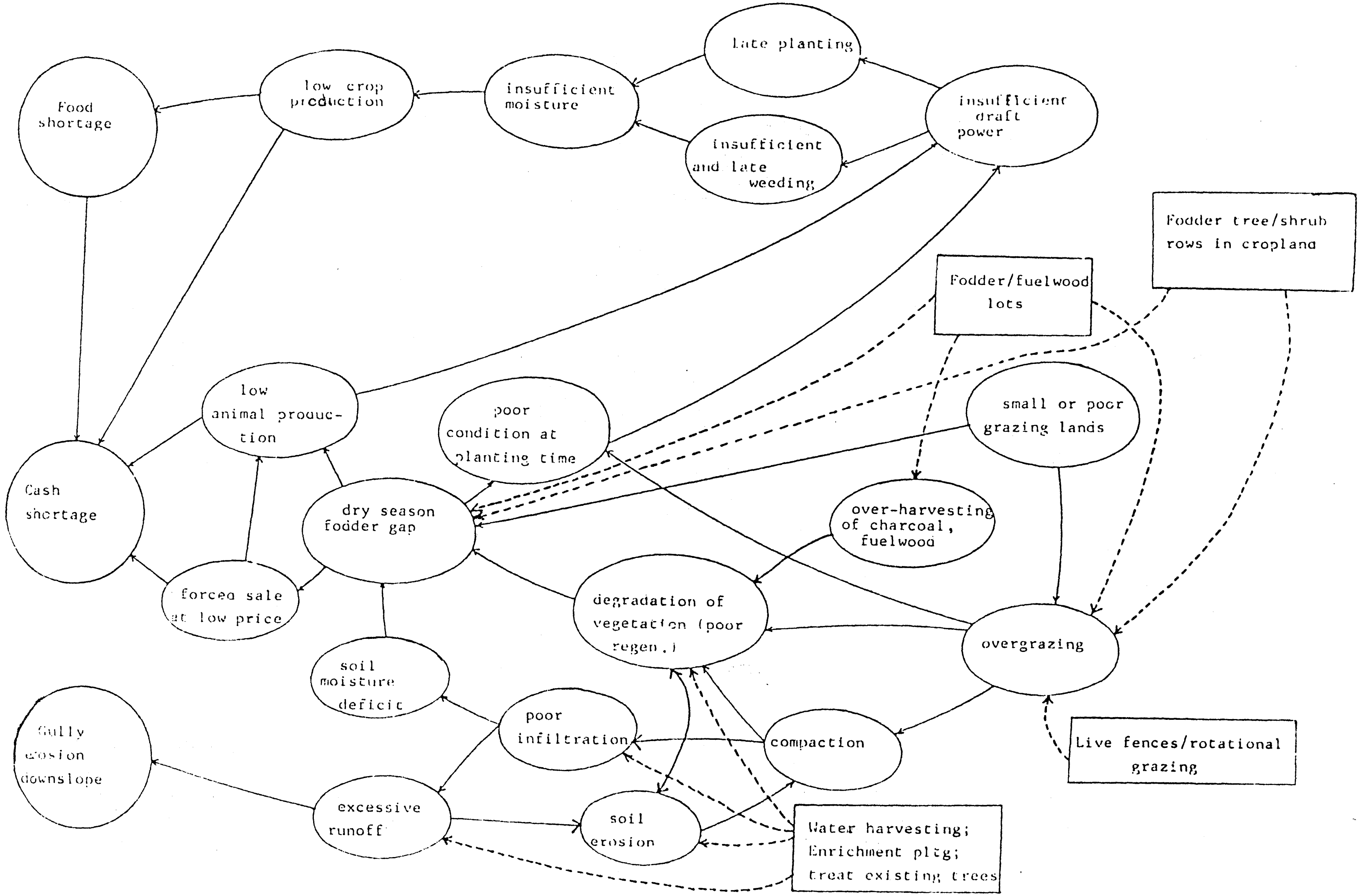
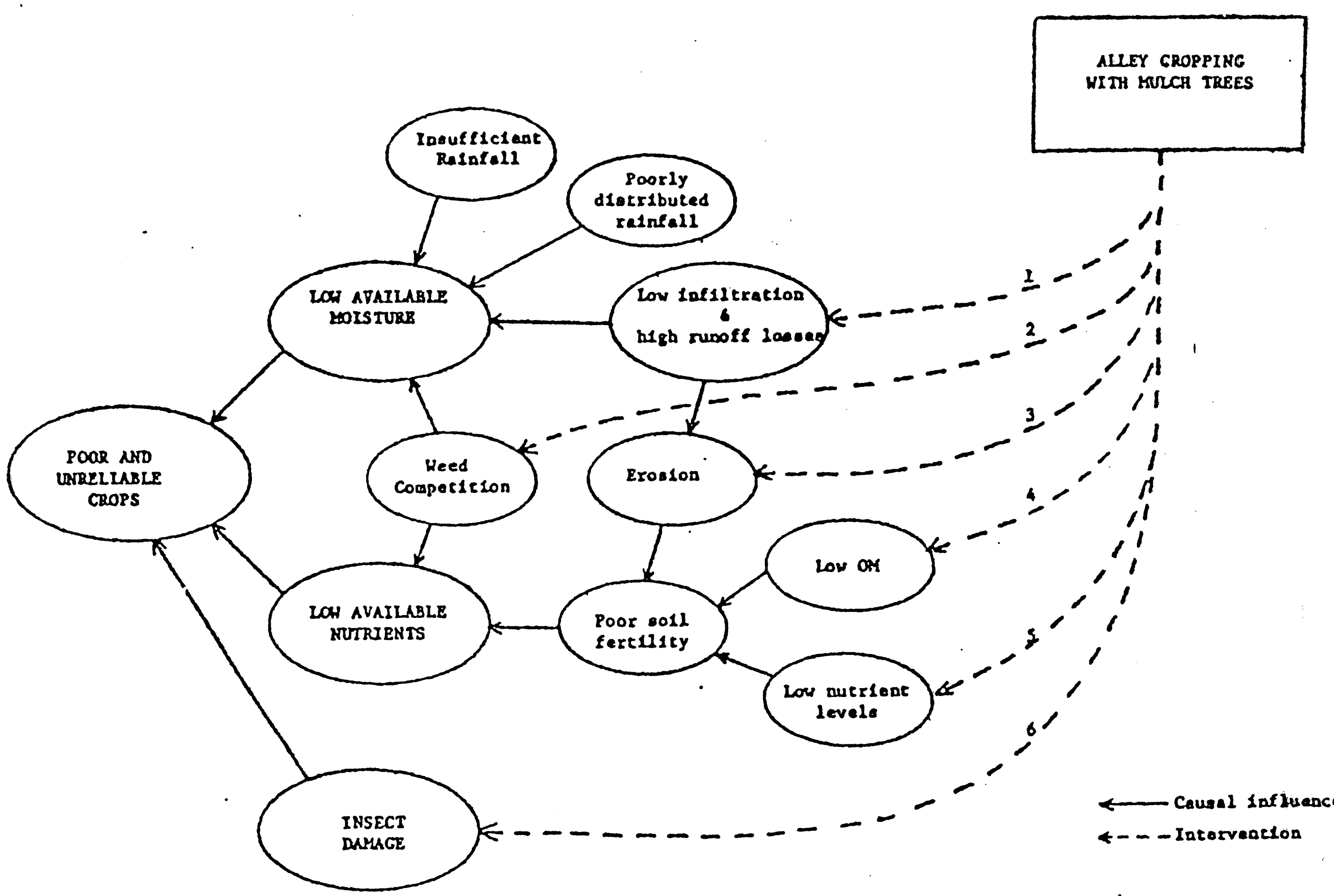


Figure 3. Causal Diagram of Animal Production Problems Affecting Food and Cash Shortages. Adapted/Updated from Vonk, 1983.



Potential Mulch Trees

N-fixing	Insect-repellent
Leucaena leucocephala	*Adhatoda vasica*
Mimosa scabrella	*Azadirachta indica*
Sesbania bispinosa	*Derris indica*

Potential Interventions

1. Improved infiltration, reduced runoff
2. Weed control with reduced labour
3. Reduced splash and runoff erosion
4. Increased organic matter
5. N-fixation and nutrient pump action of deep penetrating roots
6. Use of insect-repellent mulch species.

FIG. 4 . DIAGNOSIS AND DESIGN - CAUSAL DIAGRAM

The partial causal diagram depicts causes of food problems in the mixed farming system of Kathama, with suggested technological interventions. (Source: Raintree, 1983).

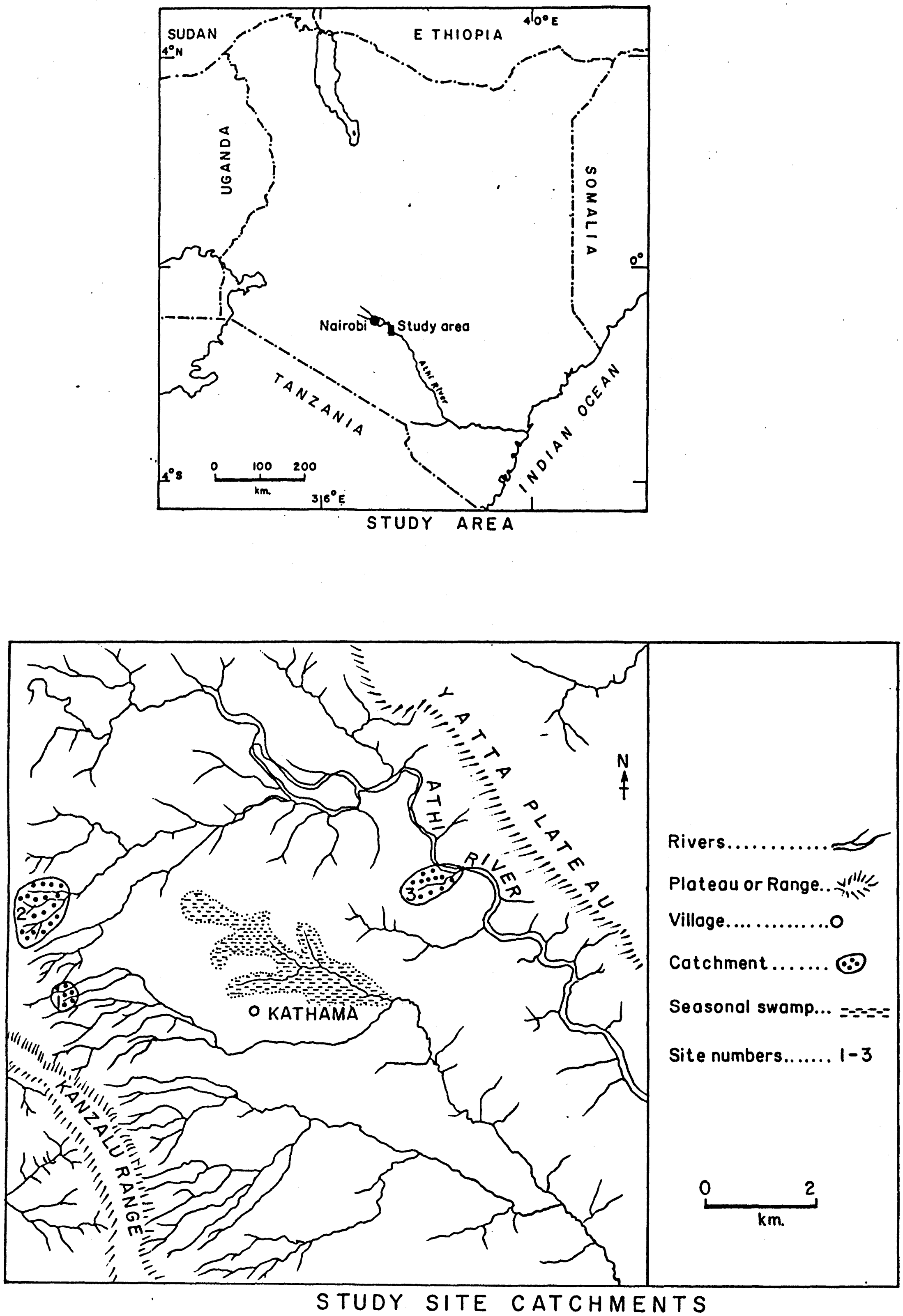


FIG. 5: Location map of study area and work sites.

LAND UNIT	RELIEF	SLOPE
A. KANZALU RANGE	A1. ridge	A1.4. flat to very gentle
	A2. dissected hilly slopes	
	A3. steep slopes with rocks	A3.1. steeply sloping
	A4. rolling footslopes	A4.1. moderately sloping
B. UNDULATING UPLAND	B1. undulating uplands	B1.1. flat to very gentle
		B1.2. gently sloping
		B1.3. moderately sloping
	B2. flat/almost flat depression	B2.1. flat to very gentle
		B2.2. gently sloping
	B3. rolling slopes	B3.1. flat to very gentle
		B3.2. moderately sloping
C. ATHI RIVER LANDSCAPE	C1. river island	
	C2. floodplains	
	C3. riverbed	
D. YATTA PLATEAU	D1. plateau	
	D2. slopes	

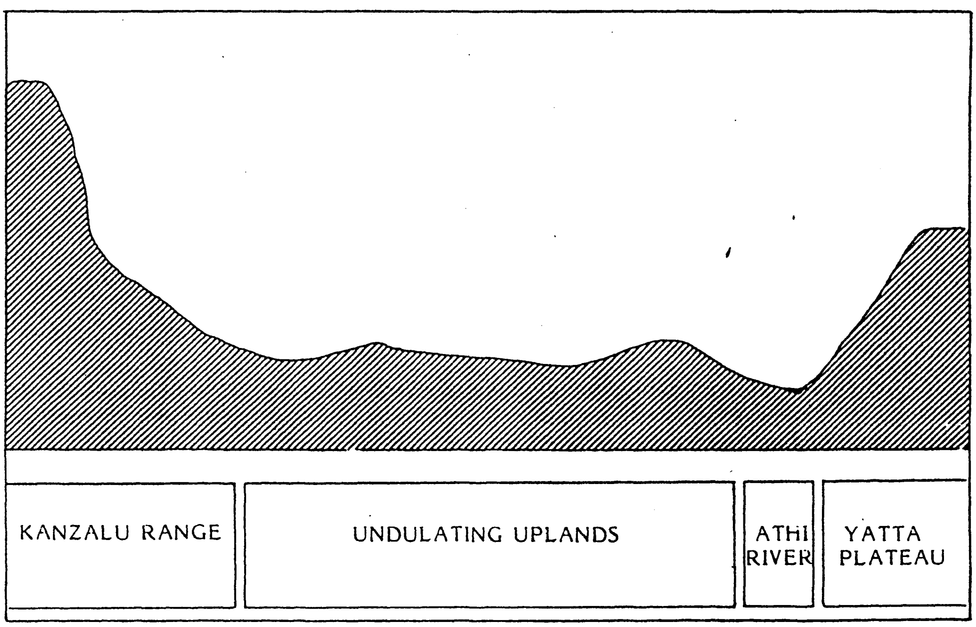


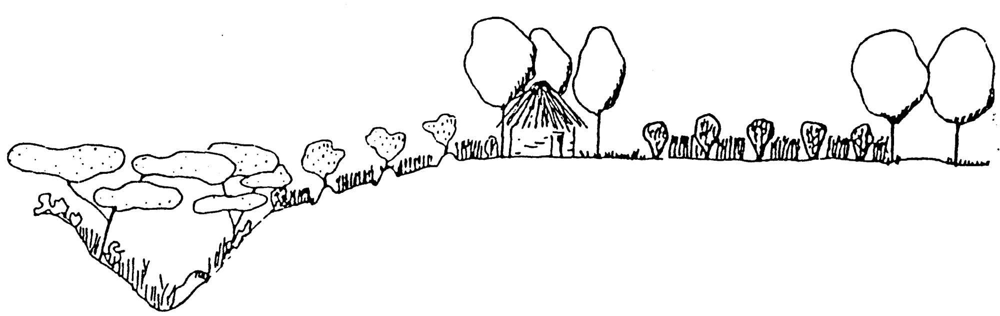
FIG. 6: TOPOGRAPHIC PROFILE WITH LAND UNITS
(Hoek, 1983)

FIG. 7 : INTEGRATED AGROFORESTRY SOLUTIONS NESTED IN THE LANDSCAPE

Tree, shrub and grass combinations

on the farm

on boundaries, in gullies and along roads

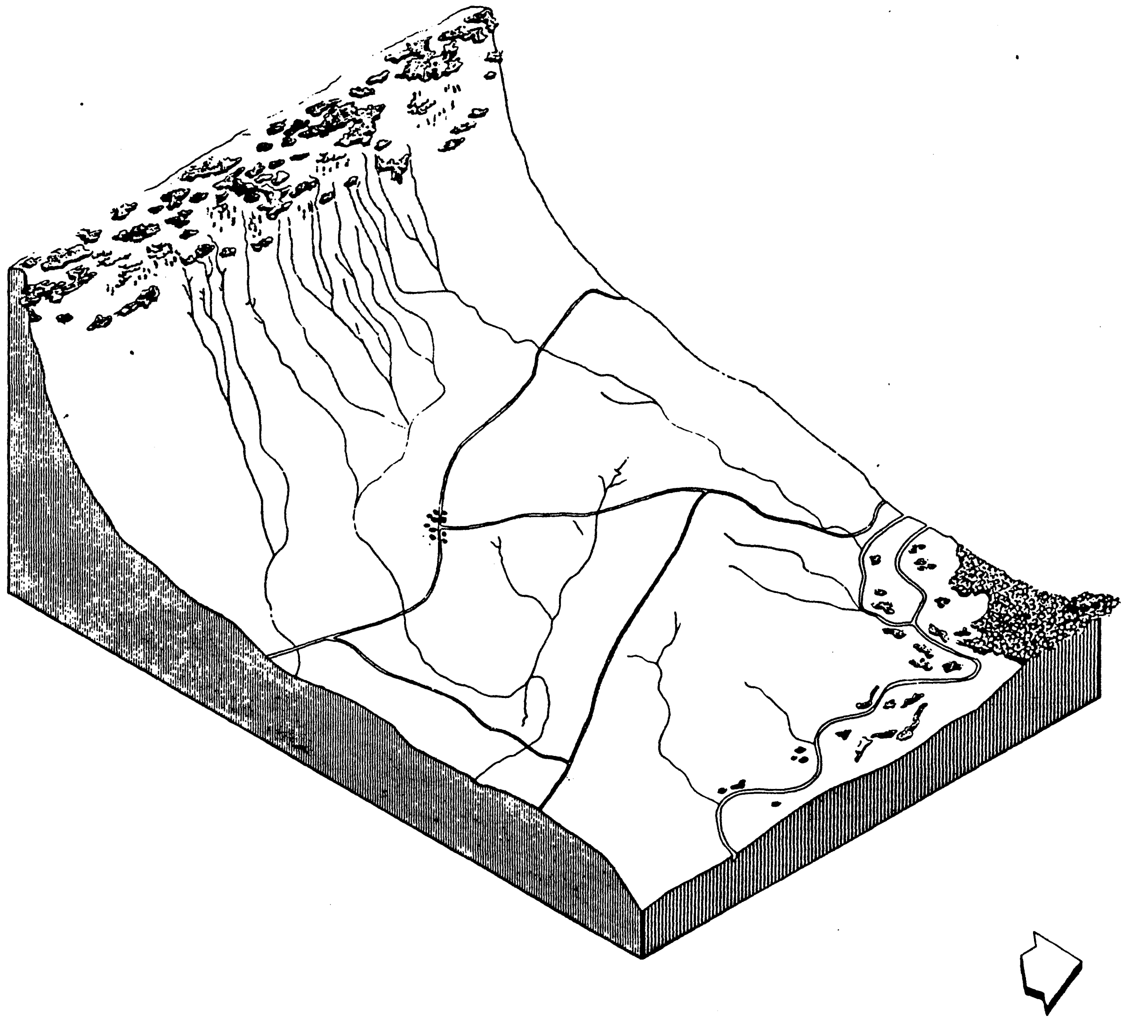


Landscape Niche Affected:

Gully and grazing lands		Cropland	Home compound	Internal boundary zone	Cropland	Road
erosion control in gully and grazing land for: Improvement of the drainage condition by -checkdams and natural vegetation - control of grazing and improvement of grass, fodder and fuelwood production	Living fences	grass and fruit trees on the benches of the terraces for: -erosion control -improvement of fruit, fodder, wood and grass production	trees around the home and boma (corral) for: fodder production, shade, shelter and decoration	grass for: erosion control, production of fodder	hedgerow system: trees are planted in rows between the crops to: -provide mulch fodder and wood -control erosion, improve drainage condition	trees along the road or path for: shade and decoration, improvement of drainage condition

(Hoek, 1983)

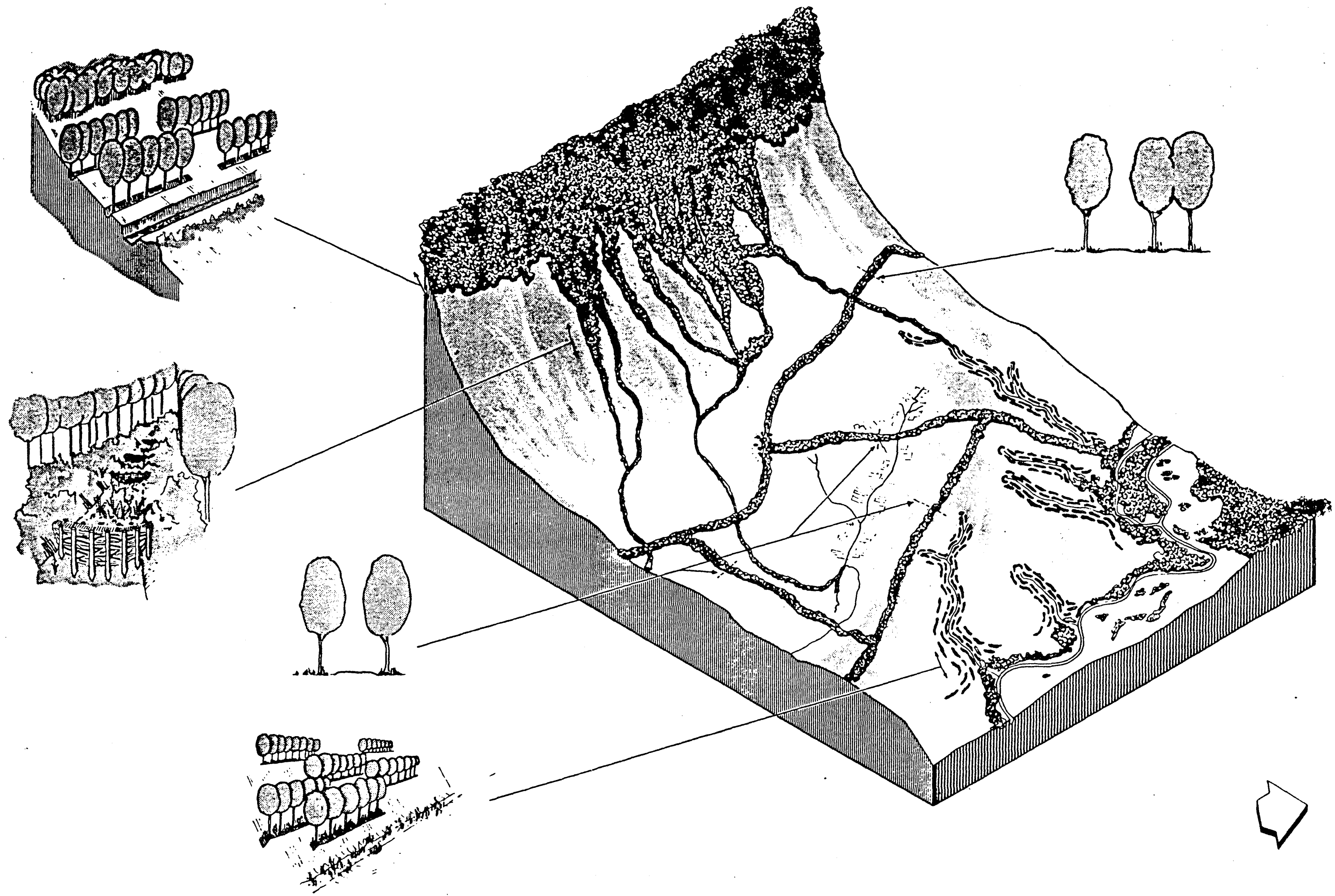
Fig. 8



PRESENT SITUATION

(Hoek, 1983)

Fig. 9 : Landscape Design Sketch



(Hoek, 1983)

FIG. 10: STUDY AREA FOR DETAILED LANDSCAPE ANALYSIS AND GROUP WORK

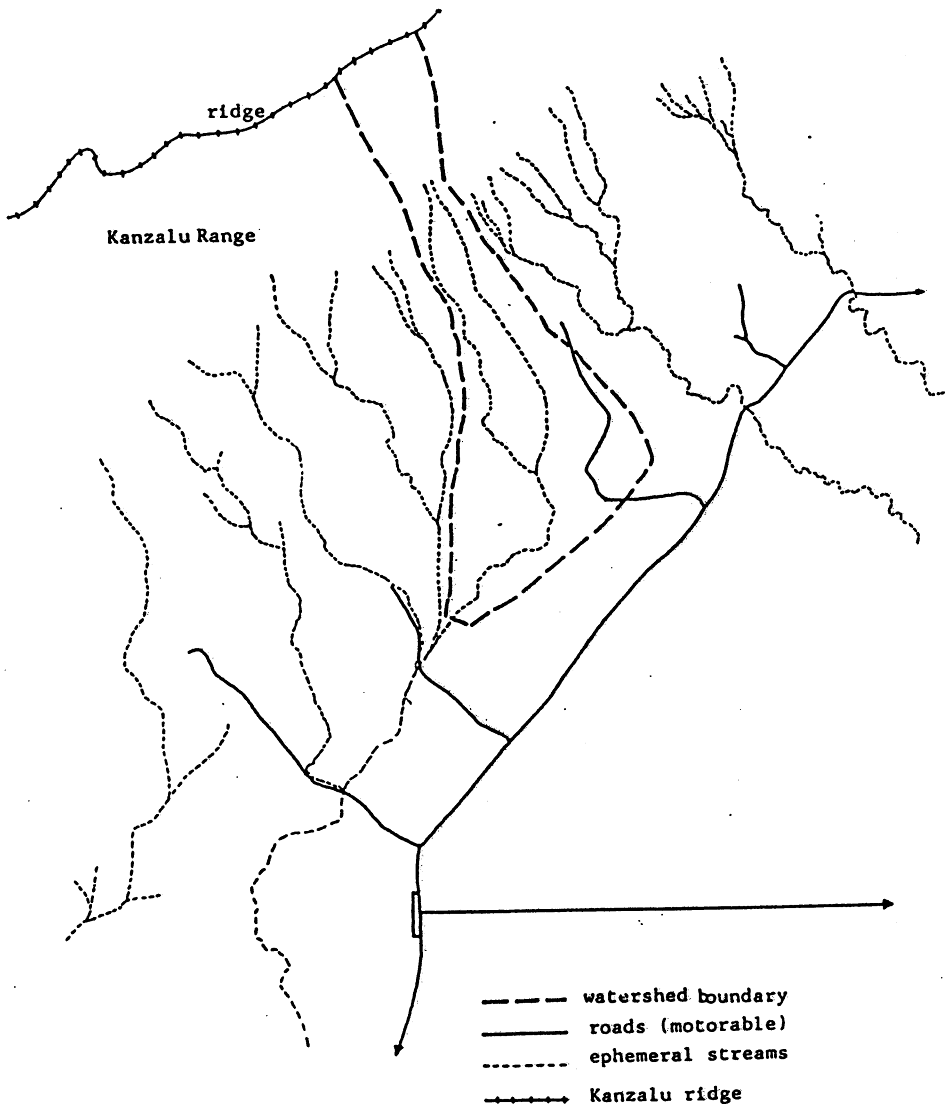
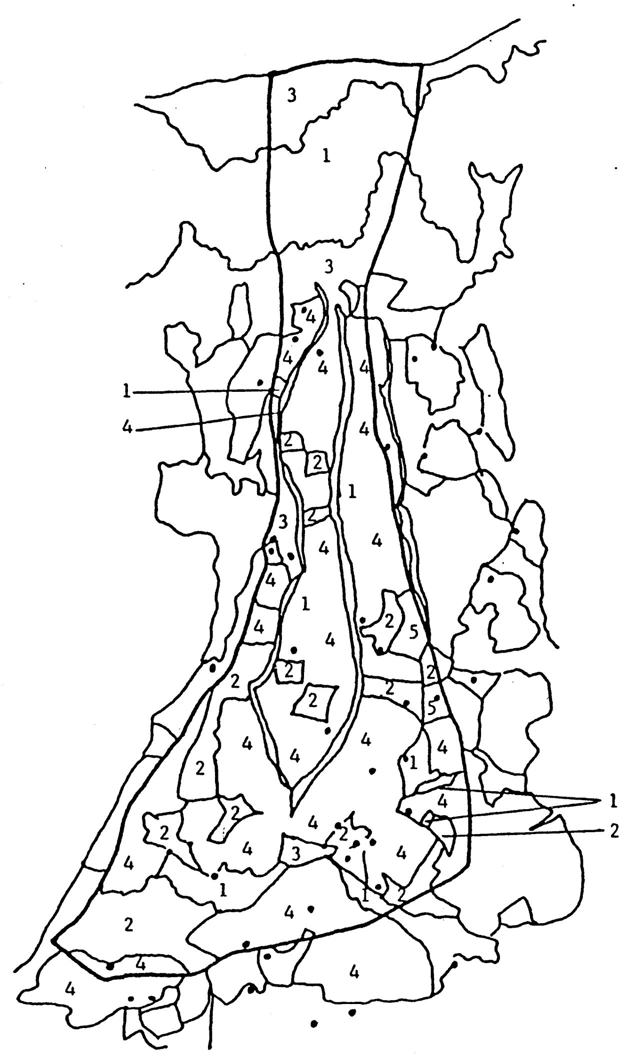


FIG. 11 :   LAND USE IN THE WATERSHED

1. Woodlands - some grazing
2. Pasture - sustainable
3. Degraded grazing lands
4. Cropland
5. Public land, sparse cover



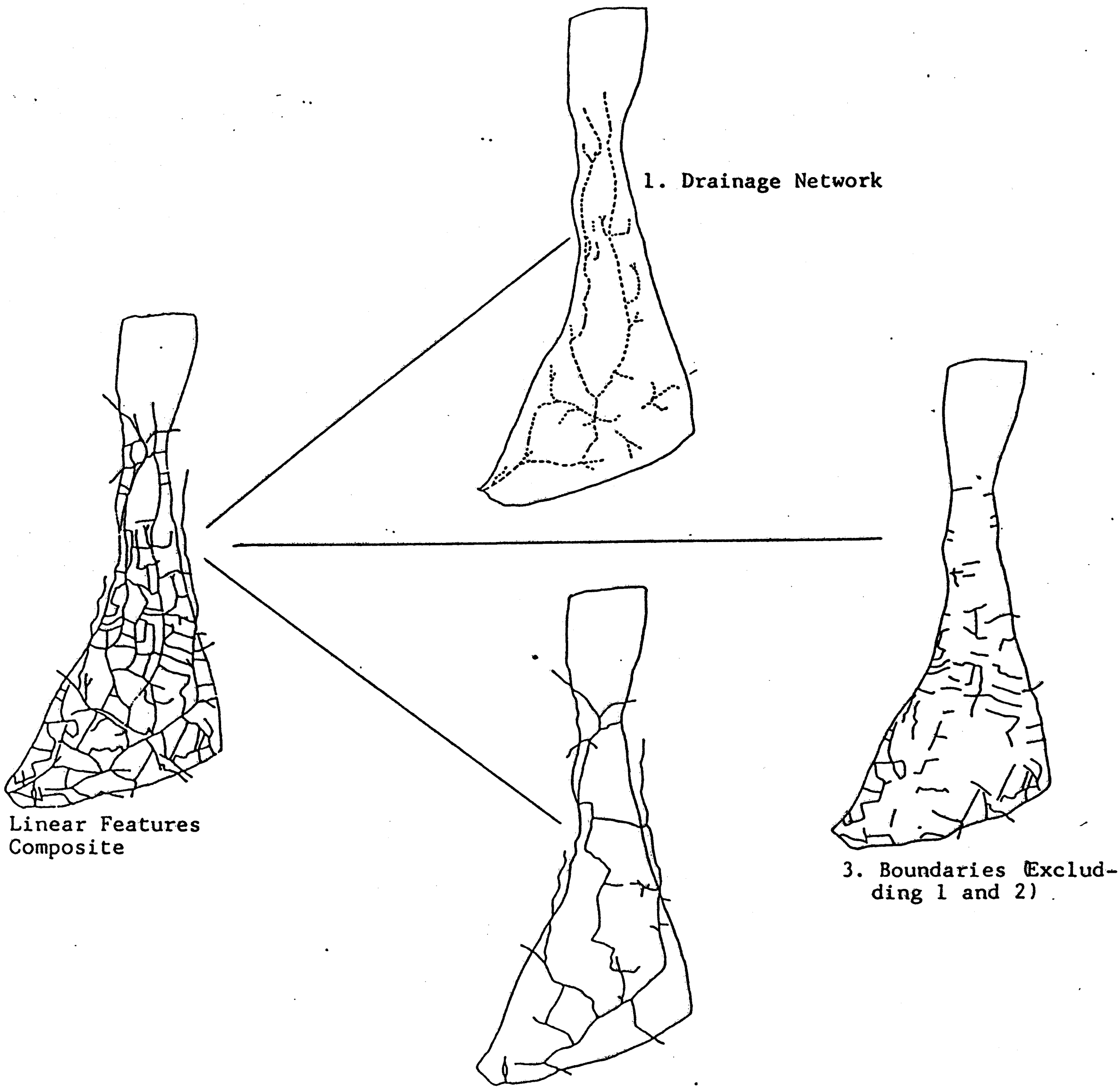


FIG. 12: LINEAR ELEMENTS OF LANDSCAPE WITHIN THE WATERSHED

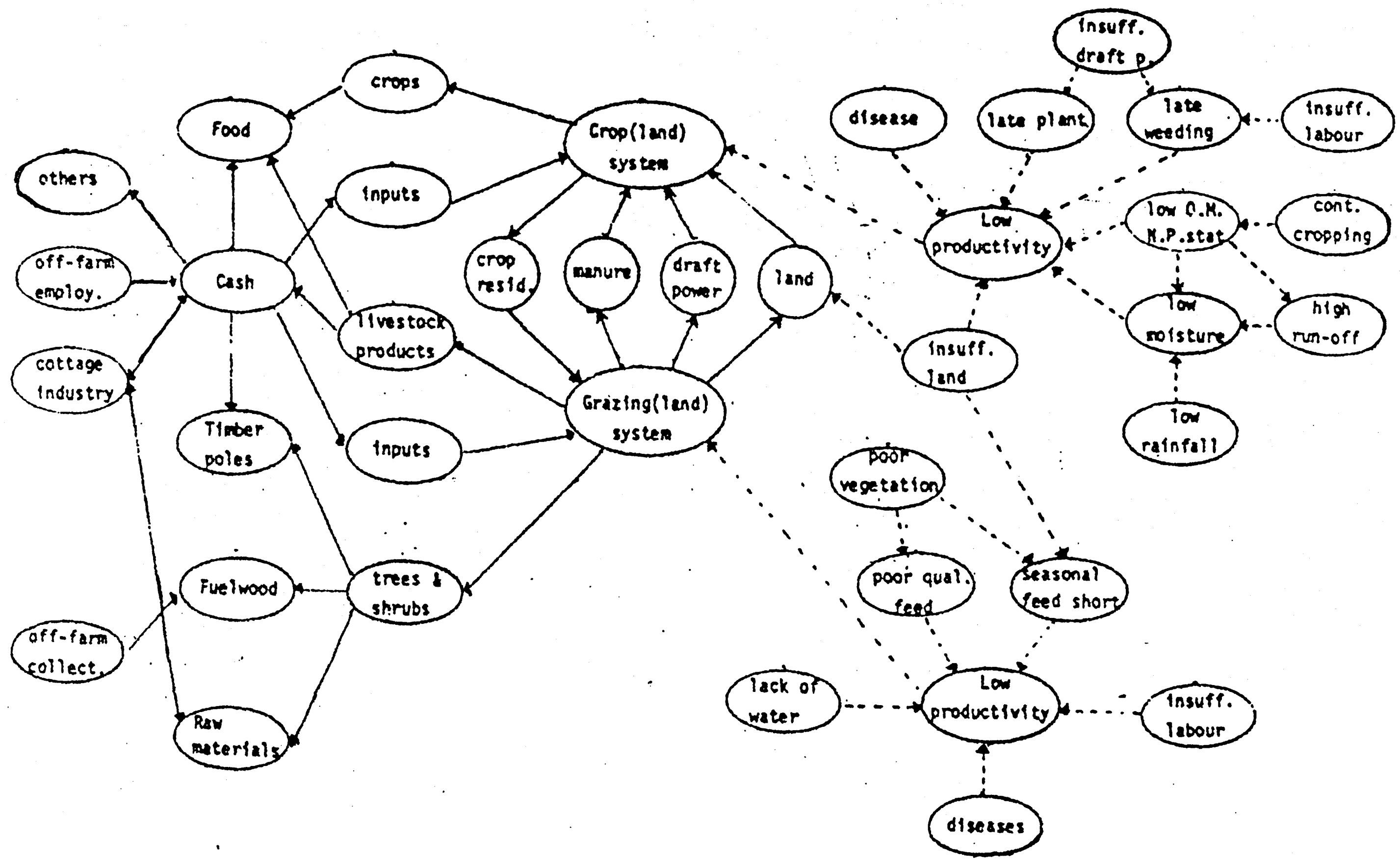


Figure 13. Combined input-output and causal factors diagram (small farms). Unbroken lines (———) indicate the flow of inputs and outputs within the farming system. Broken lines (- - -) indicate the chain of causal influences responsible for diagnosed problems.

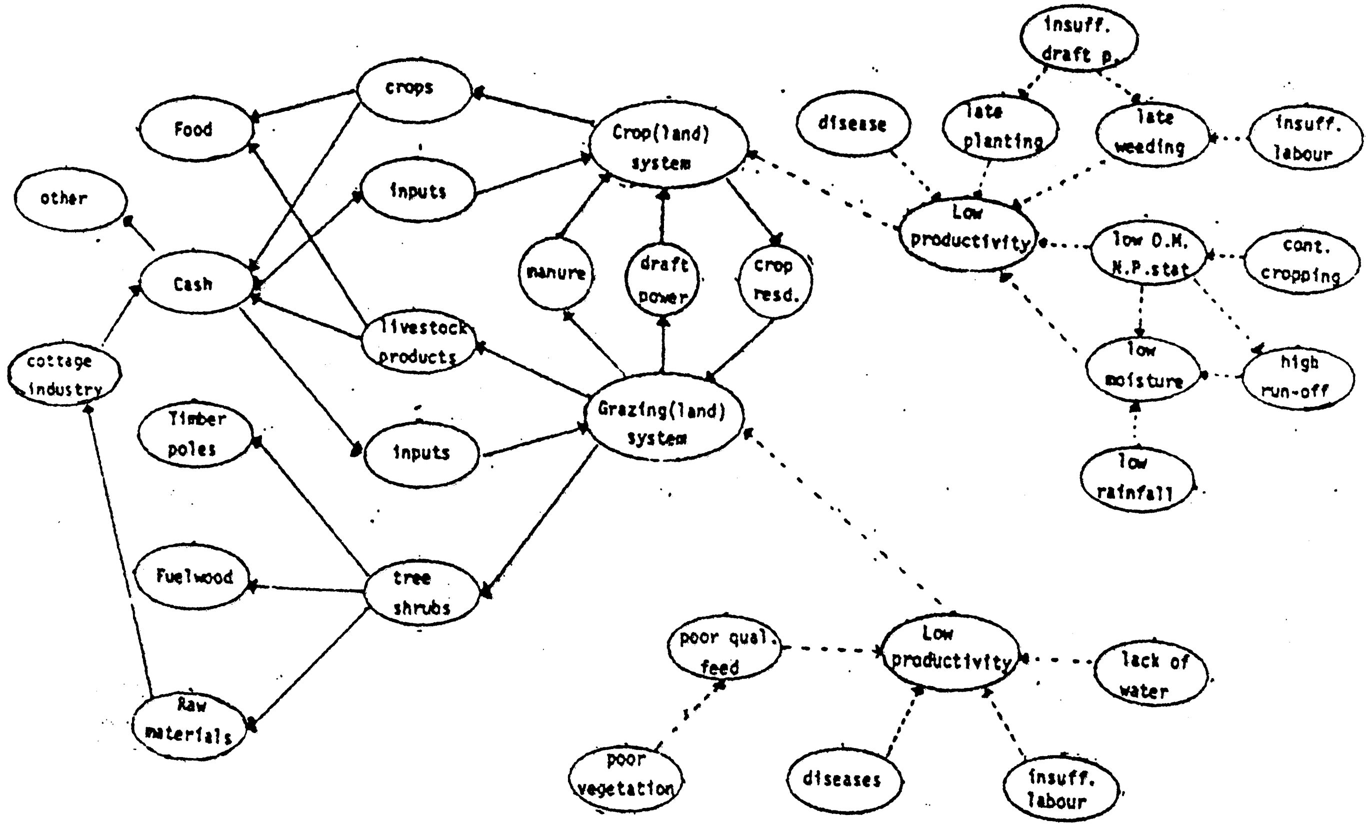


Figure 14. Combined input-output and causal factors diagram (large farms). Unbroken lines (———) indicate the flow of inputs and outputs within the farming system. Broken lines (- - -) indicate the chain of causal influences responsible for diagnosed problems.

TABLE 1 SUMMARY OF FARM LEVEL DIAGNOSTIC AND DESIGN INDICATIONS FOR A TYPICAL FARM (3.5 ha) AT THE KATHAMA RESEARCH SITE. (From Vonk 1983, Raintree 1983)

KATHAMA
MACHAKOS DISTRICT
KENYA

SITE SUMMARY OF AGROFORESTRY DIAGNOSIS AND DESIGN INDICATIONS
ON A REPRESENTATIVE FARM

SYSTEM DESCRIPTION	LAND USE SYSTEM DIAGNOSIS		AGROFORESTRY POTENTIALS
	HOUSEHOLD SUPPLY PROBLEMS	PRODUCTION CONSTRAINTS	
<u>Climate</u> Semi arid-sub-humid <u>Soils</u> Sandy loams over sandy clay loam to sandy clay; imperfectly drained in places <u>Farming System</u> Mixed farming <u>Crops</u> Maize, beans, pigeon peas, cowpeas <u>Livestock</u> Zebu cattle, goats and sheep <u>Economy</u> Subsistence farming <u>Population Density</u> 172/Km^2 <u>Growth Rate</u> 3.4%	<u>Problems in Basic Needs Supply Sub-Systems</u> <u>FOOD</u> - Seasonal staple food shortages normal, must purchase; drought related crop failure on avg. of once in every five years; low milk and meat production due to dry season feed shortage for livestock <u>FUEL</u> - Insufficient production from own land, must purchase fuelwood for household and cottage industry uses; lack of large trees for brick burning. <u>SHELTER</u> - Lack of construction quality timber and poles, must purchase; lack of large tree for brick burning; lack of fencing and shade trees. <u>RAW MATERIALS FOR HOUSEHOLD INDUSTRY</u> Must purchase fuelwood for brick making. <u>CASH</u> - Low net household income due in part to cash outflow for staple foods, fuelwood, and construction wood; savings and earning potential of livestock enterprise limited by dry season feed shortage <u>CONSERVATION PROBLEMS</u> Erosion Declining Soil Fertility Degradation of grazing land vegetation	<u>Antecedent Causal Factors</u> <u>Crop Land</u> 1. Low fertility and declining yields 2. Lack of manure 3. Low available moisture 4. Oxen too weak for dry season ploughing/planting; hence inefficient use of limited soil moisture. 5. Soil erosion and water loss due to heavy runoff. 6. Waterlogging on low spots 7. Labour bottleneck at ploughing and weeding time. 8. Insect pests. <u>Grazing Land</u> 1. Small grazing area 2. Insufficient dry season feed production. 3. Insufficient production of fuelwood <u>DESIGN CONSTRAINTS</u> Low capital Low available labour Long dry season, frquent droughts Termites & other pests	<u>Specific Problem-Solving Agroforestry Potentials</u> 1. Elimination of dry season feed gap by planting of multipurpose fodder trees in grazing areas and as hedgerow in cropland with concommitant erosion control effects and fuelwood and mulch coproduction possibilities; improved feed situation should allow dry season ploughing/planting. 2. Cut-and-carry fodder trees for increased pen feeding and usable manure production. 3. Alley cropping/mulch farming with leguminous and other trees to control erosion, increase water infiltration, conserve soil moisture, improve soil fertility and structure, reduce the need for tillage and lessen the labour requirement for weeding, insect repellence 4. Hedgerows and living fences of high-yielding fuelwood species and fruit producing thorn bushes (as a hedge against famine in bad years, for supplementary livestock feed in average years). 5. Multistorey fruit trees with undersown grass-legume pasture.

	firewood	coppicing	poles/posts	timber	animal feed leaves	human food	animal feed pods	honey	water and soil conservation	insecticidal	thorns	living fence	N-fixing	slow decaying mulch	medicinal use	drought resistance	alley cropping	erosion control hedge in shamba	living fence	grazing area improvement	fodder fence & woodlot	shade tree	widely spaced trees in shamba	windbreak
Leucaena leucocephala																								
'K8'	x	x	x	x	x	x	x	x	x			x	x				x	x	x	x	x	x	x	
'K28'	x	x	x	x	x	x	x	x	x			x	x				x	x	x	x	x	x	x	
'Peru'	x	x	x	x	x	x	x	x	x			x	x			x	x	x	x	x	x	x	x	
Cassia siamea	x	x	x	x		x			x	x				x		x	x	x				x		
C. sturtii	x	x			x				x								x			x	x			
Atriplex nummularia	x	x			x			x	x							x				x	x			
Sesbania grandiflora	x	x			x	x	x		x			x	x							x	x			
S. bispinosa	x				x		x		x				x			x				x	x			
S. sesban	x	x			x		x		x				x							x	x			
Stylosanthus scabra		x			x				x			x				x					x			
Zizyphus mauritiana	x	x			x	x	x				x	x		x	x			x	x	x	x			
Prosopis chilensis	x	x	x		x	x	x	x	x				x			x				x	x			
P. juliflora	x	x	x			x	x	x	x		x	x	x			x				x	x			
P. nigra	x	x	x		x	x	x		x				x			x				x	x			
P. pallida	x	x	x		x	x	x		x				x							x	x			
Grevillea robusta	x	x	x	x				x	x					x						x		x		
Acacia albida	x	x	x		x	x	x	x	x		x		x			x					x		x	
A. tortilis	x	x			x		x	x	x		x				x	x				x				
A. holosericea	x	x			x			x					x			x	x			x				
Parkinsonia aculata	x	x			x	x	x		x		x	x	x			x			x	x	x			
Croton megalocarpus	x	x	x	x								x				x			x					
Jacaranda mimosifolia	x	x	x																			x		
Tamarindus indica	x				x	x	x				x	x	x									x	x	
Azadirachta indica	x	x	x	x				x	x	x				x	x	x					x			
Melia ezedarach	x	x	x	x				x	x	x					x	x					x			
Acrocarpus fraxnifolia	x			x									x							x	x			
Casuarina equisetifolia	x	x	x	x	x				x				x			x				x	x			x
Balanites aegyptica	x	x	x		x	x	x	x	x		x				x	x					x			
Moringa oleifera						x									x									
Samanea saman	x	x	x	x	x	x	x	x	x			x	x		x	x				x	x	x		

TABLE 2 RECOMMENDED SPECIES LIST BASED ON FARM TRIALS AND OBSERVATIONS IN SIMILAR ENVIRONMENTS

Excerpted from Vonk, 1983.

References: Fernandes, 1983.
Getahun, 1983
Haller, 1981
Barrow, 1982
National Academy of Sciences, 1980
Buck and Teel, 1983

Table: 3

SUMMARY OF AGROFORESTRY DIAGNOSIS AND DESIGN FOR THE COMMUNITY AND SURROUNDING WATERSHED

SUPPLY PROBLEMS	SUSTAINABILITY PROBLEMS	CONTRIBUTING FACTORS	AGROFORESTRY POTENTIALS OF COMMUNITY LEVEL
FOOD - Low grain yields throughout sub-location; dependence on imports from other districts, food relief in drought years.	Declining yields predicted on existing crop land; poor yields and land degradation anticipated for newly opened marginal lands.	High cost of fertilizers, inadequate supply of manure, and low soil fertility; inadequate labor for weeding at peak demand periods; introduction of grain crops innappropriate to ecological zone; expansion of grain crops onto marginal sites (steep, dry, gullied).	Promote fruit and nut trees to supplement diet through group nursery projects. Mix group vegetable gardens with tree nurseries. Promote mulch (green manure) strategy through group participation in farm trials to determine best species, management.
WATER - Inadequate supplies for domestic and agricultural use; uneven distribution of access by wealth, relative location; inadequate development of municipal sources.	Existing water sources subject to deterioration by siltation, flooding lowered water table.	Excessive runoff on grazed lands upslope reduces infiltration and groundwater recharge; floods and siltation plague impoundments, dry river-bed wells.	Use group contacts to locate nuseries, veg. gardens at permanent waterholes on group member's property. Combine water-harvesting with AF experiments using available materials, soil conservation groups; use MPT's and grasses to protect impoundments.
FUEL - Charcoal and brick-burning trees scarce throughout sub-location; high expenditure of time and labor to procure fire-wood; uneven distribution of quality, quantity by land facets, farm size.	Browsing keeps trees at shrub size; Degradation of source areas (soil compaction) is preventing regeneration of favored species.	Overgrazing hillslope woodlands and small plots downslope by all households on slope.	Promote zonation of fuelwood production on upper slope, trade for food; convert selected gullies to ravine woodlots (fodder lots if controlled access). Increase fuelwood production in boundary lands of finely sub-divided landscape.
INFRASTRUCTURE - Drainage roads inadequate to service sub-location; lack of integration within each network and between networks.	Existing roads, drains, crossings threatened by gully erosion, siltation individual (piecemeal) decisions to modify drainage and paths.	Frequent movement of cattle upslope causes severe gullies in midslope woodlands; flash floods remove even trees in gullies; use of sledges for water carts erodes roads, disrupts drainage.	Divert drainage from selected drainage channels to croplands and/or fodder lots. Use vegetation (MPT's, grasses) to define and stabilize permanent drainage and road network, while producing poles, fuel.
RAW MATERIALS - Commercial charcoal and brick-burning tree sources depleted throughout sub-location; shortage of construction poles - purchased from other locations.	Degradation of source areas in over-grazed over-harvested woodlands is preventing regeneration of pole wood species; degradation will hamper future efforts to re-establish favoured species.	Lack of training and infrastructure (physical and organizational) to propagate desired species within the sub-location.	Plant polewood trees on internal farm paths and along roads. Integrate charcoal and brick-burning trees into ravine woodlots, fencerows Develop nurseries, seed collection with self-help groups.
CASH - Reliance on charcoal as cash crop by poor small-holders; almost no off-farm employment; marketing disadvantage relative to nearby towns; remittance income from absentee men sporadic.	Remittance income dwindles, becomes less dependable with time away, and rising urban unemployment; charcoal stock being depleted in adjacent source areas - enterprise not sustainable as is.	Land cannot accommodate new full-sized holdings of young families, food crops given priority; promoted cash crops high risk for zone (cotton), market for other cash crops unreliable.	Integrate fruit (citrus, guava) and nut (macademia, cashew) trees into terraced cropland, with concurrent organization of market channels already used by a few farmers. Integrate training into group trials, nursery work.
SAVINGS/INVESTMENT - Dry season fodder gap forces untimely sale of goats, sale or loss of cattle; land prices prohibitive - shortage of arable plots.	Degradation and subdivision of grazingland; widespread conversion of grazing areas to cropland preclude maintenance of herd size under current practice.	Best dry season fodder trees (pod trees) have been harvested for charcoal; animals allowed to range freely during long dry season; land conversion to crops.	Use MPT's to sub-divide larger grazing lands for rotation. Use N-fixing species planted in strips or microcatchments to reclaim degraded grazing areas; Plant pole trees for cash on farm and along roads, with tree rights assured (group, individual, through chief).

Table 4: Estimated Land Use in the Watershed Aggregated by Category

	Wooded Ravines	Grazed Woodland	Sustainable Pastures	Degraded Grazingland	Cropland	Public Lands	Total
ha	5.6	17.3	18.0	11.6	52.8	1.0	106.5ha
% of total	5%	16%	17%	11%	50%	1%	100%

Table 5 : Production Potential* Estimates From Length and Area of Linear Features and Boundaries

	Roads and Paths		Gullies and Channels		Property and Internal Boundaries		Total
	Major	Minor	Major	Minor	Existing	Bench Risers or Rows	
Length m	2,600	2,400	4,200	3,200	8,340	15,000(3)	35,740 m
Width m	2	1	3	2	1	1	
Area m^2	5,200	2,400	12,600	6,400	8,340	15,000	49,940 (5.0ha)
Potential fuel production kg yr^{-1}	10,400	4,800	25,200	12,800	16,680	30,000	84,880 (84.9t) - 100,000kg (100t)
% of demand in watershed	7%	3%	17%	9%	11%	20%	67%
Potential fodder production trees kg yr^{-1}	10,400	4,800	25,200	12,400	16,680	15,000	84,880 kg yr
grass kg yr-1	4,576	2,112	12,600	6,400	6,458	6,000 (riser only)	38,746 Kg yr
Combined kg yr^{-1}	13,420	5,856(4)	16,632(2)	8,448(2)	20,943(4)	19,356	84,655 kg yr
Assume 5 kg A.U. day	6%	3%	8%	4%	6%	6%	39%

1. Estimated assuming 1 lopped tree per m^2 producing 2kg DM leaf and 2kg DM wood $tree^{-1}$ and .88kg m^{-2} yr^{-1} grass (1.44kg m^{-2} $season^{-1}$) and 1kg m^{-1} of Napier grass in gullies (based on rapid appraisal and data from Otarola and Ugaldi. 1983; Baggio, 1982).

2. $\frac{2}{3}$ area in grass strips, with $\frac{1}{3}$ area in fodder trees

3. Assume only 500m per farm 30 farms

4. Grass production reduced by $\frac{1}{3}$ to account for weeding near trees.

Table 6. Estimated[1] Ideal Requirements for Structural Treatments and Plants Within the Watershed

Gully repair with related land treatment

	Major channels 4200m	Minor channels 3200m	
No. Check Dam Structures	250[2]	250[2]	
Length of Drains, Diversions		450m	
Volume of storage[3] in pits or micro-catchments in grazing-land upstream		$4500m^3$	45,000 structures of $0.1m^3$ storage each
No. trees and shrubs[4]		25,000	
Napier grass (initial beds for seed, demo.		3,000 units (slips)	

1. Based on rapid appraisal and rough calculations
2. Assume direct treatment of 1,000m. at the upstream end, small structures every 4m
3. Assuming 5cm rainfall storage
4. Assuming grass to be seeded or naturally re-seeded.

Table 7 Time-and-Labour Estimates for Self-Help Groups Working in Watershed Rehabilitation[1]

Task	No.	Time[2]
Small checkdam	2	1 session
Cut-off drain (narrow)	40m	1-2 session(s)
Pitting	40	1-2 session(s)
	1 ha	25+ sessions
Microcatchments	60	1-2 session(s)
Fencing site	400m or 200 trees	1-2 session(s)
Planting Holes	400	1 session
Tree-planting	500	1 session

Realistic Goal for Planning One Year's Work, 4 sites at or near origin of gully, each with "package" of treatments:

> 5 small check dams with necessary drains, diversions; 500m^2 treated microcatchments or pits with trees and shrub planting and appropriate fencing or tree protection.

1. Based on 2 groups operating in this area, with 20 working members each at every session, 32 sessions per year of public conservation work, each session spanning one morning, with 2 full hours physical labour per person.

2. Varies with texture and structure of soil, condition of site.

Table 8. Species included in first round of tree-seedling distribution to group.

Citrus spp (rough lemon: 1 budded*, 1 plain	(2)
Anacardium occidentalis	(1)
Psidium guava	(1)
Cassia siamea	(2)
Carica papaya	(1)
Leucaena leucocephala	(2)
Acacia holosericae	(1)
Acacia albida	(1)
Azadirachta indica	(1)
Melia Azidirach	(1)

* with Washington navel orange

** all of the above had shown some promise in existing production systems or in previous farm trials in the area. In addition to the above selected species, some farmers agreed to plant rooted cuttings of Gliricidia sepium, Albizia amara and/or Sesbania sesban to test ease of establishment and survival under farm conditions. All three are potential components of fuelwood/fodder production technologies for small farms in Kathama.

Table 9a. Original D+D.

ORIGINAL DIAGNOSIS	ORIGINAL DESIGNS	RESEARCH PRIORITIES/PROGRAMS
FARM LEVEL		
Cash Problems		
Poor animal production due to dry season fodder gap;	Enrichment planting in grazing lands	Establishment trials, several spp; various site preparation planting, and mgt.techniques.
High seasonal cash outlays for staple food purchase	Fodder and fuel lots (cut and carry) on small unused plots	Same as above different spacing and land pup. technique
Off-season animal sales due to both of above.	Multistorey fruit tree stands over grass and legume cover(fodder)	(low priority)
FOOD PRODUCTION PROBLEMS Low yields and crop failures Soil capping - late tillage; poor soil moisture;poor soil fertility;soil erosion.	Hedgerow intercropping for mulch, (with N, O.M. additions and protective cover for better soil moisture, lower temp.) and stick wood as by-product	*Cassia siamea* and *Leucaena leucocephala* at 2.5 m between-row and 0.5 m in-row with maize and pigeon pea, on cropland.
FUELWOOD SHORTAGE High dependence on off-farm sources; fuelwood purchase, charcoal tree purchase by some.	see above, plus: Hedgerows and living fences with fruit bearing spp. and high - yielding fuelwood spp.	spp. trials along fencelines and in lots (low priority)
COMMUNITY LEVEL		
Cash No facilities for plant propagation marketing, and farmer training to support farm level technology tested (above) at farm level. Degradation of grazing lands.	Provision of "sampler" seedling packages (13 spp.) and some training to group members in soil conservation projects,	Follow-up to seedling distrib, on 60 farms re: survival and placement by spp. Qtrly follow-up at 30 farms re: performance, damage, maintenance, farmer assessment, farmer learning.
Net purchase of construction wood from other communities.	Involvement of groups in establishment of fodder and timber spp. upstream of gully sites.	
Food Inadequate storage & credit & mktg, facilities at community level.	Low priority	Not pursued
Degradation of gathering sites	See survey, below	Interviews with groups re: wild fruits and other foods preferred spp.? dwindling ssp? (in amt.or access)
Fuel Depletion of favoured spp. for fuel and charcoal in Kathama itself, and uneven distribution of what remains.	Distribution of sample fuelwood spp. see survey below.	Follow-up of sampler seedlings as above, special attention to fuelwood spp: suvival? willingness to plant more? where on farm?
Savings Investment Need community-level support for improved savings mechanisms; alternative investments	Low priority Involvement of groups in resting AF(fodder and fuel trees with grasses, and living structures) into public soil conservation works.	Informal polling of groups re: alternative investments, group savings, preferences of farmers.
Disinvestment in land resources and infrastructure at community scale (degradat) of grazing and gathering lands, water supply, roads and paths)	No design: Pilot survey on use of off-farm resources (water, fodder, fuel groups labor row materials)	

Table 9b. Revised D+D.

Feedback D&D

From Farm Trials

- Hedgerow intercropping is still risky mainly due to apparent water compe tition esp. with pigeon pea, but farmers interested in "Zonal mulch".
- Pest control, water harvesting and browsing damage problems on grazing land left most farmers with mgt. of existing trees as best option.
- Water supply for on-farm nurseries poses a problem for most individual farmers - public supplies or access to others' private supplies is needed for nurseries (if seedlings used).

From Groups

- Groups are not public works or purely communal in orientation; they are associations based on exchange/rotation of labor on members' lands to benefit individual members and families.
- Follow-up of "sampler" seedlings indicated greatest interest in fruit trees and fodder trees, both on croplands (for estab. and protection)
- Group requests for nursery project, participation and results show need for training plus simpler, cheaper methods of plant propagation, and pest control(confirms fruit and fodder priority; would consider local wild fruits)

- From surveys plus Interaction of Groups and Individual Farms:

- There are 3 main design client-groups;

1. Labor-short, land-poor, limited mobility families.
2. Largeholders interested in investment over long term .
3. medium-small holders interested in mixing fruit trees ,fodder,improved practice into cropland.

- Subdivision of lands is a critical issue, as is land conversion; we need to plan present placement and spacing of trees accordingly.
- Use of boundaries is especially important to smallholders, as is use of gullies; roadsides are also heavily utilized by same, but lack definition re: rights of use (for example, for new trees). Women and poor men may be able to use gullies and fencerows. Most are willing to start with fencerows.(for fuel, timber)
- Some members have tried boma-mulching(pre-composting with tree biomass in corrals) and some have pits for rough-composting; other group members interested in increasing "Manure" yield from corrals.

Changes in Research Programs and Priorities for Farms and Groups

Priority 1:fruit trees in cropland and internal fencerows. questions:spp? spacing? combinations?mkts? processing or storage? multiple uses? (food, cash; fodder and fuelwood by-products?

Priority 2:fodder trees in cropland, intercropped or in small plots (one terrace)

questions: spp? spacing on risers? or in lots? fodder production? effect on crop production? cut vs. once-a-year browse?

Priority 3:Use of tree biomass for pre-composting (" boma mulching") and composting.(combine with fuelwood production).

Question: fencerow or dispersed trees? best spp.? timing? quantities? labor input? nutrients and O.M. in mix? effect on soil? yields? farmer assessment.

Priorities for related systems research (support)

Priority - 1a. progagation methods with and without nursiries (e.g. cuttings, direct seeding; and bare-root and stumping)

1b. Pest control for propagation, establishment (local resources)

Priority 2:serves 1, 2, and 3:should be included in each case. Landscape planning with families and groups, accounting for access to,and ownership of, different places within -farms and within - communities.

Time-series planning to account for tenure and access shifts, land subdivison and land use conversion at farm and community level. Develop and propose various components, mixtures, arrangements and social organization options, determine with clients most acceptable avenues to pursue, then monitor performance as-per-usual in 1, 2, 3 above.

Priority 3:also serves 1, 2, 3 and 2 above (landscape) Training and Extension approaches- assessment of alternative approaches and techniques (for Kathama and other similar areas) decision points, and decision criteria (usable by research, development, and extension field personnel).

FSR/E ISSUES

Michael M. Cernea and Scott E. Guggenheim

Timothy R. Frankenberger

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IS ANTHROPOLOGY SUPERFLUOUS IN FARMING SYSTEMS RESEARCH ?

by

Michael M. Cernea, Scott E. Guggenheim[1]

The role of the non-economic social sciences, particularly of sociology and anthropology, in farming system research (FSR) is being gradually and increasingly recognized. As a consequence, these disciplines are being brought into interdisciplinary agricultural research programs. The theoretical insights, methodological approaches and operational findings contributed by these disciplines are strengthening both technical research in agriculture and the actual development interventions based on farming system research.

Yet, we are still coming across instances in which the role of anthropology/sociology in farming system research is either directly ignored, confusedly mispercieved, or de facto contested. Some times such a denial is even expressed explicitly and aggressively. The present paper[2] is using the opportunity offered by a recent instance of explicit denial of the role of anthropology/sociology in FSR, in order to refute the argument that underlines it (and possibly other such positions) and to develop, in response, the positive argument for recognizing the social and cultural variables that need to be studied with adequate sociological and anthropological methodologies under the FSR approach. The paper which we challenge is a state-of-the-art review report on FSR. The World Bank commissioned Norman W. Simmonds from the Edinburgh School of Agriculture to prepare such a review, and the resulting paper[3] was

[1] Michael M. Cernea is Rural Sociology Advisor at the World Bank. The Agriculture and Rural Development Department. Scott Guggenheim is a researcher and Rockefeller Postdoctoral fellow at CIAT Colombia.

[2] This paper is a slightly amended version of a rejoiner written by the authors to a report prepared by Norman W. Simmonds on FSR (see Footnote 3).

[3] Simmonds, Norman W. The State-of-the-Art for Farming Systems Research, Agriculture and Rural Development Department, The World Bank, Washington, D.C., January, 1984, (processed).

presented in summary at the World Bank Agricultural Symposium of January, 1984 and widely circulated within the international agricultural research network.

Norman W. Simmonds' treatment of anthropology in his state-of-the art review of farming systems research (FSR) is unfortunately ill-informed and misguiding. The reviewer seems rather unaware of the anthropological premises and components of farming systems research. When it discusses the anthropological contribution to FSR, the Simmonds review, contrary to the call of a state-of-the-art paper, does not objectively inform the reader on the considerable body of opinion that differs from the author's own (mis)judgement. And in discussing the methodological issues confronting farming systems research, it fails to grasp the interplay between the social sciences that jointly further such ongoing research.

In the limited space of this paper, we shall first substantiate the above points, and then sketch some of the reasons why anthropological and sociological[4] concepts and skills are indispensable to farming systems research teams.

The reviewer's flippant dismissal of anthropology appears during a discussion of the institutional role of economists and anthropologists in agricultural research programs. Arguing that farming systems research is essentially a product of farm management economics, Simmonds adds that the complexity of the economics now needed for proper analysis of small-scale farming is beyond the grasp of the agricultural scientist. Consequently, economists are indispensable members of FSR teams.

The reviewer thinks, however, that anthropology is expendable. To support his opinion, Simmonds resorts to caricature rather than to intellectual argument. He writes:

> "One recalls the not altogether unfair stereotype of an anthropologist living in a village for years and emerging at the end with the view that the villagers are all splendid chaps

[4] In this paper, and for the purpose of the issue discussed, we are using "sociology" and "anthropology" interchangeably.

> who ought to be allowed to get on with agriculture in their own way regardless of the fact that the world around them will not allow them to do so."

Caricature, and such anecdotes, do not tell the full story. Stereotyping is distorting and meaningless, even if apparently witty. Using a stereotype for want of a better argument only indicates the weakness of the reviewer's position.

Simmonds next suggests that "if there is a place for anthropology at all" it would be for "the economic anthropologist rather than the strictly social kind", who could answer certain "important questions beyond the reach of economics" (difficult to imagine though this might be for the reviewer...). In any case, even this kind of anthropologist is probably superfluous, because:

> "...there might be little to distinguish him from the economist with well developed social perceptions".

The contradiction in the reviewer's position is obvious, although his thinking seems to walk by without noticing it. If he concedes that there are in FSR "important questions *beyond the reach* of economics" — and indeed there are — than it is inconsistent to deny the need for those social sciences that do "reach beyond" and explain those admittedly "important questions". Sociology and anthropology do precisely that. They reach into the *social fabric* in which the economic activity of farms is embedded. It is therefore preposterous to assume that the tools (conceptual and investigative) of these social sciences, anthropology and sociology, can be substituted by "well developed social perceptions" of the economist. And what are these vague "social perceptions" which Simmonds doesn't bother to define? Should FSR, or any research, be left at the whim of the presence, or lack of, a researcher's subjective "perceptiveness" of "important questions" for which he has not been professionally trained? If Simmonds' displayed perceptiveness for the socio-cultural dimensions of farming offers any clue, then it definitely proves that a serious, systematic approach should never rely only on "perceptiveness" outside one's own technical discipline.

The reviewer doesn't appear, however, to be interested in these issues and self-confidently steps over them, in a brisk walk towards his crowning final pronouncement:

> "...any generalized adoption of social anthropology would be, I believe, merely an expensive way of avoiding a few, not very costly, mistakes by OFR/FSP teams."

In other words, counsels the reviewer, researchers should forget about any general use of social anthropology in FSR, even under the penalty of making some mistakes; he generously offers his tolerance for such "not very costly" mistakes.

Another methodological error in the reviewer's reasoning is to confuse the general for the singular. We can readily admit that there have been anthropologists who would fit Simmonds caricature of the outsider who lives in a village several years, only to emerge afterwards with no more than trivia as his "findings". But what does this prove about a scientific discipline? Nothing. For each and every discipline there are enough champions of trivia, yet this is is not a reason to indict the discipline itself.

The regrettable consequences of the fact that the reviewer let himself get carried away with his caricature are that (a) the review paper remains incomplete and biased vis-a-vis the intellectual history of FSR; and (b) it offers a poor and misguided judgment, and a truncated picture, as advice for future work in this area.

Our concern is not so much with the reviewer's biased opinions — these can be left to him as a private matter — but with the damage resulting from his allowing his own bias to affect his compiling of the state of the art report; he refused to take stock of existing experiences and screened out from his report the voluminous work done specifically by sociologists and anthropologists in many international agricultural research centers of the CGIAR network, in national centers, and outside them, in universities, projects, etc. (see, for instance, the many works presented at the ARPT/CIMMYT workshop on the role of sociologists in farming systems research, Zambia, 1984, or the IRRI/UNDP workshop on "the role of anthropologists and other social scientists in interdisciplinary teams developing improved food production technology", Los Banos, IRRI 1982; and the several annual workshops on FSR at Kansas State University — e.g. Flora, 1985 etc.) The intellectual richness of these research efforts, their integration with other disciplines, the research sinergy thus created and the resulting findings, are not captured in the state of the art paper. Therefore, the report remains deficient by not deriving some of the lessons which are essential for further guiding the development of FSR.

To assess what has already been the place of sociology and anthropology in evolving the FSR approach, one can listen to several authorized,non-anthropological voices. Many researchers who know what skills are useful in FSR from actually doing it, have said clearly that anthropology has provided important insights. John Gerhard, for example, writes that "...anthropologists add a qualitative and holistic perspective which is badly needed" (1984:13). The farming systems field manual developed by the CYMMIT Economics Program (Winkelmann and Associates) adds that "...an anthropologist might aid in understanding interactions between household members in decision making for particular crop operations or interactions between households in the cases in which a technology might require cooperation of groups of farmers" (1980: 4) — hardly a minor domain of FSR, as implied by Simmonds.[5]

Perhaps the reviewer did not realize that the OFR/FSR approach that has been developed at CIMMYT, and to which he frequently refers, has in fact been shaped and is practiced at CIMMYT *with* anthropologists present in the OFR teams, incorporating anthropological perspectives and procedures. He extensively quotes the paper of a CIMMYT staff anthropologist, Robert Tripp, without identifying him as such and apparently without realizing that Tripp *is* a social anthropologist who brings his disciplinary skills into the OFR/FSP at CIMMYT.

In another center, the international potato research center (CIP,

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[5] Elsewhere in the state of the art paper, mentions are made of the "human factors" including "farmer attitudes", "community relationships" or of some social characteristics of the small farmers; these only underscore how unsubstantiated the pronouncement about anthropology is in the context of a review that remains contradictory.

Peru), agro-technical and economic researchers who have spent many years working on potato post-harvest technologies, potato processing and other FSR-related aspects, have significantly modified their recommendations precisely because of the research contributions of professional anthropologists and sociologists on CIP staff (Rhoades, 1983; Rhoades and Booth, 1982). CIAT has similarly found anthropologists useful in its bean and cassava programs, where they work closely with agronomic and biological researchers.

The second contribution of anthropology to FSR flows naturally from the first. To a growing extent, as farming system research incorporates off-station experiments, sociologists have become increasingly involved in experimental design. Jacqueline Ashby, for example, has worked extensively to develop models and methods to include variable amounts of small farmer participation in technology assessment and adaptive research. Experiments carried out with these methodologies have produced results significant for agronomic research (Ashby 1984, Ashby and Leon 1983). Agronomic researchers using these techniques benefit not only from accurate baseline information and dynamic, continuing evaluation of agricultural technology when farmers are included in crop trial design, but they also benefit from much more carefully attended and protected experiments when farmers also have a direct interest in studying the experimental outcomes. That these benefits are appreciated by farming system researchers is evident in their enthusiasm for participatory techniques (Woolley 1984; Wooley and Pachico, 1983).

In turn, Michael Collinson's seminal articles on farming systems research cited by the reviewer took pains to underscore various commonalities between anthropological fieldwork and the proposed FSR methodology, noting, for example, that the crucial "exploratory survey" adopts "...almost an anthropological approach to understanding the local farming system" (1980:441). Collinson, the leading economist researcher in the area of FSR in Africa, is certainly well placed and fully backed by his entire work to draw attention to the similarities between farming systems research and anthropological analysis (Collinson, 1985).

In fact, understanding farming from the farmer's point of view, especially in non-Western cultures, has been a central preoccupation of anthropology practically since the founding of the discipline. A quick look at Malinowski's *Coral Gardens and Their Magic* (1935), Firth's *Primitive Polynesian Economy* (1938), Redfield's *Chan Kom* (1934) or Richard's *Land, Labor, and Diet in Northern Rhodesia* (1939) will show both this long developed scientific tradition and its current validity.

What, then, can social anthropology or the sociology of agriculture specifically contribute to farming systems research? This is the crux of the matter.

We contend that this contribution is substantial for understanding many of the issues and variables now being addressed by farming systems researchers, as for instance: farm decision making patterns; non-economic factors in farmers' economic behavior; the relationship between landholding and social structure; alternative economic activities; the developmental cycle of the farm family; the social organization of family labor resources; family authority systems and their impact on sex and age division of work; family values and objectives; causes and consequences of cognitive and behavioral changes; short and long term farm strategies and so on.

To various degrees, these variables have been at the core of sociological and anthropological investigation for a substantial time. However, what is even more significant, these variables have been brought to the forefront of the research agenda in the sociology of agricultural development and in development anthropology particularly during the last ten years (Cernea, 1985; Sutherland, 1984). A convincing argument has been made that the strong emergence of such a research agenda among rural sociologists signifies the development of a "sociology of agriculture" which is not co-terminus with the traditional rural sociology; it represents a new approach, theoretically more fruitful, substantively innovative, holistic, critical and directly relevant to the problems facing rural societies (Newby 1982, 1983). Such new developments in sociology, which ought to be signaled as symptomatic of the current "state of the art," make the inter-disciplinary exchange in FSR studies even more promising. The progress of the sociology of agriculture justifies, therefore, a stronger plea for channeling its contributions also into the conceptual framework and practical organization of farming systems research.

Being of a social or cultural nature, these variables do not fully fall under the realm of economic or agricultural/biological sciences, which have not been concerned with developing the conceptual or methodological apparatus to study and interpret them. But these variables have been and are studied by disciplines like sociology and anthropology, which have worked out conceptual instruments and observation procedures tailored for such variables and have accumulated a substantial body of relevant information on them. (Cernea, 1985; Flora, 1985) Farming Systems Research differs from many prior approaches, such as farm management studies, (Flora, 1983) or cropping systems studies, inter alia precisely because it recognizes the relevance of the sociological/cultural variables and more holistically integrates their study with the study of economic and agro-technical dimensions.

The recognition of these variables becomes particularly relevant, as Chambers and Shildyal (1985) have convincingly demonstrated, when agricultural research is geared towards fitting the needs and opportunities of resource-poor farm families.

It is hardly possible for us to summarize the entire anthropological/sociological body of relevant research that was left out despite the review's one hundred pages. The literature dealing with the type of sociological variables listed above is vast, and it is essential. Additionally, we shall merely point to several other specific areas where current anthropological/sociological work has proved, and shall prove itself further, useful for farming systems researchers.

The first lies at the level of method. Dealing with small-scale farmers poses difficulties that are of a different nature from those normally encountered by researchers more familiar with statistical aggregates or archival sources. Very often, for example, large scale formal sample surveys are either inappropriate or impossible. With a long tradition of fieldwork in small communities, anthropology and rural sociology have developed procedures of participant observation, informal survey, in depth case studies, use of key informants etc. which routinely combine direct and indirect research techniques to gather and interpret reliable field data.

Second, understanding how productive (including labor) resources are culturally organized and deployed is another traditional sociological/ anthropological domain currently of primary *technical* interest to farming systems research. It is not always clear exactly what comprises the family farm, how it changes over time, what are the goals of production, how the farm fits into larger social units such as the kin system, the village or region, and so on. The reason why a knowledge of these features is quintessential is not just to avoid "a few, not very costly mistakes"—although even this statement by Simmonds is deceptive and insensitive to the major human and economic costs of programs that failed because of their incompatibility with the cultural context. More than that, the whole point of farming systems research is to investigate what makes farming systems work, why small-scale farming systems differ in both potential and performance, what rationale governs their operations.

While a great many reasons for variation in farm productivity are due to strictly technical factors — differential soil fertility, irrigation techniques, and so on — other are social and cultural: e.g., the sex and age division of labor, patterns of informal cooperation, channels of information diffusion, authority systems and decision making rights, and the like.

These factors are important to understand not only the causes of variation in farm productivity. They are also essential to understand the consequences of development interventions. Briscoe, for example, has carefully documented the impact of the replacement of long-stemmed rice varieties by dwarf strains on energy costs in a Bangladesh village. Although Briscoe is not an anthropologist, he concludes that the most important variable for understanding why the change in cropping systems affected farm and farmers the way they did is local social structure — and that conventional economic methods of evaluating problems of this type in rural areas cannot adequately assess the dynamics of agricultural change in relation to energy use (1979: 636). In a similar vein, farming systems researchers are increasingly concerned about the impact of new technologies on disadvantaged groups — and how this knowledge can be used to set research priorities. Again, the anthropologists preoccupation with the economists' "externalities" — social class, ethnicity, politics, family, etc. — would seem to be of growing relevance to farming system research programs.

Third, sociology's and anthropology's well-known concern with social organization promises to be of growing use, especially in development strategies that seek to build upon local organizational arrangements. Again, knowing something about patterns of leadership, organizational flexibility, functional links with other organizations and so on are *technical* questions of interest to farming system researchers. The CIAT cassava program, for example, is currently using an anthropologist to analyze the possibilities for expanding cassava production in the north coast of Colombia, as well as to assess the ability of Colombia's organizational infrastructure to handle the increased demands projected for it by the development of new production and storage technology.

Anthropologists' normal familiarity with local culture should not be downplayed in the exclusive search for theoretical contributions to farming systems research. Knowing *why* people run farms the way they do is as important as knowing *what* their farm practices are. The qualitative side of farming systems research is all too frequently overlooked in the search for quantitative measures, yet that qualitative knowledge is critical to interpret the distributions produced through surveys and other similar quantifiable procedures.

Finally, related to the last point is that anthropology, like farming systems research, tries to look at "the native's point of view", not just as the only effective approach, but as part of an overall effort to produce as complete a picture as possible of how local systems work. There are two aspects to this theme. First, indigenous technical knowledge is an important resource too easily ignored. The fact that the Hanunoo in the Philippines recognize and use more than two thousand varieties of plants is of interest not only to ethnobotanists, but also to planners or economists trying to induce the Hanunoo to adopt mixed cropping farming. In the same vein the familiarity of the Balinese with complex, self-built decentralized irrigation systems, and the understanding of their structure, for which Clifford Geertz (1967) has offered such an extraordinary anthropological description and analysis, is proving crucial right now in recent small scale irrigation development projects in Indonesia and elsewhere. Second, and perhaps more importantly, is that knowing what local producers want and need is the *sine qua non* for designing programs that will be successfully adopted by small farmers.

Both methodologically and conceptually, anthropology and sociology are better equipped than other social or technical sciences for discovering and presenting this information, and they continue to refine their tools for such research. The sociological/anthropological study of peoples' organization, motivations, value systems, and behavioral patterns, should be regarded as a substantial and irreplaceable contribution needed by farming systems research. The task ahead is to explore and make full use of the potential available along these lines.

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ADDING A FOOD CONSUMPTION PERSPECTIVE TO FARMING SYSTEMS RESEARCH

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INTRODUCTION

This paper will suggest ways in which a food consumption perspective can be better integrated into each stage of the farming systems methodology. These suggestions are derived from a review of the literature focused on the topic (Tripp, 1982, 1983; Whelan, 1982; K. DeWalt, 1983; Smith, 1983, etc.) as well as the author's own experience with incorporating consumption concerns into farming system fieldwork. The paper will not attempt to outline a methodology for conducting separate, full-blown nutritional studies, but rather will focus on how food consumption concerns can be integrated into production oriented FSR procedures. Special emphasis will be given to the linkages between agricultural production and food consumption. Taking these linkages into account, this paper will address ways in which consumption consideration can and should be incorporated in target area selection, reconnaissance and formal diagnostic surveys, recommendation domain definition, on-farm research, evaluation, and extension. Recent FSR projects which have attempted to implement such procedures will also be identified.

Before proceeding with the discussion, it is important to emphasize why this paper focuses on a food consumption perspective rather than nutrition. The primary reason is that agricultural production is more directly linked to food consumption than to nutrition. A number of factors other than access to food may have an impact on the nutritional well-being of the farm family. For example, poor sanitation and/or exposure to disease could adversely impact nutritional status. Because of these confounding influences, FSR projects which bring about improvements in food consumption may not always improve nutrition. Thus, FSR projects should not be held accountable for nutritional consequences outside of their control. Since food consumption is more directly influenced by FSR production activities, it is more reasonable to expect FSR projects to take such considerations into account.

CAN CONSUMPTION CONCERNS BE INTEGRATED INTO FARMING SYSTEMS RESEARCH?

The FSR approach provides an excellent framework within which to integrate consumption concerns into agricultural development. As it is based upon the analysis of production possibilities (the technical element), FSR identifies the potential livestock and crop enterprises which are technically feasible in such an environment. Through its focus on exogenous factors, it identifies the social, economic, and political institutions outside the control of the household which place limits on livestock and crop enterprise potential (Gilbert, et al., 1980). Exogenous factors such as community structures, norms and beliefs, as well as the marketing systems can have limiting effects on consumption patterns. Finally, its concentration on endogenous factors allows for the identification of the available resources (land, labor, capital, and management) which are under the household's control. The relative scarcity of such resources can limit production/consumption alternatives.

If the aim of FSR is to increase the welfare of farm households as defined by the goals of the farmers themselves, then both consumption and production considerations must be taken into account. Promotion of production alternatives which maximize income will not always maximize the farm household's welfare. FSR practitioners should attempt to understand how each proposed production recommendation will affect household consumption. This would help to ensure that recommmendations optimize nutritional benefits and minimize adverse impacts, thereby enhancing the well-being of the entire farm family.

Greater understanding of the interrelationship of production and consumption decisions by households can begin by focusing on the linkages between them. Certain resource allocation decisions can influence food consumption levels and patterns, and vice versa. As Smith, et al., point out, "decisions concerning food consumption form part of a unified decision-making process which governs production decisions as to the extent to which households shall depend upon the market (either as a source of income or as a source of food) and decisions as to the use of household labor in farm, non-farm or off-farm production activities" (1979). Understanding these linkages is essential if we wish to predict whether proposed recommendations will be accepted or rejected by farm households and what will be their likely effect on household consumption.

The following discussion focuses on some of these linkages. Taking these linkages into account, cost-effective data collection procedures will then be proposed which can be implemented at each stage of the research process to better integrate consumption considerations in FSR activities.

PRODUCTION-CONSUMPTION LINKAGES

Although research in this area is fairly recent, a number of production-consumption linkages have already been identified in the literature. Some of the more important aspects of production which are closely linked to consumption include: 1) seasonality of production (seasonality of food availability, malnutrition, human energy expenditure, incidence of disease, and terms of trade for the poor); 2) crop mix and minor crops (subsistence vs. cash, non-food crops); 3) income (regularity, kind, and recipients); 4) role of women in production; 5) crop-labor requirements; and 6) market prices and their seasonality. Although many of these linkages are strongly interrelated, they will be addressed separately to highlight their importance. In this discussion, strategies will be proposed which might overcome some of the adverse effects of these linkages.

SEASONALITY OF PRODUCTION

Agricultural production has a seasonal dimension in most places in the world. This seasonality has significant implications for low-income farmers attempting to secure adequate food supplies throughout the year. Farmers attempt to implement strategies which ensure adequate food supplies by making the best use of wet and dry seasons (Longhurst, 1983). However, many farmers suffer every year through a period of deprivation just before harvest often referred to as the "hungry season" (Longhurst, 1983; AID, 1982). The hungry season has a number of adverse effects on the nutritional well-being of low income farming households. These include the following:

1) Food shortages tend to occur during the peak labor period of the farming cycle when energy expenditures are at their highest (field preparation and weeding operations) (Longhurst, 1983; Smith, 1983; Chambers, 1979).

2) Periods of stress have a negative impact on the nutritional status and growth pattern of children (Longhurst, 1983; Smith, 1983).

3) Adults may lose as much as 7% of their body weight during the hungry season (Longhurst, 1983).

4) A higher incidence of disease (i.e., diarrhea, malaria, guinea worm, etc.) coincides with food shortages immediately before harvest (Longhurst, 1983; Chambers, 1979).

5) During pre-harvest food shortages, food prices rise and short-term loans are obtained at high interest rates to purchase food. At harvest, the bulk of the crop is sold immediately after (when the prices are low) because they need to pay back loans. Thus, the terms of trade turn against the poor (Longhurst, 1983; Chambers, 1979).

6) To meet their daily consumption needs, some farmers may be forced to sell their labor to other farmers. This pattern reduces labor input into their own fields, thereby lowering production of food crops. This process leads to food shortages in the coming pre-harvest season.

These periods of deprivation every year serve to perpetuate the poverty of the poor year-round (Longhurst, 1983). These households lack the technology to cut back on energy expenditure, the money or time to receive medical treatment, and the food reserves to cushion them through periods of scarce food supplies (Longhurst, 1983). They are trapped in a cycle of poverty which often prevents them from meeting their daily consumption needs.

If FSR programs are to have a greater potential for a positive impact on the comsumption levels of low-income farm households, the seasonal dimensions of production, food availability and malnutrition must be taken into account. Ways must be sought which make food available when supplies are low. To do this effectively, FSR teams should first assess whether seasonality is a a problem in a particular recommendation domain. Second,, the FSR team should consider the dimension of the "hungry season" in any recommended change in the amount of labor needed to conduct field activities at planting and pre-planting time. Most farmers recognize the limitations the hungry season places on labor quantity and quality, and adjust farming practices accordingly (S. Poats 1984, personal communication).

Research should begin by focusing on the timing and extension of production as well as preservation and storage of food. Some possible strategies to overcome the detrimental effects of seasonality are presented in Table 1.

CROP MIX AND MINOR CROPS

According to studies conducted in traditional societies, farm households have food production systems which make use of a wide variety of staple and non-staple food. In addition to cultivating minor crops such as vegetables, minor grains, tuber, legumes, and fruits, they collected a wide range of wild plants including leafy greens, fruits, roots, and mushroom (Fleuret and Fleuret, 1980). These foods supplemented the diet with key nutrients year round and may have provided as much as 15-20% of the total energy intake (Longhurst, 1983). During pre-harvest periods when traditional staple foods were usually in short supply, these minor foods were an essential input into farmers' diets (Longhurst, 1983).

In addition to a tremendously diversified diet, traditional small farmers reduced levels of risk and smoothed out irregularities in food supply by following multi-plot and multi-crop production strategies (Fleuret and Fleuret, 1980; Brokensha and Riley, 1978; Neitchman, 1973). These risk-averse strategies were followed in order to ensure that subsistence needs were met.

Presently, although many societies still have diversified diets and follow similar production strategies as those previously described, very few societies are purely subsistence oriented. Virtually every society in the world today is integrated into regional, national, and international markets (DeWalt, 1983). This integration has affected consumption patterns and preferences (both food and material goods) as well as crop production decisions. Non-food cash crops are becoming widely grown as well as a number of non-indigenous food staples and vegetables which may be sold. Although the extent of the adoption of cash crops varies, a number of trends associated with their adoption have arisen which could have detrimental consumption effects. Some of the trends worth noting include the following:

1) Commercial production of cash crops can lead to a decline in crop diversity thereby limiting the range of possibilites for food production (Reutlinger, 1983). Supplementary non-staples may be deleted from crop inventory putting the household at greater risk during pre-harvest periods when staple foods are in short supply (Fleuret and Fleuret, 1980).

2) Non-food cash crop production can exaggerate seasonal cycles of plenty and want (Fleuret and Fleuret, 1980).

3) Production of cash crops involves more risk than production for home consumption (Wharton, 1971). The risks associated with the production of subsistence crops are entirely production risks, whereas, the risks associated with cash crops are production as well as market related (Reutlinger, 1983; DeWalt, 1983). This may explain why some farmers may limit the time and land they are willing to devote to cash crops despite project desires to the contrary (Pines, 1983).

4) Commercial crop production can eliminate nutritious wild plants through the use of herbicides to control weeds (DeWalt, 1983; Messer, 1972).

5) Increasing allocations of land for non-food cash crops may decrease the land available for food crops. This could result in shorter fallow periods for land grown in food crops thereby lowering production year after year (DeWalt, 1983; Stavrakis and Marshall, 1978). This process is currently occuring in the Sudan and Liberia.

6) Non-food cash crops are usually introduced to and grown by male farmers in households. Although females may also grow non-food cash crops, they are usually responsible for the cultivation of food crops, particularly in parts of Africa. Since technical assistance and inputs are generally oriented towards the male farmers growing non-food cash crops, women as producers are often ignored (Longhurst, 1983).

7) As farm families shift from subsistence production to commercial production, they may experience malnutrition or undernutrition during this transitional period (Fleuret and Fleuret, 1980; Smith, 1983). This outcome often arises when families inadequately adjust to the substitution of cash purchased food for home produced food.

8) Farmers who produce their own supplies of food, store food in bulk after harvest. Farmers who purchase food with money earned from non-food cash crop sales do not usually purchase food in bulk after harvest when food is at its lowest price. Rather, they tend to buy food throughout the year in small quantities even though prices drastically rise as the season progresses. Thus, the positive income effects of shifting from subsistence to cash crop production are reduced. This difference in food securing strategies between food producers and non-food producers has critical nutritional implications (Reutlinger, 1983; DeWalt, 1983).

9) If an entire community or region shifts from producing food to non-food cash crops, local food supplies will become more limited and increase in price (Reutlinger, 1983; AID, 1982). Thus, individual household changes in production can have a cumulative effect on food availability. This could result in the transformation of an area from being self-sufficient to being a food importing area (Reutlinger, 1983). If regional

or national markets are inefficient or unstable, this area could become nutritionally vulnerable.

10) The introduction of non-food cash crops into a community may lead to the breakdown of traditional food sharing networks (DeWalt, 1983; Pines, 1983). In addition, social stratification may increase as some individuals who control the new technology and surpluses attempt to gain at the expense of the smallest landholders (DeWalt, 1983).

11) Project appraisals reviewing proposed cash cropping interventions tend to overestimate the positive income effects of cash crops and underestimate the cost of potential declines in production of food for home consumption (Reutlinger, 1983). This leads to overestimation of the nutritional benefits which farmers are supposed to receive by adopting cash crops (Reutlinger, 1983).

Although these negative consumption effects can occur through the introduction of cash crops into traditional societies, this does not mean farm families in near subsistence economies should abandon cash cropping. Anthropologists and nutritionists have been too critical of cash crops without offering a suitable alternative for governments to earn badly needed foreign exchange (Longhurst, 1983). Aside from their high market return, the attractiveness of cash crops stems from the fact that they tend to be more responsive to inputs such as water and fertilizer than food crops (Reutlinger, 1983). In addition, the productivity of land and labor seem to be higher when allocated to the production of cash crops (Reutlinger, 1983).

Further, cash crops can be regarded as complementary to food crops (Longhurst, 1983). The income generated from such crops can supplement subsistence production with purchased foods if market supplies are sufficient and reliable. Cash crops may also allow the farmer to pay for inputs such as fertilizer which can increase the production to all crops in the rotation. Farm families also have need of cash itself for items they cannot "produce" for themselves, such as metal tools, medicine, and education.

Care must be taken to ensure that FSR programs designed to introduce cash crops have carefully assessed the impact such crops may have on food crop production and the availability of food (Longhurst, 1983). Specifically, the FSR team should assess the effect of cash crop promotion on the availability and prices of food in local markets. If the cash crop is food, then the same exercise is necessary to ensure that complementary food items will be available locally. Where feasible, the FSR team (or planners operating from a farming systems perspective) should provide suggestions as to how to encourage marketing of food crops locally from other regions. The recommended cash crop mix can be assessed on the basis of whether it limits food crop variety, and whether food versus non-food cash crops might be preferable. In this way, the risk of a negative impact on consumption can be minimized. At the same time, farmers should be encouraged to maintain the production of food crops for home consumption. Farmers who produce some or all of their own food avoid some of the risks associated with fluctuating and inefficient markets. Likewise, farmers should be encouraged by FSR projects to maintain diversified diets because of the positive nutritional benefit accruing from such diets. One factor inhibiting project promotion of minor crops is the reluctance of international donors to invest in such crops because of their low market return (Longhurst, 1983). The potential of these crops as exports is limited due to their perishability and low demand (Longhurst, 1983). Ways should be sought to overcome these biases. For instance, emphasis could be placed on the high positive consumption returns of these crops in benefit-cost ratios (Reutlinger, 1983).

The interrelationships between cash crops (food and non-food), food crops (both staple and minor crops) and consumption can be complex, and should be thoroughly investigated in FSR projects. Taking some of this complexity into account, Table 2 list several possible strategies which could be expected to result in positive consumption effects.

INCOME

Although the linkage between income and consumption is strongly related with crop mix (e.g. cash crops) and seasonality, there are several aspects about income which can be taken into account separately. Income can have an impact on consumption levels depending on how regularly it is received, what form it is in and who is the recipient in the household (AID/Africa Bureau, 1984). The possible effects which income can have on consumption include the following:

1) The regularity in the flow in income tends to be a more important determinant of nutritional status than the total amount (AID/Africa Bureau, 1984; Pines, 1983). Lump sum payments for cash crops often lead to inappropriate expenditures on non-food items which could endanger the household's nutritional well-being as the season progresses (Katona-Apte, 1983; AID, 1982). It is often difficult for households to adjust to spending money on food, and to save enough to carry them through the next harvest season (Katona-Apte, 1983).

2) The appearance of excess cash may (temporarily) drive up the price of food in a community or region (Fleuret and Fleuret, 1980).

3) When income is in the form of food rather than in equivalent amounts of non-food crops or wages, there is a greater likelihood that consumption will increase (AID/Africa Bureau, 1984). When cash income replaces food income, there is a greater chance that a larger portion of the household budget will be spent on non-food items (AID, 1982a).

4) When women are the recipients of income, more of the income is spent on food than when men are the recipients (Katona-Apte, 1983; Bender, 1967; Guyer, 1980; Kumar, 1971; Tinker, 1979; Tripp, 1982; AID, 1982a). Women are less likely to make

non-food purchases with earned income because of their household responsibilities for food cultivation, preparation, and childcare duties (Pines, 1983; Savane, 1981).

Persons planning and managing FSR programs should be aware of these income effects when developing research strategies. Many of the possible strategies proposed for the effects of seasonality and crop mix (Tables 1 and 2) are also applicable here. For instance, one way to decrease seasonal fluctuations in income would be to generate opportunities for off-farm employment (AID/Africa Bureau, 1984). Similarly, the form which the income stream takes can be influenced by the farm household if they invest in both food crops and cash crops. Finally, development projects which include women and crops primarily grown by women would be most likely to have a positive impact on consumption.

THE ROLE OF WOMEN IN PRODUCTION

The production activities of women play a significant role in the nutritional well-being of most farm households. As Longhurst points out, "in rural economies, women are the pivot between production and consumption" (1983). Some of the interrelationships between women's activities and consumption include the following:

1) Women are usually responsible for growing food crops in many parts of the world, especially Africa. In addition most of the income women receive is used for food purchases (Katona-Apte, 1983; Pines, 1983; Smith, 1983; Longhurst, 1983). It has been estimated that women's income is twice as important in determining the nutritional status of children as men's income (AID, 1982a).

2) It appears that children of working women are less likely to be malnourished than children of non-working women (AID, 1982a).

3) Cash crop interventions which increase the labor demands of women may result in a change in cooking habits (Fleuret and Fleuret, 1980). Quicker, less nutritious preparation techniques may be substituted for more nutritious traditional methods of preparation (Knuttson, 1972). In addition, women may resort to preparing only one meal a day (Katona-Apte, 1983). Foods that are prepared long in advance are at risk of becoming contaminated; children, anyone who is ill, the elderly and the undernourished are most likely affected by this food spoilage (Longhurst, 1983; Katona-Apte, 1983).

4) Increasing the agricultural labor demands of women through cash crop development programs may lead women to plant less labor intensive and less nutritious food crops as a substitute for more nutritious but more labor intensive food crops (Fleuret and Fleuret, 1980). For instance, cassava may be substituted for yams (Idusogie, 1969).

5) Cash crops which increase the agricultural labor demands of women may give women less time to devote to childcare and breast feeding (Katona-Apte, 1983; AID/Africa Bureau, 1984). This could have significant nutritional consequences because the quality of care and the food intake tend to go down when sibling or elderly members of the family are taking care of the children (AID, 1982).

6) Women are often neglected by agricultural extension services, while men are usually the beneficiaries of such services. This tendency could lead to a reduction of family food production, and increased male control over income (Pines, 1983; Boserup, 1971). This pattern was observed in Tanzania (Knuttson, 1979).

Understanding the patterns and extent of female participation in agriculture is essential for planning FSR programs if negative consumption effects are to be minimized. Such data could be collected during the diagnostic phase of FSR projects. Those individual research activities which have potential positive impacts on both the well-being and income earning capacity of women should be encouraged (Longhurst, 1983). Taking this into consideration, Table 3 lists some possible strategies.

CROP LABOR REQUIREMENTS

In addition to the adverse consumption effects associated with increased labor demands on women, other effects associated with new crop labor requirements are worth noting (Figure 1). These include the following:

1) The introduction of new cash crops may require more human energy input than previously grown crops (Fleuret and Fleuret, 1980). This increased energy requirement may be greater than the value of the output (Smith, 1983). Gross and Underwood (1971) found such a situation existing in Northeastern Brazil where sisal was being introduced as a cash crop.

2) The increased energy demands imposed on some members of the household through the introduction of new cash crops may have deleterious nutritional effects on intrahousehold food distribution patterns (Fleuret and Fleuret, 1980; USAID/Africa Bureau 1984). If male members of the household require more food to meet the labor demands of the new crop, less food may be available for women and children (Katona-Apte, 1983; Smith, 1983; Gross and Underwood, 1971).

Farming systems researchers should attempt to assess the labor impacts of new technologies which they are introducing. Such labor assessments can be done during on-farm testing so that researchers can determine the probable impacts on consumption should the household choose to adopt the technology under investigation. Careful consideration should be given to changes in intrahousehold food distribution patterns which may result from these strategies.

MARKET PRICES AND SEASONALITY

As stated earlier, limited resource farmers in most areas of the world are integrated into regional, national, and international markets. Thus, market prices of food crops as well as cash crops have an impact on the consumption patterns of small farm households. Price fluctuations due to world market buying trends, national market policies and seasonal variation can place the small farm family nutritionally-at-risk. Some possible effects which marketing trends can have on consumption include the following:

1) As stated earlier, retail food prices tend to peak before harvest and then drop immediately after harvest. These high retail prices coincide with farmer food shortages. To purchase food, loans are taken out. These loans must be paid back immediately after harvest when crop prices are at their lowest. Thus, the terms of trade do not favor the poor (Longhurst, 1983).

2) Urban populations can pay higher prices for scarce nutritional foods such as meat, thereby removing these foods from the diets of poor farmers (Fleuret and Fleuret, 1980). This marketing pattern was recently observed in Liberia (personal observation, July 1984). Wild meat which previously had been a major protein source for small farmers in a particular region was being sold in Monrovia for cash.

3) Food imports may adversely affect the prices of crops grown locally (Marchione, 1977). This trend was observed in Jamaica.

4) Food stocks can be hoarded by local big merchants and middle men to drive up prices (Longhurst, 1983).

5) Governments in most developing countries attempt to keep farmgate prices of export crops low in order to increase their foreign exchange earnings (Reutlinger, 1983). This has had the adverse effect of keeping the purchasing power of small farmers low when food prices are high (AID, 1982a).

6) Market inefficiencies and periodic market instability can place a region that is dependent on market purchased food in a vulnerable position. Unless distributive marketing networks and prices are stable, small farmers will be nutritionally-at-risk (Fleuret and Fleuret, 1980).

In most FSR activities, not enough attention is given to markets. A good understanding of the local markets will indicate whether a crop that is being introduced has the potential to be sold. Likewise, if new crop mixes are advocated which partially displace food crops with cash crops, the researchers should take into account whether marketed food will be consistently available to avoid adverse consumption effect. Thus, a good marketing study will be useful for prescribing appropriate crop promotion programs and should be a prerequisite to any proposed modifications to existing farming systems.

Although this paper has attempted to deal with a number of linkages between production and consumption, it has not addressed them all, nor has it addressed the many other factors which contribute to malnutrition. The primary purpose of the preceeding discussion was to demonstrate how complicated these linkages are and how important it is to be aware of them. An understanding of these interrelationships is essential if FSR is to produce new information which will enhance the well-being of small farmers. Farming systems researchers should be cognizant of the unexpected effects which newly introduced production alternatives could have on consumption. To obtain such an awareness, consumption concerns should be integrated into every phase of the FSR process. This does not mean that full-blown consumption studies should be conducted every time a farming systems project is implemented. Rather, cost-effective date collection techniques should be incorporated into existing data collection procedures. How this can be done is the topic of the next section of this report.

INCORPORATING A FOOD CONSUMPTION PERSPECTIVE INTO THE STAGES OF THE FARMING SYSTEMS RESEARCH PROCESS

To better integrate a food consumption perspective into FSR activities, cost-effective data collection procedures which focus on such considerations can be included in target area selection, diagnostic surveys, (reconnaissance surveys, ethnographic surveys, and formal surveys), recommendation domain definition, on-farm research, evaluation, and extension. The following discussion will address the kinds of data that can be collected at each stage, beginning with target area selection. This information is summarized in Table 4.

TARGET AREA SELECTION

The first step to take to ensure that FSR projects will have a positive impact on the well-being of participating farmers is to integrate consumption-related criteria into target area selection. By making sure that nutritionally-at-risk populations are included in the research target area, there is a greater chance that production increases brought about by the project will improve consumption levels (Mason, 1983). Although flexibility in the selection process is usually limited by program mandates and government policy directives, a balance can be struck between potential nutritional benefits and agricultural returns.

Since extensive consumption and/or nutrition surveys are unlikely to be included in an FSR project's implementation plan, existing data sources may be used to aid in area selection. Secondary data sources include government administrative and census documents as well as reports from previous studies conducted in the area (Mason, 1983). The types of data needed for each alternative area include: 1) information on ecological conditions (physical and biological); 2) information on agricultural characteristics (main crops grown, size of holdings, yields, etc.); and 3) indicators of nutritional conditions. Nutritional indicators might include: 1) clinic derived data (records of malnutrition, birthweights); 2) census derived data (mortality rates, quality of housing, water supplies, literacy rates); 3) school records (height and weight information for anthropometric measures); 4) household budget surveys; and 5) previously analyzed consumption surveys (Mason, 1983). In addition to these secondary data, the research team may want to visually examine potential areas to estimate the nutritional level of each area (D. Galt, 1984, personal communication). This simple approach could help cut down on the amount of secondary data which is needed as well as help verify the data which is used.

Although it is not necessary to have information on all these variables, several indicators should be used to ensure that a problem area is properly identified. The particular combination of indicators used will depend on the kinds and quality of data available, the time and resources allocated to identify and collect such data, and the specific objectives of the project. The type of data and method of analysis chosen should be compatible with that performed on other areas of concern.

Once these data have been assembled, they can be tabulated by area to determine which areas are nutritionally vulnerable but also have some agricultural potential. Although a very poor agricultural region may benefit from the introduction of new foods or "simple" system improvements, the government could probably not base most of its agricultural development on such regions agricultural potential. The target area finally chosen should balance nutritional considerations with those criteria specified by government policy directives and project mandate (if the latter is applicable).

Recently, some efforts have been made to integrate a consumption/nutrition perspective more systematically in target area selection for agricultural projects. Rafferty, et al. (1982), combined nutritional status indicators with agroeconomic information in classifying rural Kenyan population groups. In Papua New Guinea, Heywood, et al. (1983), have classified areas using a combination of variables including physical environment, food production systems, and nutrition. Using this classification scheme, development planners in New Guinea can more effectively orient agricultural development projects towards areas that are nutritionally-at-risk (Heywood, 1984, personal communication). Both of these efforts indicate that it is feasible to make targeting efforts more responsive to consumption concerns.

THE DIAGNOSTIC STAGE -- PROBLEM IDENTIFICATION

The diagnostic stage of FSR may consist of three substages, which include a reconnaissance survey, and ethnographic study and a formal diagnostic or verification survey. Some or all of these procedures will be implemented, depending upon the project's resources and the existing information . Each procedure will be discussed separately.

Reconnaissance Surveys. Reconnaissance surveys (rapid rural appraisal, sondeo, etc.) are quick, informal, cost-effective surveys that attempt to identify the key characteristics of the farming systems found within the target area. They represent an intermediate step between using existing data and conducting formal surveys (Mason, 1983). Reconnaissance surveys are usually implemented at the beginning of an FSR project to familiarize the research team with the key constraints facing farmers within an area. Thus, they provide descriptive information as well as identify opportunities for research (Tripp, 1983). The hypotheses generated from such studies may later be tested and refined in the formal diagnostic surveys, if required. Reconnaissance surveys also identify aspects of the existing system that are confusing or initially difficult to interpret without indepth inquiries. In addition, such surveys begin to identify the key variables that can be used to classify farmers into different recommendation domains. Again, these domains may be modified or refined after a formal diagnostic survey.

Reconnaissance surveys are usually conducted with the aid of a semi-structured guide or checklist of topics to direct interviewing and observation (Pacey, 1982). These surveys do no employ detailed or rigid questions like those used in more formal surveys. Consumption patterns can be investigated with such a checklist. General topics of inquiry which could be added to the list might include:

1) household food supply -- Interviews should attempt to identify what are the potential food resources or pathways through which food enters the household (DeWalt, 1983), for example, home produced foods, purchased foods, shared foods, donated foods, etc. This information will give some idea of what types of crops to focus on at the design stage (i.e., food crops or cash crops or both).

2) types of foods and preparation techniques -- What are the various types of foods eaten (both traditional and newly introduced) and how are they commonly prepared (Tripp, 1982)? This information will give some indication of diet diversity and whether preparation techniques are nutritionally appropriate. Preliminary information on food preparation will also give some notion of the qualities households look for in crops regarding ease and type of preparation. In addition, information collected on preparation techniques can indicate the fuel requirements of certain foods. The interaction between food preparation and fuel requirements is an important factor to consider in any proposed food crop interventions.

3) food preferences -- Determining what types of foods are preferred and their distinguishing features will aid researchers in devising acceptable cropping programs.

4) seasonality --Preliminary investigations regarding seasonal or periodic fluctuations in food consumption can begin with these informal surveys. Questions concerning previous seasonal shortages of marketed food and fluctuations in food prices can also be asked (Mason, 1983). Such information can generate hypotheses that can be followed up in formal, in depth surveys. These data can then be compared to historic records

of price fluctuations and previous studies of seasonal changes in food consumption to gain a better picture of household vulnerability to food shortages.

5) meal times and number of meals -- Inquiries regarding the number of meals consumed in a day can give some indication of inadequate caloric intake (Tripp, 1984). This information may also indicate whether the agricultural labor demands placed on women are limiting the number of meals which are prepared (seasonal differences in the number of meals prepared should be taken into account).

6) food habits -- Preliminary information could be gathered on eating patterns, intrahousehold food distribution, food taboos, specialty foods, etc.

The qualitative data gathered in the reconnaissance survey combined with other secondary data sources can give FSR researchers a general overview of household consumption patterns in a given area (Tripp, 1982). Such surveys can indicate what are the potential consumption problems associated with the existing farming systems (Mason, 1983).

Recently, the role of the reconnaissance survey has increased in importance relative to the formal survey (Franzel, 1984). This is primarily due to their cost effectiveness and rapid turnaround of results (Franzel, 1984). However, such surveys tend to be insufficiently focused to determine the relative importance of factors which are contributing to adverse consumption patterns (Mason, 1983). Therefore, other diagnostic procedures may be required to verify and fine tune the hypothesis generated by reconnaissance surveys. Ethnographic surveys are one of these procedures.

Ethnographic Surveys. Although ethnographic surveys are not always included in FSR diagnostic analyses, they can provide a considerable amount of useful information and insights. Given that the agronomic research system may not be able to carry out an ethnographic survey, efforts should be made by the FSR team or experiment station to obtain such a survey from another national institution with interest in social data. If information collected during the reconnaissance survey is confusing or very complicated, an ethnographic survey can be the focus for a more indepth study. In this way, hypotheses generated from the initial survey are fine tuned. Ethnographic research can also help in the design of specifically focused formal surveys by determining the key consumption variables that should be pursued in interview schedules. In addition, they provide some understanding of the social, cultural, and political aspects of poverty and poor consumption patterns (Mason, 1983). Ethnographic surveys allow more prolonged contact with a culture, providing more detailed information, and facilitating exploratory questions. Finally, such surveys give some indication of potential household consumption responses to proposed changes brought about by project activities (Mason, 1983).

Consumption issues which can be pursued by ethnographic research may include more detailed information on: 1) food availability, preparation, and distribution; 2) commonly used wild foods; 3) demonstrated cooking techniques; 4) ways food is categorized and classified; 5) place of food in celebration and ritual; 6) food beliefs; 7) market sales and purchases; and 8) seasonal and longterm changes in food consumption patterns (DeWalt, 1983a; Tripp, 1983). In addition, dietary surveys such as 24-hour recalls can be conducted during this research phase. (This will be discussed later).

Some FSR practitioners feel that extensive ethnographic surveys are too costly and not time effective enough to be conducted prior to initiating on-farm research activities (Tripp, 1983). They advocate that such studies should be implemented concommitantly with on-farm trials so detailed data generated from such studies can feed directly into the results. Others have found it useful to initiate ethnographic studies in the interim between reconnaissance surveys and formal diagnostic surveys and to continue these efforts as on-farm trials are being conducted (Reeves and Frankenberger, 1982). If formal diagnostic surveys are implemented, ethnographic data can feed directly into the design of interview schedules. The kind of information generated by ethnographic research can make interview schedules more concise. In addition, continuing the ethnographic research while on-farm trials are being conducted can help monitor farmer reactions to experiments and provide continual feedback between farmers and researchers.

Although differences may exist among FSR projects regarding the timing and use of such surveys, the kinds of food consumption data generated from ethnographic studies are extremely valuable. Thus, the implementation of such surveys could be beneficial to a consumption perspective for FSR activities.

<u>Formal Diagnostic Surveys</u>. Formal diagnostic surveys (verification surveys) are structured interviews which are administered to a statistically valid sample of farm households in the target area to get at variations in access to resources (both technical and human), farming practices and possibly food consumption patterns. They help verify and refine hypotheses generated by reconnaissance surveys and ethnographic research with a minimum amount of hard data. The baseline data generated from such surveys can serve three purposes. First, they provide a further basis for dividing farmers into homogeneous groups called recommendation domains. Second, these data delineate the major constraints in the existing farming (and nutrition) system and identify opportunities for research. Third, these data provide a basis for future evaluation of the effects of programs on production and consumption.

Two kinds of consumption data should be integrated into formal surveys. First, a series of food related questions should be added to the list of questions focusing on the demographic, agricultural, and economic characteristics of households. Such questions could include inquiries into: 1) varietal preferences; 2) common preparation techniques; 3) marketing habits; and 4) household food supply (e.g., seasonality of diet, use of secondary crops) (Tripp, 1982). These questions should be designed on the basis of previous informal surveys and ethnographic analyses (if conducted) to ensure their appropriateness

(Tripp, 1982).

The second set of consumption data which should be included in such surveys are referred to as consumption status indicators. These data give some indication of the nutritional conditions under which each household must adapt. The types of data which might be useful as status indicators and how these can be combined with economic variables to delineate recommendation domains are discussed below.

RECOMMENDATION DOMAINS

As stated earlier, the FSR team attempts to disaggregate farm households into homogeneous subgroups called recommendation domains. This is done in order to devise appropriate technologies that would be applicable to groups of farms with similar circumstances (Tripp, 1983). Although ecological and economic criteria are normally used in FSR projects for devising such domains, it is also possible to include consumption considerations in such criteria. By incorporating consumption status indicators into the classification systems, it is more likely that nutritionally-at-risk households will be targeted, and major nutrition problems addressed.

A number of variables or sets of variables could be used as indicators of consumption status. Data collection procedures for these variables should be cost-effective and relatively easy to implement if FSR teams are expected to incorporate them into their diagnostic surveys. The following discussion focuses on three such variables beginning with the simplest measures to implement.

One type of consumption status indicator which would be easy to measure would involve identifying one or more critical factors which have a limiting effect on consumption (Smith, 1983). For instance, the amount of food stored in the household just prior to harvest (i.e., hungry season) might be a good indicator of nutritional risk (Smith, 1983). Similarly, the income or liquid assets such as animals which are available to the household prior to harvest may also be a good indicator (Smith, 1983). Viewed together, these indicators are a cost-effective means of classifying households.

A second measure of consumption status is based on a measure of resources available to the farm household for obtaining food from the farm directly (food crops produced) or indirectly (cash crops sold to purchase food) (Whelan, 1982). The simplest indicator of resources available to the family is land area per household member. This could be calculated very easily from existing FSR "production-type" data and would give some general idea of the relative resource limitations of households as expressed on a per person basis. This indicator, however, lacks an indication of the productivity of the land, as well as, differences in age-sex composition of households which effect the food consumption requirements of these households. One indicator of food consumption resources which attempts to incorporate these factors is referred to as the subsistence potential ration (SPR) (Whelan, 1982). "In its simplest sense, the SPR is simply the ration of the household's ability to feed itself to its need to feed itself" (Whelan, 1982). The ratio compares the amount of food (calculated in energy or protein value) which a household can produce over a year with the energy or protein requirements of the entire household for the year.

The SPR is intended to estimate household resources while avoiding the problems of gathering income data. The data needed for calculating this ratio are size of farm, expected yield, and age and sex composition of the household. Expected yield is defined as the yield of the area's staple food which is possible on the farm's type of land. Alternatively, the SPR can be defined as including purchases and production of food instead of capturing just farm land resources, if the FSR team has the necessary data gathering capabilities. This definition is preferable if the SPR is to be used as an evaluation criteria.

The positive attributes of this measure, in addition to its being easy to calculate from production data readily available on FSR projects, is that it is a proxy for income (which is one determinant of consumption and nutrition status), and it emphasizes the relationship between production and consumption. Another possible advantage is it may correlate with the primary food source of the household (Whelan, 1982). This may be important insofar as knowledge of the source (along with the amount) of food can indicate those households which may be at risk nutritionally under different circumstances. For example, households that rely heavily on the market face different food-related risks than households which rely heavily on home produced food. This knowledge can be used to help better design food strategies which minimize rather than increase the degree of related risk.

An assumption inherent in the SPR is that the household would potentially use all its farmland for food if necessary. Also, the SPR should be used in conjunction with one of the measures discussed above, in order to take account of the seasonal effects of production on consumption.

A third type of consumption status indicator involves collecting simplified dietary information. Inquiries are made regarding the frequency of key foods consumed by children in the 0-30 month age group as well as household members within a 24-hour period (Villere, 1981). These interviews employ a list of locally consumed foods which has been developed on the bias of secondary data, field observation, and pre-testing (Villere, 1981). Seasonal differences in food consumption are taken into account in these dietary surveys. From these interviews, a food variety index can be constructed for each household. Although the information generated is non-quantitative and cannot be translated into quantitative nutrient terms, it can provide insights into household consumption patterns, especially for small children. Villere (1981) has identified some aspects of the diet which may indicate a household's nutritional vulnerability. These include (Villere, 1981):

1) "A monotonous diet consisting of one or two key foods is at risk of being deficient in calories and nutrients".

2) "A diet low in fat is at risk of being calorically deficient."

3) "If consumption of fruits and vegetables is seasonal, vitamins A and C are likely to be low at certain times of the year".

4) "Because milk is deficient in iron, a diet of milk only for a child beyond four to six months of age is likely to result in anemia."

In addition to obtaining information on the frequency of key foods consumed, this measure can shed light on breast feeding patterns and the use of food supplements and weaning foods (Villere, 1981).

This measure of consumption status is somewhat more complicated than the first two measures, and may require the input of a nutritionist. If the resources are available to provide such a person, the indicator could be effectively used to classify households.

Taken individually, each of the indicators previously discussed may not be precise in discriminating difference in consumption status among households. Taken together, the chances of identifying nutritionally-at-risk households is greater. For this reason, more than one indicator should be used.

In addition to the data gathered by the FSR team on one or more of the consumption status indicators previously described, opportunities for obtaining complementary nutritional data from other sources should be explored. For instance, FSR projects could collaborate with regional ministry of health projects so additional information on nutritional conditions could be gathered in the FSR project area by the health project staff. Such health projects often use anthropometric measures (i.e., weight for age, weight for height, and height for age) for assessing the nutritional status of local populations (Mason, 1983). These measurements might be used in conjunction with the other consumption status indicators for nutritional targeting.

FSR team members should be aware of the problems associated with such measures when considering their use for targeting. Some of the problems include (Sahn, 1984):

1) "Weight for age, which is a composite of stunting and wasting, may be low due to deficits incurred years previously and not to present status. Children may be misclassified as malnourished even if their status has improved."

2) "Weight for height measures are not sensitive to improvements in mildly or modestly malnourished populations."

3) "Little is known about the dose response of increased caloric intake, and how this will be manifested in terms of improvements in growth indicators."

4) There is no universal agreement as to what cut-off points and statistical techniques should be used in determining levels of undernourishment or malnourishment. Thus, comparisons between impact studies are spurious.

Despite these limitations, the additional information obtained from anthropometric measurements may still help farming systems researchers identify nutritionally-at-risk households. If these data are collected by health professionals operating in the area and are available, they should be combined with other indicators of consumption status to classify households. However, if health programs are not collecting anthropometric data in the target area, the FSR team should not be expected to collect these measurements themselves. The FSR field staff usually lacks the time, resources and training to collect such measurements.

After data have been collected on a number of consumption status indicators and have been derived from other sources of nutritional information, they should be compared across households which have been previously grouped into categories on the basis of specific ecological or economic criteria. Such criteria might include income, landholding, animal or crop production, socioeconomic status or household composition (Smith, 1983). Which variables are used for classifying households will be determined by the particular area in which the research is being conducted and the objectives of the study. Recommendation domains derived in this way could ensure that nutritionally-at-risk households can be identified and targeted.

ON-FARM RESEARCH

On-farm research involves the actual design and testing of agricultural technology on farmers' fields. On-farm trials and recommendations should follow from the assessment of farmers current practices and constraints (i.e., knowledge of existing farming system and consumption needs) as well as how such modifications may impact consumption patterns (i.e., knowledge of production/consumption linkages). Other important factors to take into account in the development of recommendations include the following:

1) In assessing a proposed recommendation's potential impact on consumption, attempts should be made to look at a number of farm households who have already adopted the change to get some notion of what the effect might be (Mason, 1983).

2) When a new crop variety is introduced that is higher yielding than the variety it is replacing, researchers should make sure variability in yield is not also increased (Mason, 1983). Some varieties are less drought resistant than traditional varieties.

3) Initially, recommendations should be oriented towards those crops that are most important to the household's diet and livelihood (Tripp, 1983). Such efforts also should take into consideration the effects these recommendations might have on minor crops (diet diversity and labor allocation).

4) The importance of wild herbs to the diet should be considered in any herbicide trials (Tripp, 1983).

In addition to testing alternative technologies and/or practices on farmer's fields, on-farm research allows researchers an opportunity to collect more specific kinds of information on consumption patterns. If ethnographic research was not conducted previously, many of the indepth inquiries applicable to that research activity can be carried out during this phase. For instance, inquiries might be focused on food tastes and preferences, preparation techniques, food beliefs, market sales and purchase, and seasonal fluctuations in food supply (Tripp, 1982). On-farm research also gives researchers a chance to investigate food storage practices of farm households (Whelan, 1982). Periodic inventories will give some indication of food availability and losses due to rodents and insects (Whelan, 1982).

Another kind of useful consumption data to collect during on-farm research is dietary information. Qualitative 24-hour dietary recall surveys are the easiest method to employ for this purpose (Tripp, 1982; DeWalt, 1983). Such a technique can provide information on the frequency and manner or use of crops, how each food is prepared, the variety of each crop being used and source of each food (Tripp, 1982). These recall interviews will also give some idea of the number of meals consumed in a day and the number of items in each meal (Tripp, 1982). The information also can give some indication of whether the household is consuming adequate amounts of calories and protein, and whether there are any vitamin or mineral deficiencies (Tripp, 1982). The major disadvantages of such recall methods are: 1) they tend to underreport foods that are not eaten in the home such as snacks, fruits and beverages; and 2) the intrinsic variation in day-to-day household and individual consumption patterns may not be accurately represented in these interviews (Tripp, 1982; Mason, 1983). To compensate for this shortcoming, recall interviews should be repeated several times for different seasons to get at seasonal variations in consumption (Tripp, 1982). In addition, recall data can be improved when the researcher is familiar with the community (DeWalt, 1983).

As with other FSR procedures, the primary purpose of data collection during on-farm research is to obtain practical information on production and consumption to feedback to researchers. During such investigations it is important to elicit farmers' opinions about the qualities of new varieties, not only from an agronomic viewpoint, but from a marketing, storage, and cooking standpoint as well (Tripp, 1982). Thus, the acceptability of a new variety should be assessed one year after on-farm experiments have been initiated to make sure families base judgements both on taste and performance (Tripp, 1982).

EVALUATION AND EXTENSION

After on-farm trials have been carried out for a particular recommendation domain of farmers, the effects of the trials should be evaluated. This evaluation should encompass both production and consumption outcomes. To accomplish this task, evaluation criteria must be established at the beginning of the FSR project to ensure that meaningful evaluation and extension can take place. Although this paper has emphasized how nutritional considerations can be handled explicitly at the beginning of the FSR project, some of the indicators previously discussed can be used in an evaluation setting as well (Table 4). The important point in doing this would be to identify whether the technology introduced has resulted in a material improvement in the quality and quantity of food consumed by all those affected by the technology. This can be done by comparing consumption-related measurements collected prior to the project with measurements collected both during and after the project. To strengthen such comparisons, any alternative explanations or confounding influences which could account for existing production/consumption outcomes must be taken into account (Mason, 1983). If such confounding influences can be controlled for, then the actual project impact on production and consumption can be assessed.

The value of such evaluations are two-fold. First, they help determine whether the present FSR activities should be implemented in future FSR undertakings (Whelan, 1982). Second, they provide extension personnel with some way of assessing whether such intervention strategies will have a positive impact on farmers in similar recommendation domains in other areas. Before such interventions are extended, however, diagnostic surveys should be conducted to ensure that the potential household participants do fall into similar domains. Following such a procedure, it may be possible to avoid unanticipated adverse consumption effects.

RECENT FARMING SYSTEMS APPROACHES THAT HAVE ATTEMPTED TO INTEGRATE CONSUMPTION CONCERNS IN THEIR RESEARCH ACTIVITIES

To date, very few FSR projects have integrated food consumption concerns systematically into their research approach. Taking this into account, five projects have been identified which have made various attempts to address such concerns. These projects have been implemented in Imbabura, Ecuador (two projects); Southern Honduras; North Kordofan, Sudan; and Southwest Virginia. The following discussion briefly summarizes how consumption concerns have been integrated into each of these FSR projects.

One example of an FSR project which has collected some food consumption information while conducting on-farm research is the Production Research Program in Imbabura Province, Ecuador (Tripp, 1982). Established in 1977 by the National Agricultural Research Institute (INIAP) with assistance from the CIMMYT Economics Program, the project assigned technicians to carry out on-farm research on maize and associated climbing beans (Tripp, 1982). The work began with a farmer survey which assessed maize practices and identified priorities for maize research. After this survey, on-farm trials were initiated on a number of farmers' fields. This trial work on lines of maize and beans focused on alternative maturity-lengths, fertilizer levels, and insect and weed control technologies (Tripp, 1982). Work was also initiated on simple methods of maize storage (Tripp, 1982).

Aside from these activities, other kinds of food consumption data were collected. These included: 1) in 1980, a number of 24-hour dietary recall surveys were conducted in three communities in the research area;

2) in 1981, a few questions on diet were incorporated into a formal survey carried out in 9 communities in the area; 3) information on food utilization was derived informally from farm families participating in on-farm trials; and 4) secondary data were reviewed which included quantitative dietary surveys from the research area (Tripp, 1982).

The information collected on food consumption was used in assessing the introduction of new maize varieties. For instance, harder endosperm materials were found to be unacceptable given the local preparation techniques (Tripp, 1982). One quick-maturing variety was identified (INIAP 101) which farmers found acceptable; both from an agronomic viewpoint as well as ease of preparation (Tripp, 1982). This variety is being considered for wider dissemination. In addition, breeders have begun including shelling characteristics in their selection procedures for further improving maize varieties (Tripp, 1982).

Another FSR project also focusing on Imbabura Province, Ecuador is presently being implemented by Cornell. Initiated in 1982, this project has been sponsored by the Bean/Cowpea Collaborative Research Support Program (CRSP), which is funded by AID/Washington. The major objective of this research is to assess the biological, environmental, economic, and social roles of bean production in the target area, in order to identify and introduce improved bean production practices (Bean/Cowpea CRSP Annual Report, 1983). Collaborative links have been established with the National Agricultural Research Institute (INIAP), and joint FSR activities have been conducted in 4 zones in Imbabura Province (Bean/Cowpea CRSP Annual Report, 1983). Interview schedules have been designed and implemented and microcomputer techniques for analyzing this information have been developed. On-farm trials were initiated on small farmer fields in 1984 at different altitudes.

Recently, Cornell has employed a nutritionist to help design a number of data collection procedures so that nutritional information can be better integrated into on-going FSR activities. Some of these data collection procedures may be implemented in upcoming FSR efforts.

A third example of an FSR project which has incorporated food consumption concerns into its research activities is a study conducted by the University of Kentucky in Southern Honduras. This study began in 1981, and was sponsored by the International Sorghum and Millet Project (INTSORMIL): another CRSP funded by AID/Washington. Host-country collaboration was established with the Ministry of Public Health, the National Planning Commission and the Ministry of Natural Resources (INTSORMIL, 1985). The major objective of this research was to do a baseline study of the production, marketing, and nutritional systems found in an area of Honduras in which sorghum is an important crop (DeWalt and DeWalt, 1982). A number of informal and formal surveys were conducted in 7 communities, focusing on aspects of production as well as consumption. On-farm sorghum trials were also initiated.

The major objectives of this dietary and nutritional research in the FSR project were threefold (DeWalt, 1983). First, information was gathered on the uses and methods of preparation of basic food stuffs (especially sorghum) so new varieties of seed which are developed may have the characteristics which are acceptable to farm families (DeWalt, 1983). Second, assessments were made of the impact of existing farming systems on the diets and nutritional status of farming communities (INTSORMIL, 1985). This information could help predict the probable impact of agricultural technologies on household diets and nutritional status (DeWalt, 1983). Third, baseline data were collected on both diet and nutritional status to provide a basis of evaluation for future recommendations (DeWalt, 1983).

To meet these objectives, food consumption and nutrition data were collected using several procedures. Ethnographic research techniques were employed to obtain information on household consumption patterns (DeWalt, 1983). Formal surveys were used to collect data on food resources, diet and health related practices and beliefs (DeWalt, 1983). Dietary data were obtained through the use of 24-hour recall surveys and "market basket" interviews (DeWalt, 1983). In addition, anthropometric measures of children under 6 years of age were collected to get an independent evaluation of nutritional status (DeWalt, 1983).

A fourth FSR project which has integrated consumption concerns into its data collection procedures was also implemented by the University of Kentucky. This project focused on limited resource farmers in a semi-arid region of North Kordofan, Sudan. Support was also provided by INTSORMIL. Initiated in 1981, the major objective of this research was to identify socioeconomic constraints to the production, marketing, and utilization of millet, sorghum, and cash crops in this region (Reeves and Frankenberger, 1981; 1982). The research was also designed to provide a data baseline to the Kordofan Regional Ministry of Agriculture, the Western Sudan Agricultural Research Project (co-sponsored by the World Bank, USAID, and the Sudan Government), and USAID Khartoum (Reeves and Frankenberger, 1981).

The study was carried out in 15 villages within 50 km of El Obeid. Information was collected on household production, marketing, off-farm employment, and consumption. Both informal and formal survey techniques were used. The diagnostic study concluded with a formal survey of 205 farmers and 58 local merchants. On-farm research focusing on new varieties of millet and sorghum was initiated following the completion of this survey.

Various types of food consumption data were collected in this study. For instance, information was gathered on the types of food eaten and how these are normally prepared (Reeves and Frankenberger, 1982). Inquiries also focused on general consumption patterns of the households (i.e., number and timing of meals, intrahousehold food distribution, etc.), seasonal differences in consumption, and specialty foods (Reeves and Frankenberger, 1982). Although most of this information was collected informally, formal interview focusing on food consumption were also conducted among the women of 20 farm families.

A fifth example of an FSR project which has considered food consumption in its research activities is a domestic U.S. project which was conducted by Virginia Polytechnic Institute (VPI). The project was initiated in 1981, and was supported by a USDA/OICD grant entitled

"Extension and Family Economics in Farming Systems Programs" (Caldwell and Rojas, 1983). The research was conducted in a county in southwest Virginia. Three objectives of this research were: 1) to develop an interdisciplinary team at the paraprofessional level; 2) to incorporate a farming systems methodology into the extension program; and 3) to include the family system in the farming system (Caldwell and Rojas, 1983).

Initially, informal reconnaissance surveys were conducted in the area. These were followed by indepth time allocation surveys and dietary recall surveys in 1982. Based on these surveys, broccoli was introduced as a new crop to substitute for tobacco as a cash crop and to add needed nutrients to the diet. On-farm trials were initiated as well as in-home broccoli freezing and preparation trials. This effort led to a wider dissemination of broccoli in the area. Subsequently, a cooperative took on the role of marketing this crop in the region.

CONCLUSION

This paper has set out to accomplish three primary objectives. First, it has emphasized the importance of consumption considerations in the goal sets of small farmers. Development efforts which ignore such goals are likely to fail because the technology packages will be rejected. Thus, these efforts are not likely to enhance the level of well-being of project participants. Second, the paper has identified a number of production and consumption linkages which FSR teams must be aware of if they are to properly evaluate alternatives. To ensure extension packages maximize consumption benefits and minimize adverse consumption impacts, greater understanding of the consumption effects of seasonality, crop mix and minor crops, income, the role of women in production, crop labor requirements and market prices is essential. Third, this paper provides suggestions for ways a consumption perspective can be integrated into each stage of the FSR process. Through the incorporation of this perspective in target area selection, nutritionally-at-risk regions and families are more likely to be included in research priorities and in project activities. By including a consumption perspective in diagnostic baseline studies, existing consumption patterns can be better understood. Such information is valuable in the definition of recommendation domains which aid in selection of appropriate research priorities and the selection of best-bet technologies for on-farm testing. Finally, evaluating proposed technologies using both production and consumption criteria should provide extension personnel with a better idea of the potential consumption impacts of alternative programs.

Given FSR's integrated approach to technological change, a consumption perspective can be effectively included. For this reason, consumption consideration should receive more attention in future FSR endeavors.

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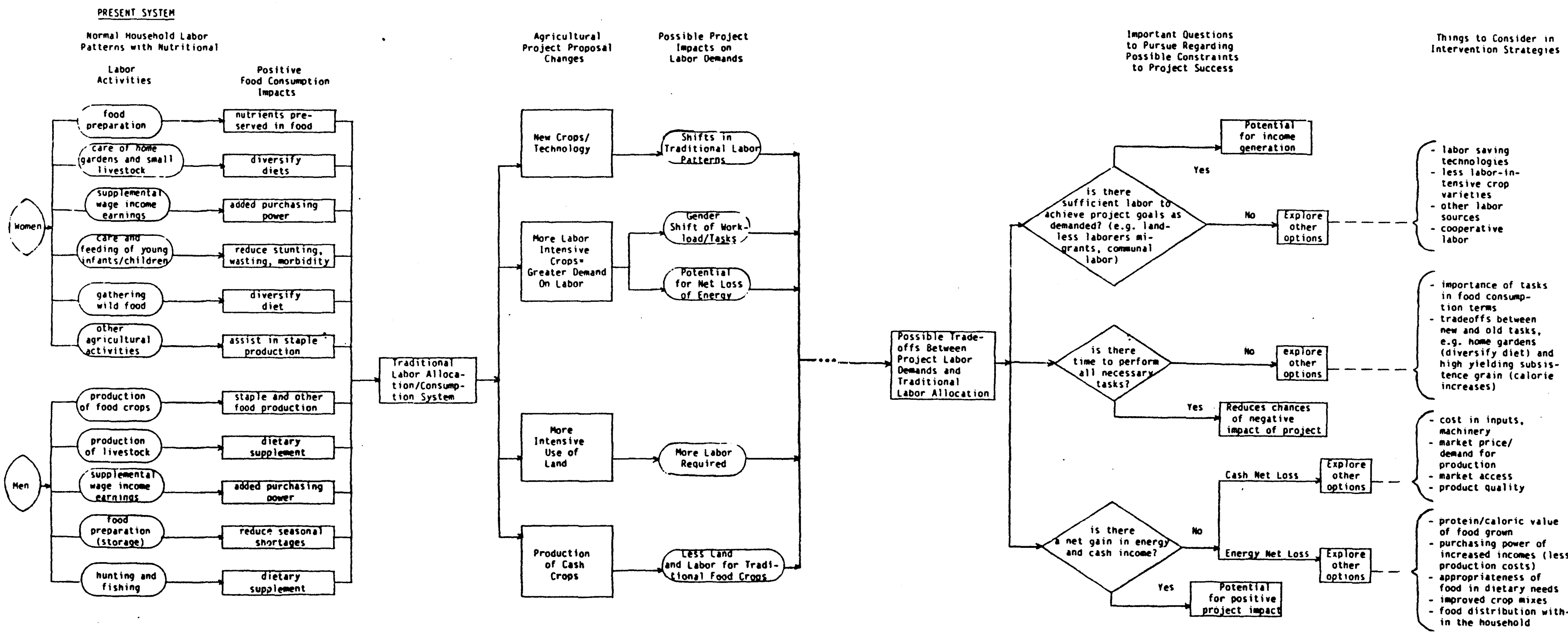

Figure 1. Labor/Consumption Linkages.

Author: Jeffrey H. Merriam (1985)

TABLE 1

Possible Strategies *for Addressing Seasonal Food Shortages and Their Effects on Consumption

Goal	Suggested Strategy	Procedure	Personnel
To fill the gap of pre-harvest food shortages	Research could be conducted on short maturing varieties of food crops	1. Determine the important attributes of existing varieties	FSR Team
		2. Develop or identify new varieties with similar desired attributes	Experiment station researchers
		3. Varieties should be tested through on-farm research	FSR team
		4. Disseminate successful varieties	Extension agents
To extend production	Better water management and irrigation techniques could be implemented where feasible	1. Assess existing techniques, constraints and feasibility	FSR team
		2. Develop improved water management and irrigation techniques	Experiment station researchers
		3. Test new techniques on farmers' fields	FSR team
		4. Disseminate successful techniques	Extension agents
To provide a buffering device for lean periods	Investment in small livestock could be encouraged	1. Assess existing husbandry patterns, constraints and feasibility	FSR team
		2. Identify appropriate livestock for farming system	Experiment station researchers
		3. Introduce livestock in on-farm experiments	FSR team
		4. Encourage the adoption of such husbandry practices if proven successful	Extension agents
To determine the best planting strategies which create complementarities in growth and canopy cover	Research could focus on farmer practices of intercropping and serial cropping	1. Assess existing cropping practices, constraints, and feasibility	FSR team
		2. Develop or identify improved intercropping and/or serial cropping	Experiment station researchers
		3. Test new planting strategies on farmers' fields	FSR team
		4. Disseminate successful planting strategies	Extension agents

TABLE 1 (continued)

Goal	Suggested Strategy	Procedure	Personnel
To reduce storage loss and extend existing stocks	Cost-effective storage and preservation techniques could be devised and utilized for food staples	1. Assess existing techniques, constraints and feasibility	FSR team
		2. Develop or identify improved storage and preservation techniques	Experiment station researchers (food technologists)
		3. Test new techniques in on-farm trials	FSR team
		4. Encourage the adoption of successful practices	Extension agents
To avoid seasonally high food prices	Price regulating measures could be implemented	1. Government market interventions may be necessary along with policy changes	Ministry level officials (FSP)
	Community grain banks could be set up as a food security measure	1. Assess the constraints and feasibility of establishing a community grain store	FSR team (maybe ethnographic research)
		2. Test the concept in receptive villages	FSR team with extension agents
		3. Encourage the establishment of such grain banks if tests prove successful	Extension agents

* These are derived from Longhurst, (1983:3) and AID (1982a:3).

TABLE 2

Possible Strategies* for Taking into Account the Relationship Between Crop Mix, Minor Crops and Consumption

Goal	Suggested Strategy	Procedure	Personnel
To maintain adequate food consumption levels to guard against nutritional stress	Research could focus on both cash crops and food crops	1. Assess existing cropping patterns for both food crops and cash crops (non-food)	FSR team
		2. In proposed crop interventions assess risks for alternative crop mixes rather than crop by crop.+	Experiment station researchers
		3. Test proposed crop mixes on farmers' fields	FSR team
		4. Disseminate successful planting strategies	Extension agents
	Projects could make careful attempts not to reduce crop diversity if adequate substitutes are not available in the market	1. Determine the existing diversity of crops grown	FSR team
		2. Review availability (amounts and types) of food in market	FSR team
		3. Assess the impact of proposed interventions on diversity (i.e., herbicides, monocropping, strategies, etc.)	Experiment station researchers
		4. Test those interventions which have a minimal impact on diversity on farmers' fields	FSR team
		5. Disseminate successful interventions	Extension agents
	Research could focus on minor food crops grown by women	1. Identify minor food crops presently grown by women; assess their constraints and potential	FSR team
		2. Develop or identify ways of improving minor food crop production (e.g., improved varieties, new planting strategies, inputs, etc.)	Experiment station researchers
		3. Test minor food crop interventions on farmers' fields	FSR team
		4. Disseminate successful technology and/or practices	Extension agents

TABLE 2 (continued)

Goal	Suggested Strategy	Procedure	Personnel
	Emphasis could be placed on expanding output and consumption of indigenous vegetables before bringing in new vegetables and fruits	(same as minor crops)	(same as minor crops)
To reduce storage loss and extend existing stocks	Processing and preservation techniques could be introduced for minor crops	1. Assess existing techniques, constraints and feasibility	FSR team
		2. Develop or identify improved methods of processing and preservation	Experiment station researchers(food technologists)
		3. Test new techniques with farm families	FSR team
		4. Encourage adoption of successful practices	Extension agents
To avoid sesonally high food prices	Farmers who purchase food from the markets with money earned from cash crops could be encouraged to buy in bulk right after harvest (depends on storage, see above)	1. Assess existing purchasing patterns, constraints and feasibility	FSR team
		2. Test new buying patterns with a few farmers	FSR team with extension agents
		3. Encourage farmers to buy food in bulk if tests prove successful	Extension Agents

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*These interventions are derived from Longhurst, (1983:4-5), Fleuret and Fleuret (1980:254-256) and Reutlinger (1983:15).

+A mix of crops can likely reduce income and food consumption risks, particularly if the sources of risk are varied.

TABLE 3

Possible Strategies* For Taking into Consideration the Linkages Between Women's Roles in Production and Consumption

Goal	Suggested Strategy	Procedure	Personnel
To avoid increasing the labor demands placed on women so that they do not reduce labor inputs into food crops, food preparation and child care	Cash crops could be introduced that don't directly compete with food crops (especially) for women)	1. Assess the seasonal labor demands of present cropping patterns and domestic duties on women	FSR teams
		2. Identify cash crop alternatives which minimally compete with present labor demands imposed on women by food crops and other duties	Experiment station researchers
		3. Test these cash crop alternatives on farm family fields to assess their demands on labor	FSR team
		4. Disseminate cash crop alternatives which are complimentary to women's existing seasonal labor patterns	Extension agents
	Labor saving technology could be developed and/or introduced to women to help reduce excessive labor inputs	1. Assess existing technology (farm as well as non-farm: potable water access, food processing, etc), constraints and feasibility	FSR team
		2. Identify or develop new labor saving technology, wells, food processing techniques, etc. which are affordable to small farmers	Experiment station researchers (including food technologists)
		3. Test the new technology with women farmers	FSR team
		4. Disseminate successful technology	Extension agents
	Adequate community child care facilities could be introduced in situations where agricultural labor demands are high on women (to avoid adverse nutritional impacts on children)	1. Assess existing child care practices as well as the constraints and feasibility of establishing a community child care facility	Social scientist of FSR team (ethnographic research)
		2. Test the concept in receptive villages	Social scientist of FSR team with extension agents
		3. Encourage the establishment of such child care facilities if tests prove successful	Extension agents

TABLE 3 (continued)

Goal	Suggested Strategy	Procedure	Personnel
To increase production of supplementary non-staples to enhance the nutritional well-being of the household	Research could focus on the crops grown by women in order to devise nutritionally beneficial interventions	(see Table 2)	(see Table 2)
To increase women's access to cash inputs and labor to maintain adequate production levels of both food and cash crops	Women's indigenous credit associations and labor organizations could be promoted and/or stengthened through project activities	1. Assess existing credit associations and labor organizations specifying their major constraints and potential	FSR team
		2. Introduce or strengthen such organizations in a few receptive villages as a test	FSR team with extension agents
		3. Encourage the establishment of such organizations if tests prove successful	Extension agents

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* These interventions are derived from Longhurst, (1983:4-5, AID (1982a:5), and Katona-Apte (1983:36)

TABLE 4

Types of Consumption Data that Could Be Collected During the Various Research Stages of FSR Projects

		Diagnostic Stage			Design and Testing Stages		
Questions to Address or Information to Gather	Target Area Selection	Reconnaissance Surveys	Ethnographic Surveys	Formal Surveys	Recommendation Domains	On-Farm Research	Evaluation and Extension
Secondary Data which are Indicators of Nutritional Conditions (e.g., clinic derived data, census derived data, school records, household budget surveys, previous consumption surveys)	*	*					
Household Food Supply (home produced foods, purchased foods, shared foods, donated foods, etc.)		*	*	*		+	
Types of Food Consumed (traditionally grown, wild food, and new foods)		*	*	+		+	
Preparation Techniques (methods, length of time to prepare food, food qualities, as they relate to preparation)		*	*	+		+	
Food Preferences (distinguishing features of preferred food)		*	*			*	
Meal Times and Number of Meals (associated labor constraints)		*	*			+	
Seasonality of Consumption (food price fluctuations, seasonal shortages)		*	*	*		+	
Food Habits (eating patterns, intrahousehold food distribution, food taboos, specialty foods, foods used in celebration and rituals)		*	*			+	

TABLE 4 (continued)

Types of Consumption Data that Could be Collected During the Various Research Stages of FSR Projects

		Diagnostic Surveys			Design and Testing Stages		
Questions to Address or Information to Gather	Target Area Selection	Reconnaissance Surveys	Ethnographic Surveys	Formal Surveys	Recommendation Domains	On-Farm Research	Evaluations and Extension
Food Classification			+			+	
Food Beliefs			*			+	
24-Hour Recalls			*			*	
Varietal Preferences		+	*	*		*	
Marketing Habits		+	*	*		+	
Food Storage Habits		*	*	*		*	
Consumption Status Indicators							
1) The amount of food stored in the household just prior to harvest and the income or liquid assets such as animals which are available to the household prior to harvest	*	*	+	*	*	*	*
2) Subsistence potential ratio (SPR) (amount of potential food production divided by energy requirements of the entire household over the year)	*	*	+	*	*	+	*
3) Frequency of consumption of key foods within 24-hour period		*	+	*	*	*	*

+ do if time, personnel and dollars permit

STRATIFICATION AND DIFFERENTIATION WITHIN SMALLHOLDER STRATA: A NORTH CAROLINA CASE STUDY[1]

Michael D. Schulman and Patricia Garrett

A central objective of farming systems research and extension is to develop agricultural technologies appropriate for small-scale producers. Smallholders, however, are a heterogeneous group. To the extent that they are internally stratified and differentiated, they have different needs for agricultural technologies.

Scholars and practitioners have long been aware that available technologies were adopted by some groups of farmers and rejected by others. During the 1950s and 1960s, the diffusion of innovation paradigm was dominant. Differential adaptation (i.e., "early adoptors" versus "laggards") was explained by the personal characteristics of producers (Rogers and Burdge, 1972). More recently, however, concern has shifted from the social psychology of the user to the characteristics of the technologies themselves (Ashby and Coward, 1980). An increasingly influential thesis is that technologies developed by national and international institutions may be inappropriate for small-scale agriculturalists (Gilbert et al., 1980; Shaner et al., 1982). Consequently, innovations are rejected not because smallholders are "traditional" but because they recognize technologies to be inappropriate.

The contemporary farming systems literature has tended to emphasize the agronomic and environmental differences among smallholders. Farming systems are defined in terms of the major or dominant crops, the important crop/animal interactions, and the range of ecological conditions under which the system is found (McDowell and Hildebrand, 1980; Harwood 1979; Ruthenberg, 1971). With reference to social stratification, the contemporary farming systems literature emphasizes the distinction between small-scale and medium/large-scale producers. This is entirely appropriate. Scale is related not only to how farmers with varying resources combine different crops and animals but also to how they organize the production of the same commodity. Although scale is certainly a fundamental distinction among farmers, it is not the only one. Smallholders who are homogeneous with regard to scale may be

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differentiated. There is an emerging consensus in the U. S. literature (Buttel, 1981; Carlin and Crecink, 1979; Heffernan et al., 1982; Thompson and Hepp, 1976) that both scale and demographic characteristics are important dimensions along which smallholders differ.

This paper examines how socioeconomic characteristics differentiate smallholders in a regionally specific segment of small farm strata. Data are based on a sample of ninety smallholders from three North Carolina Piedmont counties. Respondents were predominantly male, black, and involved in growing flue-cured tobacco. Factor analysis revealed five major dimensions of internal stratification: scale; off-farm labor and income; on-farm family labor; demographic characteristics of the farm operator; and land tenure. From this analysis, four major types of smallholders and their needs for agricultural technologies are identified.

CONCEPTUAL FRAMEWORK

In the peasant economy literature, a critical question is the relationship between social class membership and demographic characteristics. Contemporary scholarship is heavily influenced by the political debate between Lenin and Chayanov (Hussain and Tribe, 1981). With the increasing penetration of capitalism in the countryside and the emancipation of the serfs, rural communities in Russia experienced new pressures for change. Lenin (1967) argued that the long-term consequences would be polarization of communities and the eventual development of two classes--landless laborers and capitalist farmers. Increasing orientation to commercial or commodity production would encourage the reorganization of agriculture, specifically leasing land and hiring labor. Market involvement with concommitant indebtedness would make producers vulnerable to economic and/or climatic variations. Under these circumstances, impoverishment and land loss could be rapid. At the household level, this process could be labeled depeasantization. At the community level, these changes would restructure social relations and destroy traditional leveling mechanisms that redistributed resources from the affluent to the needy. Polarization along class lines would occur within communities.

As opposing interpretation was provided by Chayanov and the Russian populists (Chayanov, 1966; Shanin, 1972). A central thesis was that the rationale of peasant economies differed from that of capitalist firms. The assumption was that peasants organize production to meet consumption needs. Consequently, how much peasants produce is determined principally by the number of mouths to be fed. After basic consumption needs are met, peasants weigh the drudgery of labor against the value of increased production and decide whether to produce a surplus. In this argument, demographic factors, notably the number of household members and the amount of household labor, are critical.

Chayanov (1966) argued that communities like the Russian mir periodically redistributed productive resources to households which needed more land. Consequently, access to land changed in a predictable pattern over the domestic life cycle, as households received lands consistent with the number of able bodied workers. Superior access to productive resources, therefore, was a transient rather than a permanent aspect of rural social organization.

The influence of both Lenin and Chayanov is reflected in contemporary theorizing (Harrison, 1977; Hussain and Tribe, 1981; Shanin, 1973; 1974). Those whose principal concern is with proletarianization tend to work in the Leninist tradition (e.g., de Janvry, 1980), emphasizing the penetration of capitalism as a mode of production, with the attendant consequences of differentiation and class formation. By contrast, those who are impressed with the persistence of the peasantry (e.g., Shanin, 1973; 1974) and the resilience of petty commodity production (e.g., Friedmann, 1980) typically cast the argument in recognizably Chayanovian terms (Hunt, 1979). Others (e.g., Banaji, 1976; Lehmann, 1980) search for a synthesis.

At a theoretical level, one can argue that a process of differentiation and class formation is occurring and that this process varies throughout a demographic cycle. To make such an argument, one would need evidence that demographic composition and household labor can be empirically distinguished from characteristics of the farming enterprise and off-farm employments. These dimensions are empirically distinguishable in data collected from smallholders in three Piedmont counties of North Carolina.

METHODOLOGY

Samples of smallholders in three North Carolina Piedmont counties were selected via a complex multistage procedure.[2] A total of 107 smallholders fell into the sample, and 90 operator interviews were completed. Male and female heads of household were interviewed, and the questionnaire covered crop production, allocation of labor on-farm,

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[2]In Caswell County, the sample of smallholders is based upon those farmers who were participating in an Extension paraprofessional program during 1981. These were farmers who were under 65 and who had under $20,000 in annual gross farm sales. In Person and Granville Counties, samples of smallholders were drawn. First, census enumeration districts within each county were selected at random. Second, all farmers within each district were administered a short screening questionnaire. The sample of smallholders was drawn from the information collected by the screening questionnaire. A smallholder was eligible if he/she met the following criteria: 1) gross farm sales of $20,000 or less in 1981; 2) farm operator 65 years of age or less; 3) agriculture a significant part (20 percent) of total family income. A fourth criterion, working less than 100 days off the farm for pay, was dropped after the screening data revealed that the farmers meeting the other criteria were bimodal with regard to off-farm work: one group had less than 100 days, but another group had more than 200 days. It was decided to keep in the sample the group working 200 or more days off-farm for pay. A total of 107 smallholders fell into the sample: 27 in Caswell, 41 in Person, and 39 in Granville County. Ninety interviews were completed: 21 in Caswell, 37 in Person, and 32 in Granville (Schulman and Luginbuhl, 1982).

off-farm employment, contact with extension, and attitudes. All data pertain to the 1981 agricultural year.

This is an extremely interesting sample because it represents a subset of North American smallholders rarely studied. It includes full- and part-time farmers, the vast majority of whom are black (82%) and male (95%). On the average, the sample is middle-aged and poorly educated.

As Table 1 illustrates, the mean number of acres farmed, both owned and rented, was 30.4, and a majority of respondents (77%) reported that they farmed some land they did not own. Tobacco, which is labor intensive, was the predominant crop.[3] The majority (92%) of respondents grew tobacco, which occupied 22% of owned and leased land.

Flue-cured tobacco is grown under federal acreage allotments, poundage quotas and price supports. During the 1930s, farms were assigned allotments, and contemporary shares of national production evolved from this baseline. Tobacco land is valued not for its size or quality but rather for the allotment assigned to it (Mann, 1975). Changes in the tobacco program have replaced acreage allotments with poundage quotas as the unit of production restriction and have allowed for the lease and transfer of allotments/quotas (Pugh, 1981). Consequently, the sale/rental of tobacco allotments/quotas is a potential source of income for owners (Beradi, 1982). Under existing legislation, it is not possible to transfer allotments across county lines. This has prevented the geographic relocation of tobacco production and its concentration in areas suitable to mechanization. Should national policy change, however, the social organization of tobacco production in the Piedmont of North Carolina would be transformed. Elimination of the allotment/quota system would produce an estimated loss of $800 million in annual income to allotment owners (Sumner and Alston, 1984).

Although tobacco production is labor intensive, approximately half (54%) of the farm operators had an off-farm job, mostly in operative and craftsmen/kindred worker occupations. Thirty-five operators (39%) reported having a spouse with an off-farm job, primarily in operative or service positions. Children worked off the farm in many (25%) sample households. More than 70% of smallholders reported that children and spouses worked on the farm. Hired labor was relatively unimportant.

Sixty-two percent of the smallholders reported that wages or salary were a source of family income. Average gross farm income (1981) was $14,759, and average net farm income was $2,520. Ten respondents reported that costs exceeded income, and 16 reported that they broke even. Mean total off-farm family income was $9,103, and mean total family income from farm and non-farm sources was $14,135. Average farm debt was $9,017, and the vast majority (84%) of respondents used some form of credit during the 1981 agricultural year.

In summary, the sample has several characteristics generally

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[3]According to the USDA (1977), the average labor hours per acre required to produced tobacco was 281 (1971-75). In comparison, it was 5.1 for corn, 2.9 for wheat, 23.0 for cotton, and 161.5 for tomatoes.

recognized to be important issues for smallholders anywhere in the world--ethnic minorities with limited landbases and resources choosing labor intensive crops and earning cash income by combining cash crop production and wage labor. The data obviously exhibit a specificity that derives from the historical experience of sample households in the North Carolina Piedmont. Nevertheless, data analysis provides a rare opportunity to raise, if not answer, questions central to the analysis of small-scale agricultural production.

DATA ANALYSIS

The procedure used to delineate the dimensions of internal stratification for the smallholder sample is factor analysis. Factor analysis is a technique by which the regularity and order in phenomena can be discerned. It identifies the distinct patterns of relationships among a set of variables. Each pattern appears as a factor depicting a distinct cluster of interrelated data. The number of factors represent the number of substantively meaningful patterns of relationships, and the factor loadings measure the degree and direction of variables within each pattern. Consequently, the first factor delineates the largest pattern of relationship in the data; the second factor represents the next largest pattern, etc. Oblique rotation (promax) is used because it does not force the factors to be orthogonal when they are actually intercorrelated (Rummel, 1970).

A set of variables, all with reference to the 1981 agricultural year, is utilized to measure internal stratification and are included in the factor analysis. Principal variables and their indicators are:

Income: gross farm, total family, and total off-farm family income;
Debt: money borrowed during agricultural year, total farm debt;
Land tenure: total acres owned, total acres leased and rented;
Dummy variable for tobacco allotment ownership: yes or no;
Tobacco production: total acres grown, total pounds produced;
Household's allocation of labor: days of on-farm and off-farm labor by operator and spouse; days of on-farm labor by other household members;
Demographic characteristics: total household size; education, years farming, and age of farm operator.

Table 2 presents the results of the factor analysis. Five factors with eigenvalues of 1.0 or greater were identified.[4] The first factor represents the scale of the farm enterprise. Tobacco production

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[4]Factor analysis should not be confused with an analysis of variance from a factorial experimental design. Rummel (1970) describes factor analysis as a mathematical tool (like calculus), not a statistical technique (like analysis of variance), that is utilized to describe the regularities in a set of data. The five factor solution from the North Carolina smallholder data is an empirical result and was not determined or designed *a priori*. The eigenvalue rule of thumb, a scree test of the change in eigenvalues, and a chi-square test of a maximum likelihood factor solution all confirmed that the five factor solution was correct for the North Carolina data. Readers unfamiliar with factor analysis are advised to consult Rummel (1970).

variables load the highest, followed by gross farm income, money borrowed, total farm debt, and days worked on the farm by the operator. The second factor represents off-farm labor and income. Total off-farm family income loads the highest, followed by total family income, and the number of days of off-farm work by the farm operator and spouse. The dummy variable measuring non-ownership of tobacco allotments has a moderate negative loading on this factor.

The third factor represents family labor on the farm. The number of days of on-farm labor by the spouse and by other family members load well, as does total household size. The fourth factor is demographic, and it represents the age, education, and years farming of the operator. The fifth factor represents land tenure. Total number of acres owned and total farm debt load the highest, followed by the dummy variable for tobacco allotment ownership, and total acres leased/rented.

The five factors represent relatively independent dimensions along which the smallholders studied differed. As Table 3 demonstrates, inter-factor correlations are uniformly low. Variables measuring scale and off-farm income/labor load on different factors (1 and 2 respectively), thereby indicating that farm and family are relatively independent dimensions of work and income within the smallholder sample. Household labor can be analytically separated into off-farm (factor 2) and on-farm (factor 3) activities. All of these dimensions are distinguishable from the demographic characteristics of the operator (factor 4) and land tenure (factor 5).

DISCUSSION

Data analysis demonstrated that the smallholders studied are a heterogeneous group. Moreover, this heterogeneity is itself complex, as reflected in the identification of five relatively independent factors.

Scale is the first and most important dimension of internal stratification among the smallholders studied. Another factor is land tenure, and both relate to the access that smallholders enjoy to productive resources. Other important dimensions along which smallholders differ reflect household composition, the allocation of labor, and demographic characteristics of the operator. These dimensions affect the availability and allocation of labor, which in turn influence the adoptability of technology. It is not merely that each farm is unique. Rather, it is that systematic differences exist among farm families, which derive jointly from social class position and stage in the domestic life cycle. Such patterns have been objects of considerable theoretical inquiry by students of peasant economy because, following the tradition of Lenin and Chayanov, a central intellectual concern has been to determine the relative importance of social class and demographic factors in the organization of agricultural enterprises.

This general concern has specific applied implications for work with the smallholders studied in the North Carolina Piedmont. Theoretical and empirical analyses provide the basis for creating a typology of smallholders, and detailed information on their current farming systems suggests appropriate interventions for each strata. Guidelines for research and extension emerge from this analysis.

In the North Carolina Piedmont sample, one identifiable category of smallholders has adequate land, secure tenure, ownership of tobacco allotments, and access to adequate family labor. These smallholders can realistically expect to remain in tobacco production, providing that the current allotment program is not dismantled. This defines the parameters for technical research, and suggests that agronomic research focus on technologies which decrease the costs of production and maintain yields at approximately current levels. Males are principally responsible for tobacco cultivation, but the participation of women and children is marked, especially during periods of peak labor demand (Garrett et al., 1984). Consequently, a comprehensive evaluation of promising technologies would study the seasonality of labor, relating the labor demands of new cultural practices and the availability of jobs for all household members in the regional labor market. Initial analyses of the North Carolina agronomic data suggest that operators fail to perform tasks at the most opportune time, and this may be caused by off-farm commitments. To serve the needs of smallholders in Category 1, an ideal team would combine agronomic scientists specializing in tobacco production and agricultural economists familiar with production economics and regional labor markets.

The second category of smallholders identifiable in the North Carolina sample has a less adequate landbase, no ownership of tobacco allotments, and adequate access to household labor. The central distinction between Categories I and II is socioeconomic, because Category I has superior access to land in general and to land for tobacco production in particular. These differences are critical because they suggest that extension workers should facilitate the transition of Category II farmers from tobacco to alternative crops. Tobacco is both labor intensive and high value, so viable alternatives must have similar characteristics. Vegetable and fruit production may be particularly attractive. For example, one acre of strawberries in North Carolina can provide almost the same income as one acre of flue-cured tobacco (Adams, 1981). Nevertheless, vegetable and fruit operations may pose the same problems of seasonality as tobacco, suggesting the importance of analyzing labor availability in relation to the limits of tolerable variation for specific tasks and crops. Ultimately, an alternative that appears promising from a socioeconomic perspective must be evaluated in an ecological context. Physical conditions, like the ecology of the farm and its location in relation to market infrastructure, are critical determinants of what is appropriate for individual growers. An ideal team to work with this category of smallholders would include crop scientists specializing in different vegetables and fruits, and agricultural economists specializing in production economics and marketing, including "You Pick" operations.

A third category of smallholders in the Piedmont sample is defined by the importance of off-farm employment to household income and the scarcity of family labor for farm enterprises. It is the availability of both labor and land that are the critical factors limiting agricultural alternatives. Households with larger and superior landbases might consider crops or livestock enterprises with low labor inputs. Limited resource households, however, would need to adopt a nonagricultural strategy. Both subgroups benefit greatly from programs that integrate farm and nonfarm alternatives. Especially beneficial are programs formenting community development, employment generation, and job retraining. For young families, agricultural programs can complement community development programs, especially if they emphasize production of crops and/or livestock that will be consumed on-farm. Work with youth, especially through 4-H, is also important, and home economists can complement the agriculture and youth components, emphasizing food preparation and nutrition education. Those serving Category III might define women and youth as their priority constituents, something that might be entirely inappropriate for teams serving Category I and II households. An ideal team for Category III households would include professionals and paraprofessionals with expertise in gardening, animal raising, and food preparation/storage.

The fourth category of smallholder is elderly, with limited resource bases, and no dependable access to free labor. Income from agricultural production is likely to be relatively less important than income from social welfare programs like food stamps or social security. Nevertheless, the farm is a resource, and it is particularly important that these smallholders be able to pass the legacy of farming to a new generation (Groger, 1983). The legalities of inheritance are critical. Smallholders, in general, and blacks in particular, may not hold clear title to lands and may lack adequate wills (Browne, 1973). Black land loss is a serious personal and social problem throughout the South (Salamon, 1976), and the unmet legal needs of elderly, black smallholders contribute to land loss. An ideal team to deal with smallholders in Category IV would include social welfare workers who can facilitate access to public services and lawyers who can clear land titles and prepare wills.

A consideration of these four categories of North Carolina smallholders illustrates that there is variation across categories not only in the emphasis of agricultural research and extension activities but also in the disciplinary composition of the ideal team. These principles can themselves be placed within a broader framework.

The theoretical literature from which this paper is derived is seldom cited by practitioners of farming systems research and extension. Nevertheless, it is entirely germaine because researchers and extension workers need to consider the influence of the domestic lifecycle and its interaction with social class in order to develop appropriate agricultural technologies. In addition, the results of the empirical analysis question the assumption of socioeconomic homogeneity which underlies the concept of "recommendation domains."

At the 1982 Farming Systems Conference at Kansas State University, Hubert Zandstra stated that the concept of recommendation domains was originally defined by technicians at CYMMT in terms of the amount of fertilizer needed in particular zones. The definition of the concept has evolved to include general ecological and socioeconomic conditions. Through accretion, "recommendation domain" has become defined as a zone with sufficient ecological and socioeconomic homogeneity that a technology could be recommended as appropriate throughout the region (Shaner, et. al., 1982). The North Carolina data show that smallholders, who at first glance may appear to be both socioeconomically and ecologically homogeneous, are in fact differentiated according to social class and stage in the domestic lifecycle. Further research must explore this relationship both theoretically and empirically before it is prudent to assume that recommendation domains with homogeneous socioeconomic characteristics exist.

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Table 1

CHARACTERISTICS OF THE NORTH CAROLINA SMALLHOLDER SAMPLE:

1981 Agricultural Year

DEMOGRAPHIC VARIABLES

Average Age	50.2 years
Average Education	8.9 years
Ethnicity	82% Black
Gender	95% Male

LABOR VARIABLES

Mean days on-farm work, farm operator	229
Mean days on-farm work, spouse	135
Mean days on-farm work, other family	244
Mean days off-farm work, farm operator	127
Mean days off-farm work, spouse	135
Mean days off-farm work, other family	105
Mean days hired help	31

ACREAGE VARIABLES

Mean total acres farmed	30.4
Mean total acres tobacco (92% grow)	6.7
Mean total acres corn (68% grow)	7.1
Mean total acres small grains (41% grow)	9.7
Mean total acres soybeans (24% grow)	10.2

PRODUCTION VARIABLES

Mean tobacco yield	1706 lbs/acre
Mean corn yield	2294 lbs/acre
Mean small grain (wheat) yield	3573 lbs/acre
Mean soybean yield	2124 lbs/acre

INCOME VARIABLES

Mean money borrowed	$ 3,983
Mean total farm debt	9,017
Mean gross farm income	14,759
Mean net farm income	2,520
Mean total off-farm family income	9,103
Mean total family income (all sources)	$14,135

Table 2
ROTATED FACTOR PATTERN*
SAMPLE OF NORTH CAROLINA SMALLHOLDERS
IN THREE PIEDMONT COUNTIES

	1 Scale	2 Off-farm	3 Family Labor	4 Demographic	5 Land Tenure	h^2
Gross farm income	(.782)	-.075	-.050	.020	-.023	.65
Total family income	.050	(.833)	-.058	.088	.091	.72
Total off-farm family income	-.118	(.840)	.033	-.060	-.080	.75
Total farm debt	(.456)	.097	.020	-.221	(.543)	.63
Money borrowed	(.673)	.034	.104	.045	.247	.55
Total acres owned	-.140	-.231	-.109	-.147	(.537)	.32
Total acres rented	.151	-.044	.010	-.166	-(.401)	.20
Ownership of tobacco allotment (0=yes; 1=no)	-.135	-(.355)	-.020	-.269	-(.450)	.40
Total acres tobacco production	(.945)	-.029	-.085	-.046	-.163	.91
Total pounds tobacco production	(.952)	.009	-.089	-.004	-.197	.91
Education, farm operator	-.075	.036	-.095	-(.663)	.201	.51
Days off-farm work, farm operator	-.109	(.704)	.136	-.211	-.103	.60
Days off-farm work, spouse	.025	(.389)	-.290	-.161	.035	.31
Days on-farm work, farm operator	(.383)	-.200	.222	.030	.032	.31
Days on-farm work, spouse	.046	.114	(.511)	.140	-.158	.25
Years farming	-.130	.004	-.136	(.552)	.148	.38
Age, farm operator	.010	-.141	.031	(.686)	.100	.51
Household size	-.052	.008	(.837)	-.099	-.010	.73
Days on-farm work by other family members	.061	-.137	(.730)	-.064	.057	.64
Eigenvalues	3.93	2.40	1.82	1.14	1.00	

*Promax (oblique). Only factors with eigenvalues in excess of 1.0 were computed. Loadings greater than an absolute value of .350 are shown in parentheses. Loadings can be interpreted as standardized regression coefficients.

Table 3

INTER-FACTOR CORRELATION MATRIX

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1 Scale	1.0				
Factor 2 Off-Farm	-.196	1.0			
Factor 3 Family Labor	.137	-.206	1.0		
Factor 4 Demographic	-.045	-.165	-.187	1.0	
Factor 5 Land Tenure	.043	.167	.073	-.103	1.0

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