OFCOR
Case Study
No. 5

PN-ABE-272 64588

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Special Series on the Organization and Management of On-Farm Client-Oriented Research (OFCOR)

OFCOR – Case Study No. 5

ZIMBABWE

Organization and Management of On-Farm Research in the Department of Research and Specialist Services, Ministry of Lands, Agriculture and Rural Resettlement

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November 1989

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International Service for National Agricultural Research

INTRODUCTION TO THE ISNAR STUDY ON ORGANIZATION AND MANAGEMENT OF ON-FARM CLIENT-ORIENTED RESEARCH

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Introduction

In 1986, ISNAR initiated a major study on the organization and management of on-farm, client-oriented research (OFCOR) in national agricultural research systems. The study was developed in response to requests from leaders of national research systems for advice in this area and was carried out with the support of the Government of Italy and the Rockefeller Foundation. The objective is to analyze the critical research policy, organizational and managerial factors which affect national agricultural research institutes' capacities to integrate and sustain on-farm, client-oriented, research as a stable and productive component of the research process.

What is on-farm, client-oriented, research?

On-farm, client-oriented, research (OFCOR)[1] is designed to help research systems meet the needs of specific clients, most commonly resource-poor farmers. It complements -- and is dependent upon -- experiment station research. It involves a farmer-oriented philosophy, a specific research approach and methods, and a series of operational activities carried out at the farm level. These activities range from diagnosis and ranking of problems through the design, development, adaptation, and evaluation of appropriate technological solutions. Farmers are directly involved at various stages in the process.

In this study, on-farm, client-oriented, research programs are analyzed in terms of the functions this type of research can perform within the larger research and extension process. We have identified the following seven potential functions as a framework for analyzing the organization and management of a range of on-farm research programs in nine national agricultural research systems. The functions are:

1) to support within research a problem-solving approach, which is fundamentally oriented toward farmers as the primary clients of research;

2) to contribute to the application of an interdisciplinary systems perspective within research;

3) to characterize major farming systems and client groups, using agroecological and socioeconomic criteria, in order to diagnose priority production problems as well as identify key

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1/ We have used the generic term "on-farm, client-oriented, research" (OFCOR) as distinct from "farming systems research" (FSR) because the latter has come to have too many different and confusing meanings.

opportunities for research with the objective of improving the productivity and/or stability of those systems;

4) to adapt existing technologies and/or contribute to the development of alternative technologies for targeted groups of farmers sharing common production problems by conducting experiments under farmers' conditions;

5) to promote farmer participation in research as collaborators, experimenters, testers, and evaluators of alternative technologies;

6) to provide feedback to the research priority-setting, planning and programming process so that experiment station and on-farm research are integrated into a coherent program focused on farmers' needs;

7) to promote collaboration with extension and development agencies in order to improve efficiency of the technology generation and diffusion processes.

Why is organization and management of on-farm, client-oriented, research important?

Over the last 15 years, many national agricultural research systems have set up on-farm research programs of varying scope and intensity to strengthen the link between research and farmers -- particularly resource-poor farmers. While significant attention has been given to developing on-farm research methods, provisions for fully integrating this approach within the research process have been inadequate and the institutional challenge often underestimated. With the accumulation of experience, it is clear that national research systems have confronted significant problems in implementing and effectively integrating on-farm, client-oriented, research into their organizations. In many cases, these programs have become marginalized and have not had the intended impact on the research process.

Improved organization and management are crucial to overcoming these problems. Effectively integrating on-farm research programs with a strong client orientation within a research system implies forging a new research approach which complements and builds on existing research efforts. This is no small task. It involves establishing new communication links between researchers of diverse disciplines, extension agents, and farmers. It requires hiring people with the right skills or systematically training existing staff. It requires changes in planning, programming, review, and supervisory procedures. It creates increased demands for operational funds and logistical support for researchers working away from headquarters. And, it often involves working with one or more donor agencies. All of these make the management of OFCOR more demanding than that of traditional experiment station research.

This study focuses directly on these issues of implementation and institutionalization. We have analyzed and synthesized the experiences of diverse national research systems in which on-farm, client-oriented, research programs have been established for at least five years. The intention is to provide a body of practical

experience upon which research managers can draw as they strive to strengthen on-farm research as an integral part of their research systems.

Operational strategy and products of the study

Our approach has been to learn from the experiences of research managers in national agricultural research systems. We have built the analysis around case studies of nine countries whose national research systems have had sufficient time to experiment with and develop diverse organizational arrangements and management systems for implementing on-farm, client oriented, research. By region, the countries are as follows:

Latin America: Ecuador, Guatemala, Panama.

Africa: Senegal, Zambia, Zimbabwe.

Asia: Bangladesh, Indonesia, Nepal.

The case studies are stand-alone products. Each is a comprehensive analysis developed by a team of national researchers with personal experience in the individual on-farm research programs. The cases provide important insights and lessons on the general issues, as well as specific guidance for research policy and the organization and management of on-farm research in their countries. The cases will be published in 1988 and 1989. A list of the reports follows.

Comparative study papers providing a systematic analysis across the case studies are a second product of the study. Synthesizing the experience of case study research institutions, these papers provide practical advice to research managers on organizational and managerial issues central to integrating on-farm research focused on resource-poor farmers within their research systems. The themes developed are:

* Alternative arrangements for organizing on-farm, client-oriented research: comparative strengths and weaknesses
* Integrating on-farm and experiment station research: organizational and managerial considerations
* Organization and management of resource-poor farmer collaboration in research
* Organization and management of linkages between on-farm research and extension
* Organization and management of field activities
* Development and management of human resources for on-farm, client-oriented, research
* Financial resource use and management in on-farm research
* Management of relations with donors and external sources of knowledge
* Issues in the institutional development of on-farm, client-oriented, research in national agricultural research systems.

We expect these papers to be published during 1988 and 1989. They are working papers presenting results of the analysis of the nine concrete case study situations. At this stage, they are intended to stimulate discussion and debate; they are not presented as "state-of-the-art" pieces on these topics.

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OVERVIEW OF THE NINE CASE STUDIES

Deborah Merrill-Sands
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The on-farm, client-oriented, research efforts reviewed in the cases vary in scope, the emphasis assigned to different objectives and functions, and the specific methodologies employed. They all conform, however, to the general definition of on-farm, client-oriented, research developed for this study. The cases reflect a variety of institutional settings and strategies for introducing and developing on-farm research. They also reflect the broad range of models used in the organization and management of on-farm research. The profiles below highlight the salient features of each case and Table I provides some key descriptive indicators for comparison across cases.

Latin America

Ecuador:

On-farm, client-oriented, research is conducted by the Production Research Program (PIP, Programa de Investigación en Producción), an autonomous program within the Instituto Nacional de Investigaciones Agropecuarias (INIAP). It has two national coordinators responsible for the highland and coastal macro-regions and 10 regional field teams assigned to different provinces under the administrative auspices of regional experiment stations. Five teams are associated with integrated rural development programs.

Initiated in 1977 with support from CIMMYT, the case allows us to trace the evolution of the organization and management of an on-farm research program from its origins as a pilot project through to its institutionalization as a full-fledged national program.

Guatemala:

A client-oriented research philosophy pervades Guatemala's 16-year-old agricultural research institute, the Instituto de Ciencias y Technología Agrícolas (ICTA). Two units, however, are specifically charged with carrying out the functions of on-farm, client-oriented, research: the Technology Testing Department and the Socioeconomics Department. The first is responsible for testing in on-farm trials all technology developed by the commodity programs. The second conducts diagnosis, on-farm monitoring, and special studies.

The 14 Technology Testing Teams are made up of scientists and technicians whose research is coordinated from regional stations, but who live and work in designated research areas. The Socioeconomics Department is organized at the national level with

representatives in some of the regions. Almost all scientists in the department are agronomists with training in social science methods. Coordination between the two departments is limited.

ICTA's experiences with on-farm research have had a major informative influence on other countries. What makes the Guatemala case especially is that on-farm, client-oriented, research was not appended onto an existing system. Rather, ICTA was set up from the beginning to incorporate such an approach. Moreover, the ICTA case also allows us to examine the organization and management of on-farm research within a regionally organized research system. This is important because a regionalized research system has generally been regarded as the institutional setting most compatible with the organizational requirements of on-farm, client-oriented, research.

Panama:

In the late 1970s, the Instituto de Investigación Agropecuaria de Panamá (IDIAP) developed a "national plan" through which priority areas for on-farm research were selected. On-farm research is implemented in some of these areas as part of the regular research programs of scientists who also work on-station. In other areas, it is implemented through projects with full-time staff, developed in collaboration with international agricultural research centers. The projects are variable in organization and operations, and there is no mechanism at the national level for coordinating the diverse on-farm research efforts. What is particularly interesting about Panama's experience is the institutionalization of on-farm, client-oriented, research as a research strategy, rather than as a formal program with a discrete on-farm research unit or units.

Africa

Senegal:

The Department of Rural Sociology of the Institut Sénégalais de Recherches Agricoles (ISRA) initiated an on-farm, client-oriented, research program in 1978. It is now part of the Department of Production Systems and Technology Transfer (DRSP, Département des Recherches sur les Systèmes de Production et le Transfert de Technologies en Milieu Rural), one of the four main research departments established in 1982 after a major reorganization of ISRA under the auspices of a World Bank project. The DRSP consists of a Central Systems Analysis Group (GCAS, Groupe Central d'Analyse Systèmes), three multidisciplinary research teams located at regional stations, a Bureau of Macro-economic Analysis (BAME, Bureau d'Analyses Macro-Economiques), and a division of thematic research. The case focuses on the on-farm, client-oriented, research part of the DRSP, namely the GCAS and the three regional teams.

Senegal is an interesting case because the classic regional team model for implementing on-farm, client-oriented, research was modified to include a core multidisciplinary group of scientists, the GCAS, which supports the work of the teams. Also of interest is Senegal's experience blending francophone and anglophone approaches to on-farm research.

Zambia:

The Adaptive Research Planning Team (ARPT) conducts on-farm, client-oriented, research in Zambia. The ARPT, initiated in 1980, is a national research program under the Research Branch of the Ministry of Agriculture. It is of equal status to and complements the national commodity programs. The ARPT comprises a national coordinator, based at the central research station, and seven teams of scientists and field technicians at provincial experiment stations. Each team is funded by a different donor.

ARPT includes two important innovations: the formal integration of sociologists and the inclusion of research-extension liaison officers in the teams.

Zimbabwe:

Zimbabwe's Department of Research and Special Services (DR & SS) adopted on-farm, client-oriented, research in 1980 as a strategy for reorienting research to meet the needs of small farmers in the communal areas. This was in response to the post-independence national policy to emphasize agricultural development for this sector.

There is no integrated on-farm research program. Several research institutes and stations and a specialized Farming Systems Research Unit (FSRU) have developed independent initiatives. The case study examines on-farm, client-oriented, research in the Farming Systems Research Unit and four institutes -- the Cotton Research Institute, the Agronomy Institute, the Crop Breeding Institute, and a regional research station. This provides us with an unusual opportunity to analyze the implementation and integration of on-farm research under several distinct models for organizing research, but all within a single institution.

In the institutes, individual scientists carry out both on-farm and station-based research, while scientists in the FSRU specialize in on-farm research. The FSRU consists of a core multidisciplinary team based at the central station and two regional teams staffed by technicians. Their research has had a strong systems perspective emphasizing crop-livestock interactions.

Asia

Bangladesh:

The Bangladesh case study concentrates on the on-farm research activities of the Bangladesh Agricultural Research Institute (BARI), the largest unit of the NARS. The On-Farm Research Division (OFRD), created in 1985, has the exclusive mandate for on-farm research in BARI. On-farm research teams are located at 23 stations and substations, from which they direct technicians in 11 farming system research sites and 83 multi-locational testing sites.

The OFRD subsumed four distinct older programs: multi-locational testing of the Soil Fertility and Soil Testing Institute (later

renamed the On-Farm Trials Division); cropping system research on the IRRI model; varietal testing and verification of the wheat program; and the adaptive research of the T & V Extension Research Program. An important aspect of the Bangladesh case study is its analysis of the consolidation of these different approaches to OFCOR under common management.

Indonesia:

On-farm, client-oriented, research is implemented in Indonesia's Agency for Agricultural Research and Development (AARD) in sub-programs of the commodity institutes, and also in multi-institute projects organized at the AARD level. The case study focuses on two examples of each major type.

The multi-institute projects are an interesting institutional innovation. These projects are staffed by senior scientists seconded from the participating institutes. They maintain contact with their home institutes and return to them at the end of the project. We wanted to examine this arrangement because of its potential for building strong links between on-farm research and station-based specialist scientists, as well as for the long-term integration of the on-farm, client-oriented, research philosophy and methodology within the national research system.

The gradual evolution of on-farm, client-oriented, research in the national research system is another important aspect of the Indonesian experience. Starting as an informal program of one institute in the early 1970s, on-farm and systems research methods were slowly integrated into other commodity institutes. Specialized teams have only been developed since the early 1980s. On-farm, client-oriented, research in Indonesia has been a national initiative which has drawn on a number of approaches, particularly that of the Asian Cropping Systems Network developed in association with International Rice Research Institute.

Nepal:

On-farm research programs of different types have existed in a variety of institutions in Nepal since the early 1970s. Out of the diverse settings of on-farm research in Nepal, we chose five subcase studies which illustrate the major models of organizing on-farm client-oriented, research:

-- OFCOR implemented through a commodity program -- the National Rice Improvement Program;
-- OFCOR implemented through a cropping systems program;
-- OFCOR implemented through a specialized unit -- the Farming Systems Research and Development Division (FSR & DD), supported by a separate socioeconomics division;
-- OFCOR implemented as a generalized strategy in two small, externally funded, regional research institutes -- Lumle Agricultural Research Centre and Pakhribas Agricultural Centre.

The contrast between the on-farm, client-oriented, research programs of the national research system and those of the externally funded institutes make Nepal an especially interesting case.

Table I
Descriptive indicators of the nine OFCOR case studies

Case Studies	National Agricultural Research System		Organization of OFCOR	Years in Operation [3]	Scale of OFCOR: (Scientist Years per Year)	
	Institutional Type	Organization of Research Program			OFCOR as % of NARS Human Resources	Size of OFCOR effort
Ecuador	Semiautonomous institute (INIAP)	Regional research stations commodity programs	Production Research Program (PIP)[f]: National program with two coordinators and 10 teams based at regional research stations	9	6	14
Guatemala	Semiautonomous institute (ICTA)	Regional research programs/commodity programs	Technology Testing Department with 14 field teams in 6 regions and national socioeconomics department with limited regional representation	14	34	65
Panama	Semiautonomous institute (IDIAP)	Commodity programs/ regional offices	National OFCOR plan identified target regions where OFCOR is implemented through special FSR projects or part-time on-farm research	·	16	24
Senegal	Semiautonomous institute (ISRA)	Multi-commodity departments/ regional stations	OFCOR, located within Department of Production Systems Research and Technology Transfer (DRSP)[g], consists of 3 regional teams and a Central Systems Analysis Group	4	13	22
Zambia	Ministry (MAWD)	Commodity and factor programs	OFCOR program with national coordinator and 7 provincial teams at regional stations	6	20	38[h]
Zimbabwe	Ministry (MLARR)	Commodity and disciplinary based institutes and stations	OFCOR implemented by - 8 research institutes/stations with combined on-station on-farm research programs; - Farming Systems Research Unit (FSRU) based at central station with two regional teams	6	18	26
Bangladesh[1]	BARI, semiautonomous institute of larger NARS with council	Disciplinary departments/ commodity programs	On-Farm Research Division (OFRD), with Central Management Unit at headquarters and 24 teams deployed through BARI's network of regional stations, has official mandate for on-farm research. Consolidation of previous OFCOR efforts	9[e]	12	104
Indonesia[2]	Ministry, Dept of Research (AARD) with multiple institutes and coordinating bodies	Commodity-based regional institutes	Two principal modes of implementation - Research institutes conduct OFCOR as part of regular programs; - OFCOR projects organized at AARD level with staff seconded from multiple institutes	11[f]	n/a	57[i]
Nepal[2]	I. NARS: ministry II LAC and PAC:[a] externally funded autonomous institutes	I Commodity programs / disciplinary departments II LAC: Multi-disciplinary research thrusts PAC: Disciplinary departments	I - Farming Systems Research and Development Division (FSR&DD) with 6 FSR sites, supported by Socio-Economics Research and Extension Division (SERED); - Commodity programs with multi-locational testing and outreach programs II LAC and PAC, regional institutes with OFCOR as a generalized research strategy	14[g]	n/a	35[i]

NOTES FOR TABLE I

1. The case study is limited to the Bangladesh Agricultural Research Institute (BARI), the largest of the 5 institutes coordinated by the Bangladesh Agricultural Research Council (BARC).

2. Data refers only to the sub-case studies unless otherwise indicated; NARS-wide data not available.

3. Base year for all statistical data is 1986.

a. Lumle Agricultural Center and Pakhribas Agricultural Center.

b. Programa de Investigación en Producción.

c. The Spanish names for these departments are Prueba de Technologia and Socioeconomia.

d. Département de Recherche de Systèmes de Production et Transfert de Technologies en Milieu Rural.

e. Refers to NARS. Several OFR programs with complex histories operate within BARI. The oldest, the On-Farm Fertilizer Program dates back to 1957. This program was reorganized in the late 1970's, about the same time Cropping Systems Research was established in BARI. The OFRD was not formally consolidated until 1984.

f. Refers to NARS. In 1973, multiple cropping research in the Central Research Institute for Food Crops took on a systems orientation and was renamed cropping systems research (CSR). CSR moved onto farmers' fields in 1975.

g. Refers to NARS. Cropping/farming systems research was initiated 9 years ago. On-farm rice research is 14 years old.

h. Includes 6 Research-Extension Liaison Officers seconded from extension.

i. Represents totals for sub-case studies only. Not directly comparable to other NARS-wide data.

LIST OF CASE STUDY REPORTS

-- Zambia: Organization and Management of the Adaptive Research Planning Team (ARPT), Research Branch, Ministry of Agriculture and Water Development. (S.A. Kean and L.P. Singogo) OFCOR Case Study No. 1. Now available.

-- Zimbabwe: A Case Study of the Organization and Management of Five On-Farm Research Programs in the Department of Research and Special Services, Ministry of Agriculture. (M. Avila, E.E. Whingwiri, and B.C. Mombeshora)

-- Sénégal: Organization et Gestion de la Recherche sur les Systèmes de Production, Institut Sénégalais de Recherches Agricules (ISRA). (J. Faye and J. Bingen)

-- Ecuador: Un Estudio de Caso de la Organización y el Manejo del Programa de Investigación en Finca de Productores en el Instituto National de Investigaciónes Agropecuarias (INIAP). (R. Soliz, P. Espinosa, and V.H. Cardoso)

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FOREWORD

Zimbabwe's Department of Research and Specialist Services has a long tradition of on-farm research. Strong linkages between research, large-scale commercial farmers, and extension have contributed signficantly to making Zimbabwe's agricultural sector one of the most dynamic in Africa. But Independence brought new challenges to the Department: Government had a strong commitment to focus development efforts on assistance to resource-poor farmers in the communal areas (formerly the Tribal Trust Lands). To meet this major policy objective, in 1980 the Department of Research and Specialist Services launched an on-farm research effort aimed at developing or adapting technologies for the communal areas.

The Zimbabwean on-farm research experience has three important aspects that set it apart from most of the other cases in this ISNAR study:

1) The Department does not have an integrated on-farm research program. The semi-autonomous research institutes and stations have developed independent on-farm research initiatives. In 1986, however, a high-level committee was established to coordinate these diverse on-farm efforts, as well as those of the extension service.

2) Scientists combine on-farm and experiment station research activities, except for those working in the specialized Farming Systems Research Unit.

3) Involvement of external agencies and donors in the development of on-farm research has been limited. The Department has used mostly its own funds for on-farm research and has drawn selectively on external sources of expertise to build up its on-farm research capacity.

The Zimbabwe case is very important for another reason: it provides a unique opportunity to analyze organizational and managerial issues affecting on-farm research under distinct models for organizing research. This case study focuses on the on-farm research efforts of a commodity institute (cotton), two discipline-based institutes (agronomy and plant breeding), a regional station, and a small farming systems unit. Through the systematic comparative analysis of these experiences the authors have highlighted the respective advantages and disadvantages of these different organizational arrangements for conducting on-farm client-oriented research.

This is a rich case. The authors, an interdisciplinary team with extensive experience in on-farm research, have produced a tight synthesis of the Zimbabwean experience and a penetrating and rigorous analysis of the organization and management of on-farm research within the Department. At the same time they have succeeded in drawing out important insights and lessons relevant for research managers working under a broad range of institutional settings.

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Study Leader

ACKNOWLEDGEMENT

The study team acknowledges the valuable contributions of the following professionals in Zimbabwe:

Dr. G. McLaren for his careful review and technical editing of the draft report.

Mr. E. Shumba for preparing the technology vignettes in Chapter 3 and assisting with the management and functional analysis of the OFR programs.

Mr. H. Dhilwayo and Mr. G. Makombe for interviewing research and extension staff and collaborating farmers.

Other research and extension staff for providing full cooperation and information.

Other heads of the case study programs for providing all requested information and reviewing first drafts of their respective sections:

Mr. R. Olver, Crop Breeding Institute
Mr. G. Rabey, Cotton Research Institute
Mr. E. Jones/Mr. I. Mharapara, Lowveld Research Station

The team also hereby acknowledges the valuable review and constructive suggestions of:

Dr. P. Bennell, ISNAR
Dr. M. Collinson, CGIAR
Dr. R. Kirkby, CIAT

and especially of Dr. D. Merrill-Sands of ISNAR for her continuous contribution and constructive criticisms in all phases of the study.

Dr. P.R.N. Chigoru, previous Director, and Mr. R.J. Fenner, present Director, Department of Research and Specialist Services, and Dr. H.G. Zandstra, Director, Agriculture, Food and Nutrition Sciences, IDRC, provided strong support and encouragement for the study.

Finally, the authors wish to thank Christine Wilson and Alan Fletcher for their assistance in editing and Tatiana van der Noordaa for her careful preparation of the manuscript for publication.

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SUMMARY

Zimbabwe is a land-locked country with an area of just over 39 million hectares. With a population of 7.5 million (1982 census), it has an overall density of about 20 persons per square kilometer, concentrated mainly in the eastern and central provinces. Since gaining Independence in 1980, the Government has placed emphasis in reconciling and integrating the key sectors -- in particular the African majority with the European minority -- into one viable national economy.

Agricultural Sector

Agriculture is the leading sector in the national economy, 70% of the population, providing 15% of the GDP and generating 50% of the total foreign exchange. As an indication of Government's support for this sector, the Ministry of Lands, Agriculture and Rural Resettlement has the fourth highest budget among all ministries.

The country is divided into five Natural Regions, Natural Region I has the highest agricultural potential; Natural Region V has the lowest potential, suitable only for livestock production.

The agricultural sector has a dualistic structure. The large-scale commercial sector, comprising about 5,000 farmers (formerly the European sector), is well-organized and well-supported by extension and research services. It has very high levels of crop and livestock productivity, comparable to levels found in any developed country. The communal-area sector, comprising about 850,000 farmers (formerly the Tribal Trust Lands), has levels of productivity only about one fourth that of the large-scale commercial sector, because before Independence the technical and support services to this sector were extremely weak and because its land and population distribution is skewed towards the lower-potential areas.

At Independence, in 1980, Government priorities shifted, setting a challenge to all public and private research and development organizations to demonstrate their commitment to the new political direction and to apply their technical expertise to improving the agricultural productivity and living standards in the communal-sector area.

Agricultural Research

The Department of Research and Specialist Services (DR&SS), the primary agricultural research organization in Zimbabwe, and the

focus of this study, has an established tradition and a high standard of scientific and productive research. DR&SS, together with the extension (AGRITEX) and veterinary services (DVS) departments, falls within the Ministry of Lands, Agriculture and Rural Resettlement. DR&SS has a divisional structure (Crops, Livestock and Pastures, and Research Services), each headed by an assistant director who is responsible for the planning, implementation, and evaluation of research programs through his/her semiautonomous institutes, experiment stations, and units. In this structure the Farming Systems Research Unit is also a semiautonomous unit focusing on crop and livestock research and is the direct responsibility of the director of DR&SS.

In infrastructure and research staff, the research system is quite centralized. Most institutes are located in the high-potential areas, close to Harare, or in the large-scale commercial-sector areas. This makes it difficult to carry out research in communal-area environments or to service this sector effectively, because most of it is in Natural Regions III, IV, and V. The few decentralized stations have a national research mandate irrespective of geographical location, except for the Lowveld Research Station, which has a regional mandate.

Ever since its establishment in 1948, DR&SS has received strong commitment and support from Government and the agricultural industry. In 1986 it had a professional staff of 142 nationals and 16 expatriates. The total staff was 1,826, including about 300 research assistants who have technical agriculture training and substantial research experience. The combined development and recurrent budget in 1986/87 was ZWD 15.7 million (USD 10 million), which represents 1.4% of agricultural GDP. Only 9% of this budget came from donor loans or grants. The 1986/87 operational budget (excluding salaries and development budget) per scientist was ZWD 39,775, approximately 2.5 times the yearly average salary.

AGRITEX was established at Independence in 1980, combining the previously separate extension services for the communal areas and for the large-scale commercial sector, the latter having been in the same ministry as DR&SS. The priority shift to the communal areas, a larger, more heterogeneous and technically challenging sector than the large-scale commercial sector, coincided with the start of a major outflow of senior personnel in both departments. This weakened the previously strong linkages between research and extension. Now, particularly in DR&SS, there is a continuous attrition of experienced staff to more attractive posts in the public and private sectors.

The major problems of DR&SS are the slow construction of approved staff housing on stations, poor maintenance of vehicles, cumbersome bureaucratic procedures for procuring inputs, and the relatively weak financial incentives for maintaining and attracting experienced staff. In spite of these problems, the research system obviously has enough resources to work with, there are no serious transportation and communication problems, and the work standards and dedication of its staff at all levels are quite admirable. The senior management (directorate and heads) has high professional and technical standards.

Development of On-Farm Research in DR&SS

On-farm research in DR&SS was initiated in 1980 and expanded tremendously between 1982 and 1984. By 1987, nine of the seventeen research institutes or stations had independent on-farm research initiates of varying scale and importance. On-farm research accounts for approximately 18% of the total professional staff time of DR&SS and between 40% and 60% of the total research programs of the institutes with the largest on-farm research programs.

The on-farm research programs are funded mainly with DR&SS resources. Clearly, the World Bank/International Fund for Agricultural Development loan assisted in the development of on-farm research by providing infrastructural investments (on station) and logistic support (mainly vehicles and laboratory equipment). The International Development Research Centre of Canada provides about 50% of the total budget of the Farming Systems Research Unit. In 1986 about 18% of the scientists having some degree of participation in on-farm research were expatriates. Thus total donor funds constitute a minor proportion of the total on-farm research budget.

The Farming Systems Research Unit was established in 1984 as a crop and livestock systems program with an interdisciplinary team in order to complement and supplement other research programs, including their on-farm research, in DR&SS. The objective was to build a strong, competent team which could function effectively within DR&SS, an organization with high standards and quality of research.

To date the on-farm research emphasis has been on crops, accounting for about 90% of the trial program, because the policy objective for the communal areas was originally increased food production and security. The crop on-farm research programs have gradually come to focus on drought-tolerant crops (sorghum, millets, sunflower, etc.) and systems for the lower-potential areas. Livestock on-farm research has had a late start and still remains modest because the Livestock and Pasture Division has had serious problems with loss of experienced staff and no major source of fresh graduates. There is also lack of relevant "on-the-shelf" technologies for communal-area livestock systems. However, this division collaborates very well with the Farming Systems Research Unit and depends on it for on-farm and adaptative research. Now there is greater emphasis on forage production, upgrading of crop residues, and goat production, which are all highly relevant to the communal-area sector.

Before 1986, various informal methods to coordinate the independent on-farm research programs were tried, through the office of the deputy director of DR&SS, in order to rationalize the use of human financial and logistic resources and to improve the effectiveness of this work with AGRITEX. In 1986 the Committee for On-Farm Research and Extension was formed, composed of heads of institutes with on-farm research and a deputy director of AGRITEX. So far the committee, through its commodity subcommittees, has successfully initiated a planning, monitoring, and review process that cuts across institutes and stations, with these specific objectives: to ensure the relevance of the work to communal areas, to avoid duplication of research, to strengthen research and demonstration designs, and to coordinate DR&SS and AGRITEX activities at the provincial level.

Case Study On-Farm Research Programs

This case study allows us to describe and analyze five semiautonomous on-farm research programs in five semiautonomous research institutes:

1) the Crop Breeding Institute;
2) the Agronomy Institute;
3) the Cotton Research Institute;
4) the Lowveld Research Station;
5) the Farming Systems Research Unit.

These are the largest and oldest on-farm research programs in DR&SS, each with a distinct organizational and management model. The Crop Breeding Institute and the Agronomy Institute, both located in Harare, are discipline-based programs. The Cotton Research Institute, located at Kadoma (150 km west of Harare), is a commodity-based program, and the Lowveld Research Station, located in Chiredzi (in the southeast corner of Zimbabwe), is the only program with a regional mandate. The Farming Systems Research Unit, based in Harare, has crop and livestock programs. It is the only on-farm research program without an experiment station research mandate and the only one with a social science capability, having two economists on its staff.

Table I provides a summary of key descriptors of the scope, content, and management of each on-farm research program in the study.

Management of On-Farm Research

Research planning, programming, and review. Each institute has its own planning and programming process, and they differ markedly. The Crop Breeding Institute research officers plan their work quite independently and rely on informal consultation with colleagues. In the Agronomy Institute, the head consults closely with his research officers about their proposed programs and encourages them to consult widely with scientists in other institutes. The Lowveld Research Station has good informal staff interaction culminating in a yearly planning and review meeting. This process is similar for the Cotton Research Institute, except other DR&SS research officers and AGRITEX specialists are involved in the planning meeting. The Farming Systems Research Unit employs a stepwise procedure to ensure strong inputs from experiment station research, AGRITEX, and farmer collaborators in the planning and review process, and most important, to develop interactive skills and improve research capacity within the team. Across these programs, the Committee for On-Farm Research and Extension is working quite effectively to coordinate and rationalize initiatives.

Site selection and trial management. The applied research objective predominates in the Crop Breeding Institute, the Agronomy Institute, and to some extent in the Cotton Research Institute and the Lowveld Research Station. Therefore, their research officers employ agro-ecological criteria for selecting sites and farmers, usually with the assistance of AGRITEX. Farmers play a limited role, basically providing prepared land and helping with weeding, except in the Cotton Research Institute program, where farmers are

Table I. Key Features of On-Farm Research Programs, 1987

Key Features of On-Farm Research Programs	Crop Breeding Institute	Agronomy Institute	Cotton Research Institute	Lowveld Research Institute	Farming Systems Research Unit
Year on-farm research in communal areas started	1982	1980	1980	1982	1984
Total professional staff, person/yrs	9	13	7	6	5
% Professional staff time in on-farm research	28	38	33	23	100
Average research experience of on-farm research officers, yrs	9.3	5.1	13	11.1	5.2
Number of disciplines in on-farm research	1	1	3	1	4
Number of research areas	24	8	3	7	2
Average distance of areas from headquarters, km	180	260	110	120	220
Surveys done to date	0	5	1	0	8
Enterprises in trial program	6	9	1	4	9
Trial sites/research areas	2	10	26	3	54
Trial sites/professional staff	19	17	33	16	22
Trial sites/resident assistant	8	4	15	4	15
% sites researcher-managed	100	100	75	100	65
Outposted field team*	none	AA&RH	RHs	none	RT,AA,&RHs
Average staff cost/trial site, ZWD**	ND	1082	ND	ND	853
Average operational cost/trial site, ZWD	ND	275	ND	ND	262

Notes:

* RT = research technician, AA = agric. assistant, and RH = research hand.
** 1985/86 estimates, not done for the Crop Breeding Institute, the Cotton Research Institute and the Lowveld Research Station.

responsible for managing and assessing trials. The Farming Systems Research Unit emphasizes the adaptive research objective and therefore considers farmer representation important for selection of collaborators on farmer-managed trials.

For trial management, the Crop Breeding Institute and the Lowveld Research Station research officers and assistants travel out from headquarters to visit their sites weekly or biweekly. The Agronomy Institute, the Cotton Research Institute, and the Farming Systems Research Unit have outposted field staff who reside in the area and are responsible for managing the trials and carrying out all necessary operations within a cluster framework. Clustering is done to improve trial supervision/management, to minimize travel time/ costs, and to facilitate building stronger linkages with AGRITEX staff and farmers.

Trial management in the Agronomy Institute program has had an interesting evolution. The original objective of on-farm research to have technological packages for all natural regions by 1984 was not achieved largely because of high coefficients of variance due to inadequate trial management. A single research officer was responsible for on-farm research, and there were too many trials in widely scattered areas for him to supervise adequately. Wide dispersion of trials also inhibited interaction between research, extension, and farmers. In 1986, the Agronomy Institute made important changes to address these problems:

- abandoned using AGRITEX to manage trials;
- introduced clustering in each area;
- reduced the number of areas or clusters by about 50%;
- moved away from farmer- to researcher-managed trials;
- assigned eight research officers to on-farm research, one per cluster in each province.

Comunication of research results. The technical annual report of each institute is the main mechanism for dissemination of on-farm research results, but these are at least two years behind schedule. Consequently, on-farm research officers have relied more on seminars, symposia, and informal consultations to exchange updated results. For example, a symposium was organized in 1986 for presenting technical papers, mostly on on-farm research, and awards were given to the three best papers presented. DR&SS has two professional journals in which on-farm researchers can publish their results. (The common tea room of the Crop Breeding Institute, the Agronomy Institute, and the Farming Systems Research Unit is evidently the informal "hub" of inter-institute planning and coordination.)

Farmer participation. Farmer participation is considered essential in the problem-identification and technology-assessment phases. Some research officers indicate that more involvement was not possible because of farmers' time and labor constraints and the need for adequate experimental quality control. The Cotton Research Institute participates in the communal-area farmer-training courses sponsored by the large-scale commercial sector and AGRITEX, thereby strengthening this linkage. The Farming Systems Research Unit has given more attention to stimulating farmer involvement in research and has used the following methods:

- farmer groups to organize meetings and field days;
- host farmers to explain trial management and performance;
- awarding of prizes to farmers or groups for best trial management;
- pre-planting demonstrations for farmers on proposed trials,
- "internal" field days limited to local AGRITEX staff and farmers.

However, on-farm research officers do not exploit the farmers' practical knowledge to advance research work in technical areas in which farmers have considerable experience.

Integration of on-farm and experiment station research. All on-farm research scientists, except those of the Farming Systems Research Unit, also have a major responsibility for experiment station research. Since there is no special discrimination or treatment for any aspect of on-farm research in the research process of these institutes, experiment station research and on-farm research are quite well integrated. Naturally, because of the wide body of existing technical information, the direction of information flow was largely from experiment station research. Gradually, the on-farm research experience is now influencing the direction and emphasis of experiment station research programs.

The Farming Systems Research Unit has solid linkages with experiment station research, particularly in the livestock units, because it has requested and obtained their participation in research literature reviews, diagnostic activities, program formulation, and implementation. The Farming Systems Research Unit has the technical expertise to discuss and contribute to their programs, and its research officers share credits (e.g., joint responsibility for on-farm research trials and co-authored papers) and have a few on-station trials with experiment station research scientists.

Linkages with extension. The Crop Breeding Institute and Lowveld Research Station invite AGRITEX participation in their on-farm research programs, primarily at the problem-identification and technology-assessment phases. Their inputs are obtained through informal meetings and field days. The Agronomy Institute has begun to promote better joint planning at the provincial level. The Cotton Research Institute has a good working relationship with AGRITEX because AGRITEX specialists reside at the Institute, participate in the research planning meeting, and jointly assist with the communal-area farmer training. In the Farming Systems Research Unit, the AGRITEX staff, in particular the field staff, participate in the pre-planting demonstrations, trial design and management, and assume a larger responsibility for the field days.

Management of field operations. For field work, the on-farm research programs have not experienced serious logistic constraints related to transport, petrol, staff subsistence, and other such support. However, the timeliness of vehicle repair and subsistence reimbursements do adversely affect the smooth operation of on-farm research to some extent. Housing for research staff in communal areas is a problem which is being overcome by the Agronomy Institute and the Cotton Research Institute through the use of mobile houses, caravans, or camping equipment. The Farming Systems Research Unit has some houses on loan from AGRITEX.

Management of staff. The academic level and research experience of on-farm researchers are higher than the professional staff of DR&SS as a whole. The research assistants, including research hands, have substantial research experience and can manage the on-farm research trials with minimal supervision from the research officers. Training in specialized areas is an important objective, and in fact, opportunities for on-farm research officers may be slightly better than for those who have only experiment station research duties. Training in special on-farm research approaches and methodologies is minimal for all units except the Farming Systems Research Unit. Their research officers are exposed to systems concepts and to most schools of thought and problems in on-farm research and farming systems research.

On-Farm Research Functions: Performance Analysis

Heads, researchers, and extension and farmer collaborators of each unit were interviewed in order to assess the performance of the five on-farm research programs on the basis of seven specific potential on-farm research functions:

1) support for a problem-solving approach within research with farmers as the primary clients;

2) contribution to the application of an interdisciplinary systems perspective;

3) characterization of major farming systems and client groups;

4) adaptation of existing technologies and/or contribution to the development of alternative technologies;

5) promotion of farmer participation in the research process;

6) provision of feedback so that experiment station research and on-farm research comprise a coherent program;

7) promotion of collaboration with extension and development agencies.

The performance of each function was rated qualitatively as weak, moderate, good, or very good. Because of differences in mandate, state of knowledge, and research objectives, the seven functions are not equally important for all institutes.

Crop Breeding Institute. For the Crop Breeding Institute, on-farm research provides an opportunity to test breeding material under a wide range of environments, thereby enabling breeders to offer appropriate varieties or hybrids to other on-farm research efforts. Their performance is good in technology development, but weak on interdisciplinarity and characterization and moderate on the others. Breeders give priority to their experiment station research, and place little importance on improving the weak level of characterization and the moderate level of farmer participation and AGRITEX collaboration.

Agronomy Institute. The Agronomy Institute achieved a good level of performance on all functions except characterization and farmer participation, which were moderate and weak, respectively. Since the Agronomy Institute has the leading responsibility to develop technical crop packages for all natural regions, the head encourages and helps his research officers to consult and coordinate with other scientists, and this is facilitated by their location in Harare. The institute has done some technical characterization, but the head feels that this function belongs to the Farming Systems Research Unit and AGRITEX. The institute's previous negative experience with farmer participation and their current emphasis on technology generation leads them to give a low priority to this function. However, the assignment of one research officer per commodity and per area, clustering of trials within the area, and the reduction of clusters to eight, should improve the performance of the functions of developing a problem-solving approach, developing alternative technologies, promoting farmer and AGRITEX participation, and integrating on-farm and on-station research activities.

Cotton Research Institute. The Cotton Research Institute achieved a good level of performance on all functions except for characterization, which was moderate. This commodity-based program has many advantages: all research staff are on the station; cotton has a strong political lobby; capacity to generate foreign exchange; strict market quality requirements; and a well-developed farmer training program. The institute has experience in working with the farming community and with AGRITEX, and there is an annual planning meeting at the institute which involves key actors in the technology generation and diffusion process. Characterization is not a priority function because they feel confident with the interaction they have with farmers and AGRITEX on problem identification and technology assessment.

Lowveld Research Institute. The Lowveld Research Station achieved a good level of performance on supporting a problem-solving approach, technology development and adaptation, and the effective integration of on-farm and station-based research. This is due primarily to the easy consensus on the key constraints in this natural region, the good team spirit and interaction among the research staff, and the logical progression of trials from simple/exploratory to complex/formal designs. It is noteworthy that the Lowveld Research Station does not use clustering and has no outposted research staff, practices which could potentially improve the moderate performance of the functions of promoting farmer and AGRITEX participation. The characterization function is weak because the staff do not put much priority on formal methods, and interdisciplinarity is also weak, probably due to the geographical isolation of the Lowveld Research Station and the lack of strong interest in Natural Region V by other DR&SS programs.

Farming Systems Research Unit. Because the Farming Systems Research Unit was established specifically to carry out most of these functions, its performance of all of them was very good, except for technology development and integration of on-farm and experimental station research, where performance was rated as good. The Farming Systems Research Unit has a fairly good technical orientation in its team, it is centrally located, it has easy access to all institutes, and it has employed procedures to promote effective interaction with

its collaborators and clients. The unit has also encouraged and assisted other on-farm research programs because their applied research emphasis and success is necessary for its own success.

Overall performance of on-farm research functions within DR&SS. The highest average rating of the actual performance as assessed by the study team for all on-farm research programs was achieved for problem-solving and technology development and adaptation (good level), and the lowest rating for characterization (moderate level), farmer participation, and interdisciplinarity (moderate to good).

The heads of on-farm research programs were requested to rate their own actual performance. Their average rating for actual performance was exactly the same for farmer participation, the lowest of all functions, slightly lower for problem-solving, and slightly higher for all other functions in comparison to the study team's. These similar results lend credibility to the assessment done by the team.

The directorate of DR&SS considers that all functions of on-farm research should be very important, but they viewed technology development and adaptation, as well as the integration of on-farm and experiment station research, as being most important. They assigned lower importance to promoting farmer participation and collaboration with AGRITEX. The difference between the directorate's rating of what is desirable and the study team's assessment of actual performance (i.e., the performance gap) was highest for characterization, followed by the functions of integrating on-farm and experiment station research and applying an interdisciplinary systems perspective. The gap was the least with respect to strengthening collaboration with AGRITEX and supporting a problem-solving, client-oriented approach within research.

According to their own ratings, all other heads and research officers viewed the functions of technology development and adaptation, supporting a problem-solving approach, and integrating on-farm and on-station research as the functions which should be the most important in DR&SS. The highest performance gap for these scientists was on characterization and integration of on-farm and experiment station research, in complete agreement with the directorate, although the directorate perceived the gap to be larger.

Lessons from the Zimbabwe Case Study

Institutional factors affecting the performance of on-farm research. The case-study team identified four key policy determinants of the functional performance of these five programs in DR&SS:

- research priority on the communal area sector;
- rewards for staff interaction;
- adequate operational resources;
- clear responsibility for adaptive research.

The team also identified ten key organizational determinants affecting the performance of on-farm research:

- the disciplinary structure of DR&SS;

- the Committee for On-Farm Research and Extension (COFRE), which coordinates on-farm research across institutes and stations;
- regional mandate of research stations;
- commodity mandate of research institutes;
- experience of on-farm research officers;
- multidisciplinary nature of team;
- good research leadership;
- location of on-farm research officers on station;
- centralized and small size of institutes;
- high quality of experiment station research expertise.

Twenty managerial determinants were also identified, among which the most important are:

- emphasis on formulation of farmer recommendations;
- research officers' exposure to other disciplines;
- inputs of diagnostic activities and their utility for experiment station research scientists;
- internal field days and awards for farmers;
- clustering of trials.

The factors found to be least important are:

- sharing credits (i.e., joint authorship);
- researchers' relations with AGRITEX provincial staff;
- participation of economists.

For this analysis, the study team qualitatively assessed the specific contribution of each determinant to the actual performance of each function. Thus, for example, to reduce the characterization performance gap, the largest according to the rating of the directorate and other staff in DR&SS, the team would suggest on the basis of the comparative analysis the following principal options: to strengthen the Committee for On-Farm Research and Extension, improve the research experience of on-farm research officers and have multidisciplinary team planning, have participation of economists, increase the participation of experiment station research scientists in diagnosis, use the clustering approach for trial work, and put more emphasis on farmers' recommendations. These options have been shown to be technically feasible and effective in the DR&SS environment. However, the decision to promote any option, or preferably a combination, should be based on a cost-effective analysis.

Principal accomplishments of on-farm research in DR&SS. The study team agrees that the main outputs of the on-farm research experience in DR&SS are as follows: understanding of adoption constraints of some technical recommendations, definition and confirmation of research priorities, technical and scientific development of the research staff, need for strong inter-institute coordination and linkages with AGRITEX, appropriate representative communal-area sites for technology development, job satisfaction of research staff, and stimulation of communal-area farmers' interest in research. Senior scientists give credibility to on-farm research because they either have a program in their institute, participate in the program of another institute, or depend on such programs to assist in defining or confirming research priorities. Thus on-farm research is serving DR&SS well.

Specific recommendations for strengthening on-farm research. Previously, the permanent secretary of the Ministry of Lands, Agriculture and Rural Resettlement would not support the request for economists, arguing that DR&SS should rely on the AGRITEX or the Ministry's head-office economists. In 1987 the Farming Systems Research Unit had two, and the Agronomy Institute, the Cotton Research Institute, and the Lowveld Research Station believe that an economic input is essential at this stage. Based on the Farming Systems Research Unit's experience and the need for a continuous supportive input from an economist in the research process, the study team believes each institute should have its own economist or share one if the volume of work is not sufficient. To put all economists in the Farming Systems Research Units would weaken the unit technically, place it in conflict of interests with other institutes and probably marginalize it in the decision-making process. The decentralization of the economic capability in DR&SS should not preclude some degree of coordinated planning (e.g., through the Committee for On-farm Research and Extension), would probably be highly effective in a regionalized planning framework and is most likely to be acceptable to the senior management of DR&SS.

The political pressure on DR&SS to service the whole country with its on-farm research is an issue directly related to AGRITEX collaboration. Planning and review should be done at the regional level on the basis of representative site selection criteria to complement experiment station research sites. The Cotton Research Institute and Farming Systems Research Unit should expand their geographical coverage but work closely with other units so that DR&SS as a whole has two to three clusters per natural region. A strong input is required at the research cluster level, particularly from the AGRITEX Field Division, with due care not to involve the extension staff too much or too quickly in trial management in the early years. Once the technology is fairly well developed and research officers have confidence, the AGRITEX staff, particularly the Technical Division, should then have the prime responsibility to extrapolate them to other surrounding analogous areas.

Inter-institute complementarity and coordination was a sensitive issue because of the disciplinary structure of DR&SS. Now the Committee for On-Farm Research and Extension is successfully addressing this problem but, if the present momentum is to be maintained, the necessary incentives and institutional authority must be accorded to the Committee.

Strategic lessons. Several strategic lessons for institutionalizing and organizing and managing on-farm research can be drawn from the Zimbabwe experience:

1) Leadership for on-farm research should be given to biological scientists.

2) Researchers should have responsibility for both experiment station research and on-farm research.

3) Trials should be clustered to facilitate good management and the development of linkages with farmers and extensionists.

4) When on-farm research is conducted by discrete research units or programs, a coordinating mechanism, such as the the Committee for On-Farm Research and Extension, should be established. This helps to consolidate on-farm research expertise, avoids duplication of effort, and fosters interdisciplinary and inter-commodity research.

5) Research programs should be given sufficient institutional flexibility to select the appropriate balance between technology generation and technology adaptation, depending on the research problems they are addressing.

These five factors were found to have had a major positive influence on the other organizational and managerial factors and on the high level of performance achieved in developing a problem-solving research approach, technology development and adaptation, and the effective integration of research conducted on farms and on experiment stations.

ACRONYMS AND ABBREVIATIONS

AA	Agricultural Assistant, DR&SS
AEO	Agricultural Extension Officer
AGRITEX	Agricultural Technical and Extension Services, MLARR
AI	Agronomy Institute, DR&SS
ARC	Agricultural Research Council,
ARO	Assistant Research Officer
CART	Communal Area Research Trials
CBI	Crop Breeding Institute, DR&SS
CIAT	Centro International de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
COFRE	Committee for On-farm Research and Extension
CPU	Crop Production Unit
CRI	Cotton Research Institute, DR&SS
CSRI	Chemistry and Soils Research Institute, DR&SS
DMB	Dairy Marketing Board
DR&SS	Department of Research and Specialist Services, MLARR
DVS	Department of Veterinary Services, MLAAR
ES	Extension Supervisor, AGRITEX
FSRU	Farming Systems Research Unit, DR&SS
GMB	Grain Marketing Board
IAE	Institute of Agricultural Engineering, AGRITEX Unit
ICRAF	International Council For Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ISNAR	International Service for National Agricultural Research
LRS	Lowveld Research Station, DR&SS
MLARR	Ministry of Lands, Agriculture and Rural Resettlement
NFAZ	National Farmers Association of Zimbabwe
OFCOR	On-Farm Client-Oriented Research
OFR	On-Farm Research
PPRI	Plant Protection Research Institute, DR&SS
SPRL	Soil Productivity Research Laboratory, DR&SS
SRO	Senior Research Officer, DR&SS
ZDB	Zimbabwe Development Bank
ZNFU	Zimbabwe National Farmers Union
ZWD	Zimbabwe Dollar

CHAPTER ONE

NATIONAL CONTEXT FOR AGRICULTURAL RESEARCH

A BRIEF OVERVIEW OF THE COUNTRY AND ITS ECONOMY

Land Area

The total land area of Zimbabwe is approximately 390,700 sqkm. Agricultural land, 83% of the total land area, is divided into the large-scale commercial sector, the small-scale commercial sector, resettlement areas, and communal areas.

Table 1: Distribution of Land, Area and Percentage According to Agricultural Sectors

	Thousand ha	%
National and unreserved land	6,603	17.2
Communal areas	16,683	42.7
Large-scale commercial	12,542	32 1
Small-scale commercial	1,367	3.5
Resettlement	1,758	4.5
Total	38,953	100.0

The most important farming sectors are the communal areas and the large-scale commercial sector. However, the resettlement sector is increasing because of priority attention from the Government.

Population

According to the 1982 census, the population of Zimbabwe was 7,539,000 with an annual growth rate of 3%. Over 55% of the population was estimated to be under 15 years of age.

The country is divided into eight provinces. Population distribution and density vary between these provinces, primarily because of cities, as in the case of Mashonaland East, which includes Harare (the capital), and Matebeleland North, which includes Bulawayo (the second largest city), or due to the traditionally high concentration of people in the rural areas, such as Manicaland and Masvingo.

More than 4 million people live in the communal areas and 1.7 million in the commercial areas. Communal areas contain most of the densely populated rural parts of the country. They include 77% of all land with densities in excess of 20 persons/sq km and 96% of that with 60 persons/sq km. The mean density is twice that in small scale-farming areas and three times that of the large-scale farming sectors.

Population trends in the agricultural sector after Independence (in 1980) are presented in Table 2. The total population and the economically active segment in agriculture have both increased in absolute terms. However, the proportion of economically active people in agriculture has declined slightly since 1980.

Table 2: Population Distribution, Total, Agricultural and Economically Active Population for 1980 and 1984 (thousands)

Year	Total population	Population in agriculture	Economically active population in agriculture	% Economically active in agriculture
1980	7360	4317	1417	58.7
1984	8461	4780	1528	56.5

Source: FAO, 1985.

The table and the 1982 census show a proportionate shift from rural to urban areas. In fact the urban population has increased from 18.4% in 1969 to 25.7% in 1982.

The Shona constitute 80% of the black population and occupy the northern and eastern parts of the country. The Ndebele form 20% of the population and occupy the western part of the country. The Europeans, Asians, and mixed are mainly in towns and commercial farms and, together with smaller groups like the Tonga, Venda, and Sena, form the minority groups. Shona and Ndebele are the two main traditional languages in Zimbabwe. All other indigenous languages are dialects of these two main languages. The official language is English.

Level of Economic Development

Zimbabwe has two principal economic sectors: the relatively advanced and diversified modern sector (commerce, industry, mining and commercial agriculture) and the peasant sector which is generally underdeveloped with poor infrastructure. The World Bank ranks Zimbabwe as a middle-income developing country. The gross domestic product per capita was $761 in 1983 (Zimbabwe Banking Corporation Ltd. 1985).

Table 3 shows GDP at factor cost by industry of origin in 1980 and in 1986. The major contributors are services (39.6%), manufacturing and mining (34.2%), and agriculture and forestry (15%). The GDP annual growth rate has averaged about 2.5% since 1980.

In 1985 the value of exports from Zimbabwe was $1243 million and imports were $1003 million, with a visible balance of $240 million (Republic of Zimbabwe, 1986).

Table 3: Gross Domestic Product at Factor Cost by Industry of Origin in 1980 and 1986

	GDP 1980 (ZWD million)	% of GDP	GDP 1986 (ZWD million)	% of GDP
Agriculture and forestry	458	14.2	1014	15.13
Manufacturing and mining	1087	33.7	2291	34.22
Public administration, education, and health	630	16.4	983	14.74
Other services	1159	39.0	2654	39.61
Less unprinted banking service charges	-108	-3.3	-239	-3.6
Total	3226	100.0	6703	100.0

Source: Republic of Zimbabwe, 1986.

THE AGRICULTURE SECTOR: AN OVERVIEW

The Agriculture Sector

As in most developing countries, the agricultural and forestry sector has a major role in the economy of Zimbabwe. About 70% of the population depends on agriculture as a source of income, and 25% of all wage earners are in this sector. It contributes raw materials like tobacco, cotton, and oilseeds to other industries. Over one-third of total foreign exchange earnings originates from agriculture and forestry. In 1986, this sector contributed ZWD 1014 million to the GDP, or 15% of the total GDP. The share contribution of agriculture to GDP has increased moderately since 1980 (Table 3).

Agriculture and Development

The objectives outlined for the agriculture sector in the Zimbabwe Government 1981 Economic Policy Statement "Growth with Equity" and reinforced in the First Five-Year National Development Plan, 1986-1990, are:

a) an acceptable and fair land ownership and use distribution;

b) a rapid reduction of the levels of absolute poverty in rural areas, together with an accelerated improvement in the standard of living of the rural people;

c) an increase in both land and labor productivity in all forms of agriculture;

d) a substantial increase in employment for the rapidly growing labor force;

e) achievement and maintenance of food self-sufficiency and regional food security;

f) extension of the role of agriculture as a major foreign exchange earner and a source of inputs to local industry;

g) integration of the two agriculture sectors; i.e., commercial and peasant;

h) conservation of land and the environment for future generations;

i) promotion of regional balance in agricultural development;

j) development of human resources in the rural areas to their full potential.

Because of the importance of the agriculture sector in providing food security, employment, and foreign currency from exports, the Zimbabwe Government has always made substantial investments in this sector. For example, the Ministry of Lands, Agriculture and Rural Resettlement (MLARR) received 8.2% of total government expenditure of ZWD 3.9 billion during the 1985/86 financial year. It ranked third among all ministries in resource allocation, following the Ministries of Education and Defense. In the 1987/88 budget year, MLARR will receive ZWD 313.8 million, of which ZWD 15 million goes to the Department of Research and Specialist Services (DR&SS), ZWD 30 million to AGRITEX, ZWD 26 million to the Department of Veterinary Services, and the major sum of ZWD 204 million will be used for grants and subsidies to agriculture-related parastatals. Thus, the allocation to research will be 4.7% of government investment in the Ministry.

The Natural Resource Base

About 40% of land in Zimbabwe is classified as arable land, and 55% as suitable for grazing. The quality is very varied. Current land use is shown in Table 4.

Out of the total arable land, about 167,000 ha are irrigated, and double cropping is practiced on most of this land. About 80% of the irrigated land is in the commercial farming sector and 20% in the communal areas.

Table 4: Area and Percentage of Land According to Use

	Area (000 ha)	% of total land
Total arable land	2,682	6.9
Permanent crops	82	0.2
Permanent pastures	4,856	12.6
Forest and woodland	23,810	61.0
Other land	7,319	18.9
Total	38,667	99.4

Source: FAO, 1985.

Zimbabwe is classified into five main natural regions or ecological regions. This classification provides a good guide to the natural factors governing agricultural production and development in each region (Figure 1).

Land Use

The farming community in Zimbabwe can be divided into four distinct sectors (Chavunduka, 1982):

Communal Farms. These are held under various forms of traditional and communal ownership and are situated in the communal lands, formally known as Tribal Trust Lands. No legal title to the land is held but each household manages its arable area privately while livestock graze on communally held areas (Hughes, 1974).

Small-Scale Farms. These are held under freehold title (private) and are situated in the former African Purchase Areas.

Large-Scale Commercial Farms. These farms are normally held under freehold title and comprise the former white commercial farming areas.

Resettlement Areas. These are established on land transferred from the large-scale commercial sector since Independence. Different models of resettlement have been employed including communal farms with the only government intervention being controlled livestock stocking rates, cooperative farming with land and equipment collectively owned, and group ranching schemes in Natural Region V.

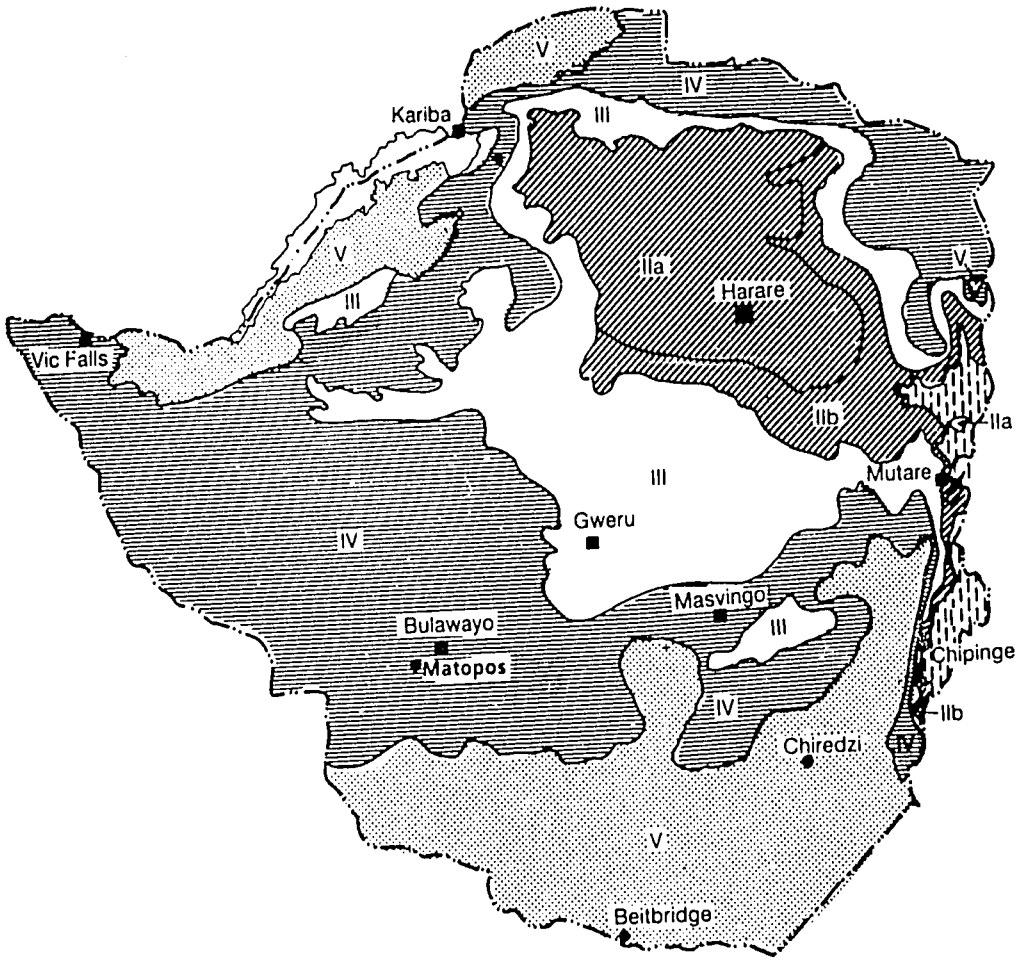
The relationship between Natural Regions and farming sectors in terms of land area is given in Table 5. Of total land area, only 16.6% is in Natural Regions I and II, so-called high-potential areas, and the rest is in Natural Regions III, IV, and V, the low-potential areas. It is important to note that only about one-twelfth of the communal areas is located in the high-potential areas, in comparison to one-third for the large-scale commercial sector. Furthermore, in the lower-potential areas, communal-area farmers intensively crop their arable areas, whereas large-scale commercial-sector farmers manage them extensively with livestock. The distribution of small-scale commercial-sector land relative to that of resettlement is more skewed to Natural Regions IV and V.

Table 5: Percentage Distribution of Land Area According to Natural Region and Farming Sector

	Natural Region						
	I	II	III	IV	V	X	Total
National and unreserved land	0.3	0.9	2.1	6.5	6.0	1.4	17.2
Communal areas	0.2	3.1	7.0	18.1	12.8	1.5	42.7
Large-scale farms	1.2	9.8	5.6	9.7	5.7	0.1	32.1
Small-scale farms	-	0.6	0.7	1.5	0.5	0.2	3.5
Resettlement	0.1	0.4	2.4	0.5	1.1	-	4.5
Total	1.8	14.8	17.8	36.3	26.1	3.2	100.0

Source: Farming Systems Research Unit, 1985.

Figure 1: Natural Regions of Zimbabwe



Key	Natural Regions	Farming Type	Annual Rainfall	Land Use
	I	Specialized, diversified	> 1000 mm low temperatures	Forestry, fruit, intensive livestock, crop production
	II	Intensive	750 - 1000 mm summer only	Crops, livestock
	III	Semi-intensive	650 - 800 mm Infrequent, heavy mid-season dry spells	Maize, tobacco, cotton
	IV	Semi-intensive	450 - 650 mm periodic seasonal drought, severe mid-season dry spells	Livestock, fodder
	V	Extensive	< 650 mm Low and erratic Zambezi Valley < 600 mm Save-Limpopo Valley	Livestock on natural veld

Principal Agricultural Commodities

The principal agricultural commodities in Zimbawe are tobacco, sugar, cotton, maize, wheat, and soyabeans. These commodities had a gross sales value of $482 million, or 67% of the total agricultural sales of principal crops and livestock. Average yields vary widely between commercial and communal sectors and within each sector, depending on agro-ecological zones. For example, the average maize yield per hectare in the commercial sector is six tons and in communal areas about three tons. Similar variations also exist for other commodities. Table 6 shows the national average yields and land allocation of various commodities. Yields have increased for all these commodities up to 1984.

Table 6: Total Area, Average Yield, and Total Production of the Principal Agricultural Commodities in 1984

Crop	Area planted (000 ha)	Average yield kg/ha	Total production (000 tons)
Maize	1,582	6,500	1,028
Wheat	17	5,882	100
Tobacco	55	2,158	118
Soyabeans	50	1,800	90
Cotton	130	1,931	251
Sugar	33	109,091	3,600

Source: FAO Production Yearbook 1984, Volume 38.

All commodities from commercial farms are sold to official marketing agencies for export or domestic use, while about 16% to 30% of the output from communal areas is sold outside those areas. However, peasant deliveries to official markets have been increasing, rising from very low levels to more than 40% of the total maize delivery to the Grain Marketing Board and to about 47% of the total output.

In terms of foreign exchange, agriculture generated 41% ($510 million) of the total export trade during 1985. Of this, tobacco accounted for 49%, cotton 20%, sugar 9.5%, coffee and tea 9.3%, and meat and hides 8.5%. However, agriculture accounted for 7.9% of the total import trade during the same year.

The current situation for the major food commodities is provided in Table 7. After two consecutive above-average seasons (198) there is a large surplus of all grain commodities, except for wheat, where annual sales by the Grain Marketing Board surpass purchases by 10% and current stocks are substantial, given the annual purchase levels. Oilseed production is relatively low, and the government has identified them as priority crops, particularly for expansion in the communal areas. Livestock products, especially beef and pork, have limited local demand but strong export market potential. However, the gradual decrease of the national cattle herd during the last few years due to drought conditions, allegedly unfavorable producer prices, and increased pressure to export to EEC countries, has caused an acute shortage of beef on the local market and raises serious policy questions for the industry. The government believes that communal areas have a major role in the livestock sector.

Table 7: Estimated Current Stocks, Annual Sales, Purchases through Official Marketing Agencies, and Export Levels by Major Food Commodity During Last Two Years (tons)

Crop	Current Stocks (as of late 1986 and early 1987)	Sales by farmers	Purchases by consumers	Export	
				Tons	% of sales
Maize	2,058,008	1,828,112	560,631	284,817	15.6
Wheat	182,282	291,754	247,555	0	0
Sorghum	104,893	82,013	21,506	13,435	16
Pearlmillet	25,556	44,699	65	0	0
Fingermillet	9,977	13,095	157	0	0
Groundnuts	4,235	5,160	2,969	0	0
Soyabeans	10,986	85,354	87,158	15,506	13.5
Beef	1,899	115,000	65,843	5,249	3
Milk	-	193,600	89,500	5,249	3
Pork products	20,000	87,102	10,565	53,000	60

Source: Economic and Marketing Branch (MLARR), Agricultural Marketing and Central Statistical Office, 1986.

Structure of the Agriculture Sector

The agriculture sector comprises four basic types of land ownership. In the communal areas, land belongs to the state, and no farmer can purchase or have title to the land. However, in each of the 170 communal areas, land is occupied by families of the same clan and subclan, and individual rights are conditioned by position within the family and the clan. The most basic right is the "right of avail", which is acquired on marriage or on attaining a "mature age". This right of avail includes rights (a) to have land for cultivation, (b) to graze livestock on the grazing areas, (c) to the use of natural resources on the land, like timber, water, and firewood, and (d) to a site on which to build a house.

In the resettlement areas a variety of land tenure exists, ranging from individual ownership, cooperatives, and leaseholds, to the right of avail, as in communal areas. In the commercial sector - large and small - ownership of all land is by title deed and is therefore private. The Government of Zimbabwe also owns some agricultural estates, where a wide range of products are produced by parastatal agencies. The rest of the land is either urban or national land used for various purposes, e.g., national parks.

The socioeconomic structure of the agriculture sector is characterized as dualistic. The commercial sector is in the most potentially productive parts of the country, with relatively high levels of infrastructure, management, and output comparable to any developed country. In this sector there is a lower average population density of 9.4 persons/sq km. All but a handful of farmers are white. In the communal areas, over 74% of the land is in the least-productive Natural Regions IV and V, with little infrastructure, traditional management, low output, and high population densities of about 25 persons/sq km. All the people are black.

Table 8 shows also that the land available for the large-scale commercial sector is almost the same size as that available for communal-area farmers, despite the large difference in population size. A large proportion of the population in the large-scale commercial sector are wage earners.

Table 8: Population and Agricultural Output by Sector (1980 Estimates)

Criteria	Large-scale commercial sector	Small-scale commercial sector	Communal areas
Population (000s)	1,763	100	3,800
Available land (000 ha)	14,798	1,500	16,000
Number of Farms	6,034	8,708	760,000
Hectares/Farm	2,452	172	21
Output/ha ($)	38.4	12.6	9.1

A number of farmer organizations are recognized by the Ministry of Land, Agriculture and Rural Resettlement as representing their members' interests in matters such as price negotiations, farmer training, and the selection of appointees to some statutory boards like the Agricultural Research Council of Zimbabwe. The large-scale commercial-sector farmers are represented by the Commercial Farmers Union, small-scale commercial sector farmers by the National Farmers Union, and the communal-area farmers by the National Farmers Association of Zimbabwe. In addition, there are commodity associations: Zimbabwe Tobacco Association for flue-cured tobacco growers, Air-Cured Tobacco Association, Coffee Growers Association, Seed Maize Association, Sugar Association, Cattle Producers Association, and National Association of Dairy Farmers. The participation of members of the various organizations on some statutory boards and committees brings strong farmer influence to bear on government agricultural policy formulation. Some farmer organizations, like the Cotton Growers Association, even carry out research on cotton and contribute to the Cotton Research Institute in the Department of Research and Specialist Services.

Before Independence in 1980 the main focus of all these farmer groups was the commercial farming sector, with no attention to communal areas. However, since Independence the government has put more emphasis on communal areas and is urging the three main organizations - the Commercial Farmers Union, National Farmers Association of Zimbabwe, and Zimbabwe National Farmers Union - to merge.

Of particular interest to communal-area development is the Prime Minister's Directive and Policy Statement in 1984 on grassroots local government and land-use planning. It outlined the role and functions of local government, particularly the newly formed Village Development Committees and the Ward Development Committees in defining the limits and management of their natural resources (World Bank, 1985). The Ministry of Local Government, Rural and Urban

Development is establishing an infrastructure at the national, provincial, and district levels to give well-coordinated support to convert development policies for communal areas into programs for action in accordance with the principles of participation and decentralization (Ministry of Lands, Agriculture and Rural Resettlement, 1985).

Development projects are formulated at the village level by the Village Development Committee, then passed to the Ward Development Committee, and eventually to the district administrator. A Provincial Development Committee coordinates all development projects in the various districts of its province, according to the wishes of the people.

Major Units in the Agricultural Technology Management System

In Zimbabwe, several government and non-government organizations are actively involved in the agricultural sector. They include ministries, statutory boards and parastatals, private companies which manufacture agricultural inputs, the University of Zimbabwe, development agencies, and private voluntary associations. Overall, however, the government-related organizations are the main actors in the national agricultural sector. The private companies tend to be more active in the commercial sector, while the voluntary associations are active in communal areas. A brief overview of the principal organizations follows

Department of Research and Specialist Services. This Department of the Ministry of Lands, Agriculture and Rural Resettlement (MLARR) is the largest research organization in the country and, with other departments in the Ministry, is entrusted with the welfare and technical progress of agriculture in Zimbabwe. It is responsible for conducting research in agricultural science, crop and livestock production, for provision of services to the agricultural industry and regulatory services under various acts of Parliament. The Department has three research divisions, each under an assistant director: Research Services Division, Crop Research Division and Division of Livestock and Pastures.

Extension. A number of government departments, parastatals, private companies and non-governmental organizations are involved in extension. The largest extension organization in staff, budget, and coverage is the Department of Agricultural, Technical and Extension Services (AGRITEX) of the MLARR. This department is an amalgamation of the former departments of Conservation and Extension and Agricultural Development, which used to provide separate extension services to the large-scale commercial sector and communal-area farmers respectively. It has two divisions - the Field Division and the Technical Division. With technical back-up by the latter, the Field Division manages a decentralized structure of administrative and information dissemination teams in each province. Subject-matter specialists of the Technical Division are attached to the provincial teams. In each province there are about six geographical regions, each managed by a regional agricultural extension officer, whose job is to plan and implement extension

programs. At the field level, frontline extension workers maintain close contact with farmers. Because the ratio of extension workers to farmers is extremely unfavorable (1 to 800), the strategy is to promote and use formal and informal groups to reach the maximum number of farmers. At present, the main thrust of AGRITEX is in the communal areas, since the development of this sector is a high government priority.

The Department of Veterinary Services of the MLARR has a field team of veterinary extension assistants in each province. They are responsible for eradication of animal diseases through various activities, such as vaccinations, inspection of abbatoirs, post mortems, collection of blood samples, and dipping services for protection against tick-borne diseases. Through liaison with other departments, such as National Parks and Wildlife Management, AGRITEX, and DR&SS, the Department of Veterinary Services educates farmers in the relationship between their livestock and the diseases affecting them.

Statutory Marketing Organizations. Several marketing boards and parastatals enable the government to monitor the supply and demand of major commodities. If well-funded and managed, these organizations can adapt to any modified or expanded pattern of production resulting from research, development, and government policy.

Development Banks and Agencies. The major participants are the Zimbabwe Development Bank, Agricultural and Rural Development Authority, Agricultural Finance Corporation, commercial banks, agricultural cooperatives, and other companies. At the national level, the Agricultural Finance Corporation is the most important. Its objectives are to promote agriculture in Zimbabwe by making credit for inputs and development available to individuals, groups, cooperatives, and societies. While most of the loans for development by these organizations are for the commercial farming sector, the Agricultural Finance Corporation has expanded its services to communal areas very significantly since 1980.

Universities. The University of Zimbabwe, through its faculties of Agriculture and Veterinary Science, is the major supplier of professional research staff in the country. It is involved in the agricultural technology management system only for generation of basic technologies. The University of Zimbabwe does have a limited on-farm research (OFR) program, however, and has been collaborating with on-farm research programs in the MLARR.

Parastatals. The main parastatal agencies in agricultural research in Zimbabwe are the Tobacco Research Board, the Pig Industry Board, the Agricultural and Rural Development Authority, and the Forestry Commission. The research program of these agencies is mainly for commercial farming, except for the Agricultural and Rural Development Authority, which caters mainly for the communal and resettlement areas. The Forestry Commission is now collaborating on an agroforestry research project, and the Pig Industry Board is initiating some diagnostic activities, both in communal areas.

Private-Sector Research. In addition to private companies manufacturing agricultural products, such as chemicals, fertilizers, and livestock feeds, a number of producer associations are also actively involved in research on their specific commodities. These include the Zimbabwe Seed Maize Association, Zimbabwe Sugar Association, Cotton Growers Association, and Agricultural Research Trust Farm.

Supporting Infrastructure for Agriculture

Roads. The main road network is along the watershed route from Bulawayo in the southwest, through Harare to Mutare in the east, and across the river valleys from Bulawayo through Masvingo to Mutare. The road network varies considerably in quality and extent between the communal areas and commercial agriculture sectors. The majority of communal-area farmers live far away from major all-weather roads. Most of the roads in these areas are gravel and earth, with limited accessibility during the wet season. The commercial sector, on the other hand, is served by good all-weather roads, and the main road network of the country is basically in these areas. The implications of this for development in both sectors are obvious.

Zimbabwe is landlocked, but there are efficient road services to all neighboring countries.

Markets. The agricultural marketing system is highly developed and organized, with all the major agricultural products controlled by statutory boards which also carry out the handling, processing, and distribution. Zimbabwe exports several commodities to neighboring and European states, the major commodities being tobacco, cotton, coffee, meat, and maize.

Credit. Agricultural credit in Zimbabwe comes mainly from either parastatals or commercial sources. The key parastatals are the Agricultural Finance Corporation and the Cold Storage Commission.

Commercial lending comes from the commercial banks, financial institutions, farmers' cooperatives, and private-sector companies. Commercial banks and cooperatives finance most of the short-term loans, and medium-term lending is from the Cold Storage Commission and finance houses. The Agricultural Finance Corporation is the only long-term lender.

The existing credit facilities are efficiently organized and adequate for the commercial farming sector but are inadequate for communal area farmers because of the requirement for collateral which they cannot provide because they do not hold title deeds to the land. However, since 1980, the Agricultural Finance Corporation has expanded credit to communal farmers. Other sources are private organizations like Silveira House, savings clubs, and informal associations.

Input Supply. Most inputs like seed, fertilizer, chemicals, machinery, and equipment are available and are used in fairly large quantities. Their supply and distribution in the commercial sector

is efficient but not in communal areas, where there are cash constraints and problems of timely distribution. Most agricultural inputs have some imported content, even if manufactured or produced locally. Because of balance-of-payments problems, most inputs have been controlled by the government through the import control system, and prices are subject to either specific or general price control regulations.

Irrigation Facilities. Irrigation facilities exist in three main areas where large-scale irrigation schemes are or can be established: the lowveld Sabi Valley, the Lundi River Catchment Area and the northeast. Several small- to medium-size farm dams are used by commercial farmers.

Some 100,000 ha of suitable irrigable soils have been proved in the west banks of the lower Sabi River area, of which only about 10,000 ha are being irrigated at present. In the north and northeast catchment areas, a further 300,000 ha of land could be irrigated if major dams were built.

In communal areas, over 9,000 small dams, boreholes, and wells have been established, but the farming community in these areas is to a large extent still dependent on surface-water resources, and home-dug wells are adequate only for home use. A large number of small irrigation schemes have recently been established in low-potential communal areas, and the government has appropriated additional funds to support these projects.

Market Structure for Agricultural Products

An efficiently organized marketing system exists for all major agricultural products in Zimbabwe. The four statutory marketing boards (Dairy Marketing Board, Cold Storage Commission, Cotton Marketing Board, and Grain Marketing Board) all offer guaranteed prices to producers and provide a guaranteed market for products within the country. The prices offered to producers by the government are decided upon after consideration of the nation's internal and export requirements, the need to maintain viable profit margins for producers, and the ability of consumers to purchase these products.

This system has resulted in heavy government subsidies for these boards: about 10% of the total annual budget of MLARR is used to cover their deficits. However, the boards serve consumers and producers and also enable the government to monitor and control production and supply of essential commodities.

The prices of some products (sugar, coffee, tea and tobacco) are not set by the government but by the international market. This can lead to fluctuations in production in response to price changes. For "non-controlled" crops, such as traditional crops in communal areas (cowpeas, bambara nuts, and squash), farmers have to rely on local markets which are usually very unstable, thus forcing farmers to produce mainly for home consumption.

TECHNOLOGICAL CONSTRAINTS TO AGRICULTURAL DEVELOPMENT

Communal Areas

In the communal areas, production systems are very extensive and the yields per unit area are still below the potential of the areas. Research is therefore needed to develop appropriate technologies to improve the management and performance of existing crops and to develop new crops that may be more appropriate to the environmental conditions of communal areas, especially those in low-potential zones. An adequate pricing structure and improved infrastructure and services would certainly motivate farmers to adopt technological innovations, as the last five years of experience with maize in the communal areas clearly demonstrates. Notable production increases may then lead to changes in the land-tenure system, objectives, and attitudes of farmers toward certain enterprises and group organizations.

Commercial Sector

Productivity in the commercial sector is at present very high and comparable to any in the developed world. However, greater economic efficiency in the use of commercial inputs may be a relevant objective for these farmers and research organizations. The potential of new commercial crops for export is largely unexplored, and it would be good policy to use this sector to introduce them, since it can readily assess profitability, can learn new management and husbandry techniques, and can probably better cope with associated risks.

CHAPTER TWO

AGRICULTURAL RESEARCH AT THE NATIONAL LEVEL

OVERVIEW OF AGRICULTURAL RESEARCH IN ZIMBABWE

Zimbabwe has a long tradition of agricultural research dating back to the beginning of this century. Research on maize, for instance, has been going on in DR&SS for 40 to 50 years. Until 1980, research was mainly directed to improving commercial crop and livestock production, thus mainly benefiting the large-scale commercial sector. Little research was for the communal areas, even though it was by far the largest sector in the country. In 1980 it was recognized that more agricultural research - particularly adaptive research - was needed to develop innovations suited to the specific environment of the communal areas.

Agricultural research in Zimbabwe is carried out by organizations in both the public and private sectors. The Agricultural Research Council was formed in 1970 to coordinate all public-sector agricultural research in the country, excluding tobacco, sugarcane, pigs, and forestry. Research is implemented by a number of government, parastatal, and independent bodies: DR&SS, Tobacco Research Board, Zimbabwe Sugar Association, Pig Industry Board, University of Zimbabwe, Seed Co-op Company of Zimbabwe, chemical and fertilizer companies, AGRITEX, Department of Veterinary Services, Department of National Parks and Wildlife, and the Agricultural Research Trust Farm. Their mandates, primary functions, and linkages with the Department of Research and Specialist Services (DR&SS) are summarized in Table 9.

Of these bodies, the following have on-farm research programs in communal areas: DR&SS (crop and livestock), AGRITEX (crop and livestock), Tobacco Research Board, chemical and fertilizer companies (crops), and the University of Zimbabwe (crops and goats).

This study focuses on the principal research organization in Zimbabwe: DR&SS which, together with AGRITEX and the Department of Veterinary Services, constitutes the technical departments of the MLARR. DR&SS is by far the largest organization involved in communal areas and on-farm research at the national level.

Table 9: Principal Research Bodies in Zimbabwe: Primary Functions and Linkage

Organization (Governance)	Primary functions	Linkages
DR&SS (MLARR, public)	Researches crops, livestock and pastures (except tobacco, sugar, tea and pigs)	Comprising representatives of farmer and other agricultural organizations
	Supervises the implementation of certain agricultural acts of Parliament	Supported by World Bank, Institute of Rural Development Zimbabwe, Centro International de Mejoramiento de Maiz y Trigo, International Livestock Centre for Agriculture, International Institute for Tropical Agriculture, British Overseas Development Administration, Center for International Agriculture, International Development Research Centre, International Service for National Agricultural Research, International Council for Research in Agroforestry
	Provides services to the agricultural industry	
AGRITEX (MLARR, public)	Extends agricultural research findings to farmers	Represented in the Agricultural Research Council
	Conducts research on agricultural engineering	Participant in On-farm Research Planning Committee
Department of Veterinary Services (MLARR, public)	Conducts research on animal diseases	University of Zimbabwe
DNPWM* (Ministry of Natural Resources and Tourism, public)	Promotes improved management of fisheries, ecology and wild game areas	National Conversation Strategy
Tobacco Research Board formed in 1950 (parastatal with financial support from the Zimbabwe Tobacco Association)	Conducts research on flue-cured and air-cured tobacco	None (informal)
Pig Industry Board (parastatal entirely financed by levies on pig producers and income from its experimental farm)	Conducts research on the management and housing of pigs, nutrition and breed improvement	Represented in Agricultural Research Council
University of Zimbabwe (parastatal research)	Teaches agriculturalists and carries out research in biological crop, animal and veterinary sciences Council	Represented in Agricultural Research
Seed Co-op Company (private)	Conducts agro-economic and breeding research on a number of crops	Procurement of breeding recommendations from DR&SS
Agricultural Research Trust Farm (private, financed by Commercial Farmers Union and agricultural industry)	Conducts agro-economic research; Conducts demonstrations; Provides land to researchers in both Government and private bodies	Commercial Farmers Union represented in Agricultural Research Council
Chemical and fertilizer companies (private)	Sells chemicals and fertilizers; tests chemicals and fertilizer recommendations	None
Zimbabwe Sugar Association	Researches into breeding, agronomy, pathology, entomology, etc. of sugarcane production	None

* Department of National Parks and Wildlife Management.

LINKAGES OF DR&SS WITH DONORS AND OTHER EXTERNAL SOURCES

In 1983 the World Bank, in association with the International Fund for Agricultural Development (IFAD), provided a US$ 13.6 million loan to the government to assist DR&SS in updating its infrastructure and acquiring the logistic resources to expand its research capability in communal areas. Under the loan agreement, twelve expatriate research scientists were assigned in 1985. The World Bank/IFAD loan has specifically benefited the communal-area on-farm research programs in the Agronomy Institute, the Crop Breeding Institute, the Cotton Research Institute, the Lowveld Research Station, and the Plant Protection Research Institute. The plant breeding and agronomy components of the low-rainfall stations (Matopos, Makoholi, Chiredzi, and Chisumbanje) have been expanded, and the Chemistry and Soil Research Institute was provided with support to undertake the physical resource inventory study.

The International Development Research Centre (IDRC) has provided support to the Crop Breeding Institute and the Farming Systems Research Unit. The Crop Breeding Institute received a three-year grant to expand its experiment station research and on-farm research of the sorghum and millet breeding program, which ended in 1986. The Farming Systems Research Unit was set up in 1984 with a two-year grant to organize the program, train local staff, and expand the crop program to include livestock production research, with the technical assistance of a project adviser and ILCA. At present the DR&SS/IDRC agreement is in its second phase.

IITA has provided training for local staff in DR&SS on technical topics such as root crops, tuber crops, cowpea and soyabean production and has also contributed technical assistance and germplasm materials as have CIAT and others. Since 1985 an IITA cowpea agronomist posted at DR&SS has been working closely with the Crop Breeding Institute, the Agronomy Institute, and the Farming Systems Research Unit.

ICRAF recently initiated planning and training activities with DR&SS and other Zimbabwean organizations on the potential functions and application of agroforestry systems to communal areas. This collaboration is expected to expand in the near future, as Zimbabwe has been requested to join the regional network sponsored by ICRAF.

The Faculty of Agriculture of the University of Zimbabwe participated with CIMMYT in a number of diagnostic surveys, particularly at the beginning of the on-farm research program in DR&SS. Indeed, CIMMYT was instrumental in initiating FSR in the Agronomy Institute in 1981. At present, the social scientists at the University of Zimbabwe continue to collaborate with the Farming Systems Research Unit socioeconomic program. In addition, the University of Zimbabwe supplies DR&SS with first degree graduates, supervises postgraduate degrees, and trains researchers in on-farm research procedures through its regional training workshops.

DR&SS receives many visiting scientists from institutions worldwide. Researchers participate in local and international workshops and meetings and visit international research centers.

They also train at overseas institutes. DR&SS has always made funds available to maintain and update its libraries with the most recent publications and journals. DR&SS circulates its two agricultural research journals locally and internationally.

LINKAGES WITH TECHNOLOGY USERS AND THE TRANSFER SYSTEM

Linkages to Extension

In 1970, the Agricultural Research Council was established by the then Minister of Agriculture to keep under review, promote, and coordinate all agricultural research in the country, except on tobacco, sugarcane, pigs, and forestry, which were not included in the DR&SS' mandate. Table 10 shows membership of the Agricultural Research Council in which DR&SS and AGRITEX are represented, thus coordination exists at the highest level. Before Independence and for two years after, the AGRITEX grain specialist was housed in DR&SS for close consultation with researchers. During the same period DR&SS and AGRITEX sat together at commodity meetings sponsored by the Agricultural Research Council. Unfortunately, research and extension were largely directed at the large-scale commercial sector.

Table 10: Agricultural Research Council Membership, 1987

Organization	Number of Representatives	
Commercial Farmers Union (large-scale commercial sector)	3	
National Farmers Association of Zimbabwe (communal-area farmers)	1	
Zimbabwe National Farmers Union (small-scale commercial sector)	1	
Ciba-Geigy	1	
Pig Industry Board	1	
University of Zimbabwe Faculty of Agriculture	1	(Dean)
Cattle Producers Association	1	
DR&SS	4	
AGRITEX	1	
Tobacco Research Board	1	(Director)
Department of Rural Development	1	(Director)
Total	16	

When government priorities (and consequently research priorities) shifted to the communal-area sector, it became evident that the existing organizational arrangements were not adequate to meet the challenge. The committees were then abandoned, but there is now talk of reforming them with representatives from all agricultural sectors. Some DR&SS institutes and stations are regional or national, and each has generally developed good working relations with AGRITEX provincial officers.

AGRITEX officers have been involved in the planning of research since the initiation of the farming-systems research program under the Agronomy Institute in 1981. However, the involvement of AGRITEX staff has never been very successful, due to problems such as burdening extension staff with research requirements in addition to a heavy extension workload. Recently, however, a Committee for On-farm Research and Extension was formed with AGRITEX for the purpose of promoting close linkages through consultation at the planning, implementation, monitoring, and evaluation phases of both on-farm research and demonstrations.

Linkages to Development Agencies

The major development agencies having links with DR&SS are the Agricultural and Rural Development Authority, the Agricultural Finance Corporation, the Cold Storage Commission, the Grain Marketing Board, and the Cotton Marketing Board (Table 11). One Agricultural and Rural Development Authority estate provides DR&SS breeders with facilities in a warm and frost-free area during the winter, which permits continuous generation of germplasm. The Agricultural Finance Corporation has consulted DR&SS and AGRITEX in the formulation of its credit packages for communal area farmers for the purpose of defining economic input levels, which ensures farmer benefits and ability to pay back. DR&SS has taken this opportunity to update the packages with the latest research findings, and to obtain feedback from the Agricultural Finance Corporation on the viability of current recommendations. The Cold Storage Commission has provided livestock on a short-term loan basis for station trials. The Grain Marketing Board has provided communal-area farmers with accessible buying depots, thus encouraging farmers to produce more and to adopt recommended production practices. The Cotton Marketing Board has done the same with cotton.

Linkages to Farmers

Three farmer organizations represent three sectors of the industry. The government has been encouraging them to amalgamate, but this has not yet been achieved.

The National Farmers Association of Zimbabwe represents approximately 850,000 farmers. Linkages between it and DR&SS did not exist before 1980. At Agricultural Research Council bimonthly meetings, the Association expresses its views and requirements from DR&SS. It is similar to the Zimbabwe National Farmers Union, except that this smaller group, representing about 10,000 small-scale commercial-sector farmers, has recently given a grant to DR&SS for further research relevant to small farmers.

Table 11: Parastatal Development Agencies Having Links with DR&SS

Agency	Primary Functions	Governance
Agricultural and Rural Development Authority	Manage state farms, produce crop and livestock commodities, and facilitate rural development	Parastatal
Agricultural Finance Corporation	Provide credit to farmers and administer repayments	Parastatal
Cold Storage Commission	Provide marketing structure for livestock, purchase and slaughter of animals and ensure quality of meat with DR&SS help	Parastatal
Grain Marketing Board	Provide marketing structure for grain Purchase and sales at government-controlled prices	Parastatal
Cotton Marketing Board	Provide marketing structure for cotton, and purchase and sell the produce	Parastatal

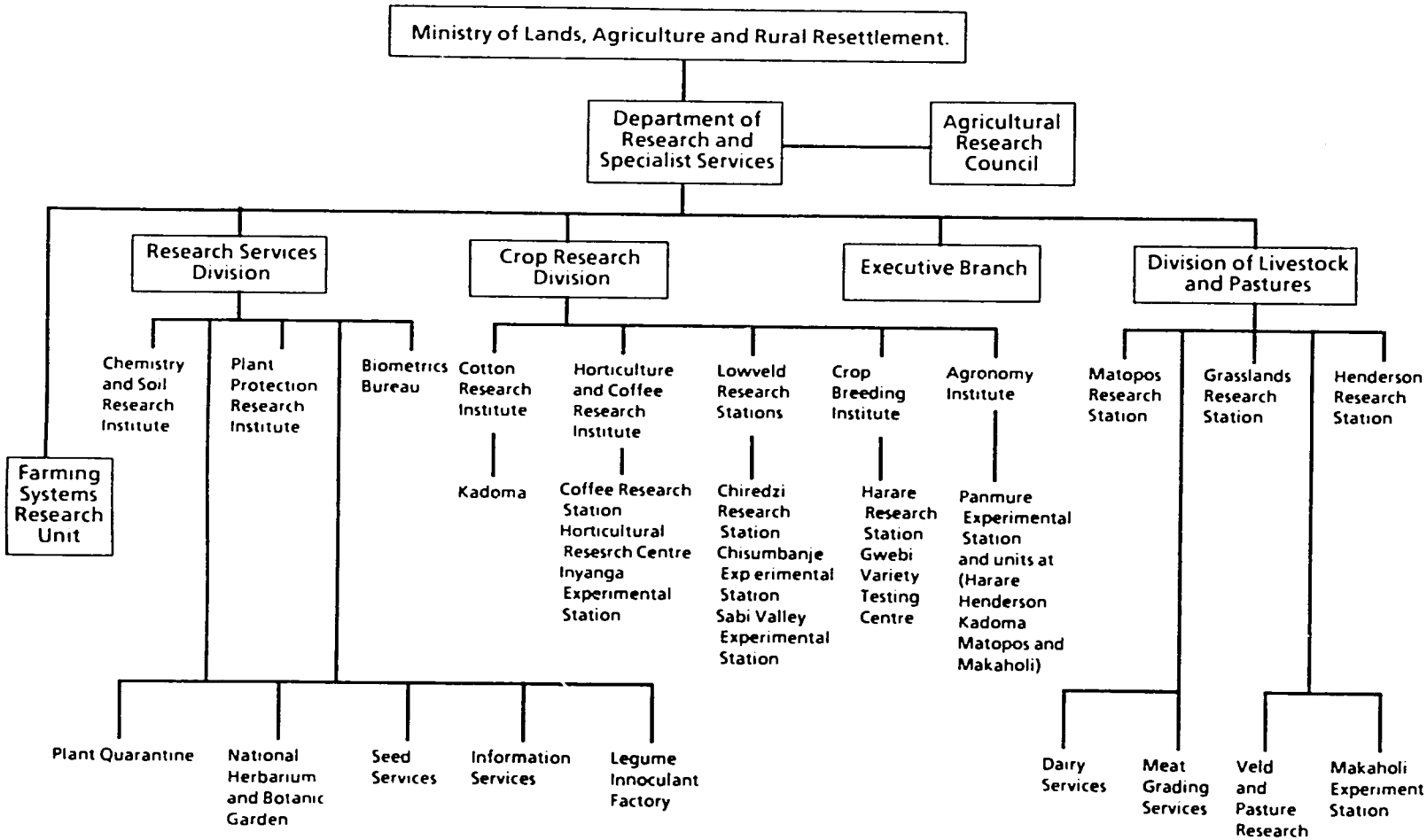
The Commercial Farmers Union has a long history of close linkages with DR&SS. Before 1982, commercial farmers were well represented in the commodity committees formed by the Agricultural Research Council. These committees are no longer in existence, but the Commercial Farmers Union continues to be fully represented in the Agricultural Research Council. This organization of about 4,500 farmers at present provides approximately $350,000 to DR&SS annually.

Besides these linkages with farmers, DR&SS provides services such as soil analysis, seed services, dairy inspection, and cattle grading and marketing to the industry or to the farmers who seek advice. However, it is evident that communal-area and small-scale commercial-sector farmers do not use these facilities as much as the large-scale commercial-sector farmers. Since 1980, DR&SS has developed direct linkages with communal area farmers and farmer groups on a larger scale.

THE ORGANIZATION AND STRUCTURE OF DR&SS

This Department comprises an executive branch under a chief executive officer who is responsible for personnel management, financial control, and three divisions: Research Services, Crop Research, and Livestock and Pastures, each under an assistant director who reports to the director. The divisions are further divided into institutes, stations, sections, or units by discipline (Figure 2).

Figure 2. Structure and Organization of the Department of Research and Specialist Services, 1987



Research Services Division

The Research Services Division is charged with the conduct and coordination of disciplinary research in the biological, physical, and mathematical sciences as applied to agriculture, and with providing services in support of the research programs of other branches of DR&SS, as well as for the agricultural industry as a whole. It also carries out several regulatory functions with respect to animal feeds, fertilizers, seeds, pesticides, and herbicides. The Plant Protection Research Institute and the Chemistry and Soils Research Institute conduct on-farm research trials and surveys in communal areas in addition to their experiment station research trials. The Biometrics Bureau is generally consulted by researchers when trials are being designed or results analyzed. The National Herbarium and Botanic Garden, Seed Services, and the Inoculant Factory are also under this Division.

Crop Research Division

The Crop Research Division is responsible for coordination of research policy and functions of institutes, stations, and research groups working on field and horticultural crops. The following institutes and stations conduct on-farm research trials in communal areas: the Agronomy Institute, the Cotton Research Institute (the only commodity research institute in the Department), the Crop Breeding Institute, and the Lowveld Research Station (the only station with a regional mandate for Natural Region V, which is generally referred to as "lowveld"). The Agronomy Institute is responsible for all aspects of field crop agronomy research other than cotton and lowveld irrigation. The Cotton Research Institute is responsible for pest control, agronomy, breeding and physiology research on their cotton. The Crop Breeding Institute is responsible for the breeding or selection of hybrid maize, wheat, barley, sorghum, millet, soyabeans, groundnuts, sunflowers, beans, and potatoes. The Lowveld Research Station undertakes variety testing, crop selection, research on subtropical fruits and vegetables, and irrigation agronomy. The station has extended research into communal areas in Natural Region V.

Division of Livestock and Pastures

The Livestock and Pastures Division is responsible for all aspects of livestock production, including cultivated pastures and natural grazing areas. In addition to its research functions, it has a regulatory role in the poultry and dairy industries and also undertakes grading of beef carcasses at abattoirs throughout the country. The Division participates only indirectly in on-farm research in communal areas through continued collaboration with the Farming Systems Research Unit on diagnostic and trial work. The Division's infrastructure at its research stations is representative of Natural Regions II, III and IV, placing it in an advantageous position to conduct research for communal areas.

Farming Systems Research Unit

The Farming Systems Research Unit, formed in early 1984, is responsible for characterizing farming systems and adaptive research trials on crop and livestock production in communal areas, and its team is interdisciplinary, comprising crop, livestock and social scientists. It reports directly to the director of DR&SS.

POLICY FOR AGRICULTURAL RESEARCH

It is widely accepted locally that technology for large-scale commercial-sector farms is available as a consequence of the long history of agricultural research by DR&SS. The highest priority now facing DR&SS is making available technology which is appropriate for communal-area conditions, that is for the harsh environments of Natural Regions III, IV, and V, and for enterprises at comparatively low levels of capital investment. This technology could be made available either through modifying current practices in the large-scale commercial sector and/or adapting them to the communal-area sector, or by developing new initiatives and technologies which take into account the communal-area farmers' physical and socioeconomic environment. DR&SS has recognized these two strategies and has taken measures to implement them such as establishing the Farming Systems Research Unit and the expansion of other on-farm research programs. DR&SS, however, continues to give support to the large-scale commercial sector.

DR&SS takes into consideration the Five-Year Development Plan, 1986 to 1990, when prioritizing its tasks. MLARR provides general priority guidelines, for example, emphasis on promoting communal-area development by increasing food production and security. Occasional ad hoc directions are given to DR&SS to follow up immediate concerns, for example, summer wheat, rice, and goats.

DR&SS maintains a close relationship with the Agricultural Research Council, although it is generally felt among senior members of DR&SS that the Council's advisory and coordinative functions are ineffective. Prior to Independence, the Council largely served the interests of the large-scale commercial sector, but its present composition indicates a change in areas of concern since farmer organizations are now represented.

Priority Setting and Resource Allocation

The DR&SS has no formal or specific mechanisms for setting research priorities. It is decentralized, and senior managers and researchers involved consider a number of important factors, including:

- government policies and the Five-Year Development Plan;
- personal interpretation of government policies and perception of researchable problems;
- definition of farmer target groups and priorities;
- commercial value or deficit production of commodities;
- research to improve support services to clients and government agencies;
- requirements for regional and international cooperation;
- contribution to knowledge and professional interest.

The criteria for the allocation of resources are size of the previous year's allocation and level of expenditure, effectiveness of the head of an institute in stating and justifying his request, the assistant director's judgement of research opportunities, and the overall budget procured, mainly from the government treasury. The exact manner of deciding on allocations is through negotiation between directors of divisions and heads of institutes on an individual basis.

Because of the absence of guidelines or strategy, the heads of institutes have considerable latitude in defining their research priorities and programs. Most believe that their research priorities are generally in line with national and agricultural development objectives, which means emphasis on communal areas.

All research projects are planned by research officers in the institutes, and planning mechanisms vary according to institute. For example, some institutes have annual planning meetings at which officers present project proposals for review, comments, and approval by other officers in the institute or other relevant officers from institutes in and outside DR&SS. Other institutes have meetings to review research progress. The heads of institutes and assistant directors participate in the planning exercise and have final authority to approve projects according to present structure and chain of command. The coordination of research activities across institutes is the responsibility of the directorate. However, multiple administrative duties have kept the directorate from performing this task effectively.

It was because of this critical problem and DR&SS emphasis on on-farm research in the communal areas that the Committee for On-farm Research and Extension was formed. The Committee consists of the assistamt director (Field) of AGRITEX and all the heads of DR&SS institutes involved in on-farm research. Its main objective is to facilitate and organize activities to coordinate the planning, implementation, monitoring, and evaluation of on-farm research and demonstration projects.

RESOURCES OF THE DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES

Financial Resources

DR&SS funds come from three main sources:

1) government;
2) farmer organizations;
3) external assistance.

Government. This contribution supports most of the DR&SS budget and has generally remained over 1% of the agricultural domestic product during the years 1964/65 to 1984/85 (Table 12). However, as the budget of MLARR has increased more than proportionately in relation to the DR&SS budget, the DR&SS percentage has declined steadily since 1985.

Farmer organizations. The Commercial Farmers Union (about ZWD 350,000), and recently the Zimbabwe National Farmers Union (about ZWD 10,000) have made yearly grants to DR&SS.

External assistance. This has ranged from 5% to 9% of the total budget from 1984 to 1986 and comes through the National Agricultural Extension and Research Project co-funded by IFAD and the World Bank under a loan agreement. IDRC of Canada supported the sorghum and millet breeding program in the Crop Breeding Institute and now the Farming Systems Research Unit.

Table 12: Government Support to DR&SS, 1965-1986

Year	DR&SS budget as % of AGDP	DR&SS budget as % of total government budget	DR&SS budget as % of Ministry of Agriculture budget
1965		1.30	19.4
1970		1.33	20.6
1975	1.23	0.75	18.0
1980	1.75	0.56	12.7
1981	1.19	0.36	7.7
1982	1.23	0.37	5.7
1983	1.57	0.29	4.0
1984	1.38	0.32	3.8
1985		0.34	4.9
1986		0.33	4.7

Source: ISNAR, 1987.

The British Overseas Development Administration is supporting three projects, the Matopos Goat Research Unit, Henderson Dairy Unit, and the development of the Sabi Valley Research Station. Staff have also been supplied to the Cotton Research Institute, the Chemistry and Soils Research Institute, the Plant Protection Research Institute, the Lowveld Research Station, and the Biometrics Bureau.

The total budget available to DR&SS has increased in nominal and real value from 1975 to 1987. Nominally, the 1986/87 budget was more than twice what it was in 1980, but in real terms it has decreased from ZWD 9,08 to ZWD 7,12 million. In nominal terms, the DR&SS budget would have to increase by at least 15% per annum to keep up with the current inflation rate. Table 13 shows the actual expenditure from 1975 to 1987 in constant Zimbabwean dollars.

Table 13: Total Expenditure of DR&SS, 1975 - 1987

Year	Expenditure (ZWD)	Constant 1980 ZWD[1]
1975/76	3,995,000	5,789,300
1979/80	6,053,400	6,053,400
1984/85	11,803,000	5,875,100
1985/86	14,243,000	6,811,600
1986/87	15,674,200	6,814,900

[1] Adjusted for inflation rate using 1980 as base year.
Source: Government Treasury Reports.

Internal sources of financing from the government and farmers' organizations account for the largest proportion of the DR&SS budget. Donor loans and grants have recently increased (Table 14). The contribution of farmers and others has declined, as it has not matched increases in the total budget.

Table 14: Sources of Contributions to Total DR&SS Budgets, 1984-1987

Source	1984/1985 %	1985/1986 %	1986/1987 %
Government treasury	91.94	87.9	88.6
Farmers and others	3.63	3.0	2.7
Donor grants	4.43	9.1	8.7
Total	100	100	100
Total budget (ZWD)	11,803,000	14,243,000	15,674,200

Source: Government Treasury Reports.

Although research managers have indicated that the DR&SS budget has had a high salary and wages component in its allocation to research in recent years, if funds from external sources are included mainly for running expenses, there appears to be a favorable proportion for operational purposes (Table 15). The percentage share has, however, declined since 1980.

Table 15: Percent Distribution of Total DR&SS Budget According to Major Items, 1988

Source	1975	1979/80	1985/86
Salaries, wages, and allowances	53.2	59.3	61.8
Investment funds	2.3	1.5	0.5
Operating funds	44.5	39.2	37.7
Total	100	100	100

Source: Government Treasury Reports.

The existence of the Agricultural Research Fund may be considered as a buffer mechanism in that if monies become exhausted, resources from this fund can be drawn upon in emergency.

It is evident that capital investments are a very small proportion of the total budget. These are vulnerable to freezes by the government, particularly at the end of the fiscal year. Because of the serious neglect of infrastructure and equipment, the government supported the World Bank/IFAD loan to update DR&SS infrastructure.

Table 16 shows the percentage distribution of operational expenditure of each Division's institutes in three different years between 1975 and 1986. The Crop Research Division has maintained its share of the budget whereas the Research Services Division has increased its share at the expense of the Division of Livestock and Pastures. Within the Crop Research Division, the major change is the appearance of the Agronomy Institute and the closing down of the Sabi Experiment Station in 1979. There have not been any major shifts in budget allocations since, except that some crop research institutes, particularly the Crop Breeding Institute, the Agronomy Institute, the Cotton Research Institute, and the Lowveld Research Station, have expanded research in the communal areas. With the increased emphasis on communal areas, these institutes have had to modify their experiment station research programs.

Within the Livestock and Pastures Division, the share of the total DR&SS operational budget allocated to every station, except Grasslands, has been slightly reduced since 1975. This may explain why these stations have not participated much in communal-area on-farm research.

In the Research Services Division, the Chemistry and Soils Research Institute and the Plant Protection Research Institute have notably increased their share of the budget since 1980. These institutes have initiated and expanded on-farm research work in communal areas.

Finally, the Farming Systems Research Unit was established in early 1984. About a third of its operational budget came from the Crop Research Division and the rest from IDRC, with some indirect support from the Livestock and Pasture Division.

Table 16: Percentage Distribution of Operational Expenditure among DR&SS Institutes, Stations, and Units, 1975-1986

Division/Station/Unit	1975/76 %	1979/80 %	1985/86 %
Crop Research Division			
Crop Breeding Institute	8.3	6.9	7.6
Agronomy Institute	-	3.1	3.1
Makoholi Crop Production Unit	0.6	0.8	1.9
Matopos Crop Production Unit	0.6	0.6	0.8
Panmure Extension Supervisor	1.1	1.5	1.0
Weed Research Unit	1.3	1.5	1.3
Lowveld Research Station and Chisum (Extension Supervisor)	7.9	8.3	7.6
Cotton Research Station	9.3	9.2	8.5
Cotton Research Station	4.1	5.9	4.2
Horticultural Research Station	1.4	2.5	2.8
Rhodes-Inyanga Extension Supervisor	1.8	2.3	2.0
Sabi Extension Supervisor	4.1	0.0	0.0
Subtotal	42.6	42.7	42.7
Livestock and Pasture Division			
Grasslands Research Station	[illegible].5	10.7	9.5
Matopos Research Station	16.3	14.5	13.4
Makoholi Extension Supervisor	4.1	4.4	3.7
Henderson Research Station	15.1	14.5	13.6
Subtotal	45.8	44.4	40.3
Research Services Division			
Biometrics	2.4	2.6	2.1
Chemistry and Soil Research Institution	4.4	4.8	6.7
Plant Protection Research Institution	4.1	2.8	4.0
Technical Development Unit	0.6	0.2	0.4
Information Services	0.0	2.4	2.8
Subtotal	11.5	12.9	16.2
Farming Systems Research Unit	-	-	0.8
Total	100	100	100

Source: ISNAR, 1985, and DR&SS records.

Table 17 shows the operational resources available to the professional staff in each division in 1985/86. The average annual operational expenditure per research officer in DR&SS was about ZWD 40,000. There are notable differences between the divisions, with Livestock and Pastures having more than double the DR&SS average, and Research Services and the Farming Systems Research Unit having roughly about a third of this average. These differences reflect the specific costs (maintenance, travel, subsistence) associated with the type of research and/or services being undertaken.

Table 17: Operational Expenditure per Research Officer in DR&SS Divisions, 1985/86

Division	Operational Budget	Number of Research Officers	Average Operational Expenditure per Research Officer (ZWD)
Crop Research	2,292,824	47	48,783
Livestock and Pasture	2,163,953	25	86,558
Research Services	869,877	59	14,745
Farming Systems Research Unit	42,957	4	10,739
Total	5,369,611	135	39,775

Source: DR&SS records.

Human Resources

The number of professional staff in DR&SS increased from 94 to 135 between 1970 and 1986, with most of the growth occurring after 1977 (Table 18). The Research Services Division has consistently had the largest share of staff, followed by the Crop Research Division and then the Livestock Division. From 1977 to 1984, the staff increases were shared more or less proportionally across the three divisions. Between 1984 and 1986, however, the Crops Division was strengthened with an addition of 12 research officers, while the Livestock and Pastures Division lost the same number. The Farming Systems Research Unit, formed in 1984, has been staffed with four research officers drawn from both the Crops and Livestock Divisions.

Table 18: Distribution of Research Officers for each DR&SS Center Division 1970-1986

	1970		1977		1984		1986	
	No.	%	No.	%	No.	%	No.	%
Crop Research	29	31	31	30	35	27	47	35
Livestock and Pastures	22	23	27	26	37	28	25	18
Research Services	43	46	46	44	56	42	59	44
Farming Systems Research	-	-	-	-	4	3	4	3

Source: ISNAR, 1985 and DR&SS records.

DR&SS professional staff are supported by four levels of research assistance: research technicians, agricultural assistants, technical assistants, and research hands. Research technicians are diplomates in agriculture; i.e., two years of technical education after secondary school. Agricultural assistants have certificates in agriculture; i.e., two years of technical education, but may not have finished secondary school or may have had inadequate grades. Technical assistants are laboratory workers with four to six years of secondary education, and research hands are field workers. Research assistants are responsible to research officers.

The overall technician/scientist ratio fell in 1985 and 1986 and is below the 1:1 ratio which prevailed during the 1970s (Table 19). The Research Services Division has had a ratio of less than one and is the lowest at present, suggesting that its scientists may be forced to divert attention from important duties. The Crop Research Division has the best ratio, which suggests that its scientists are better supported. The Farming Systems Research Unit has the second highest ratio. The Livestock and Pastures Division had the highest ratio during the 1970s but this fell to less than half up to 1986. This ratio is an important indicator because it is believed that a favorable ratio should increase the possibility and efficiency of on-farm research.

Table 19: Ratio of Technicians to Scientists for each DR&SS Division

	1970	1977	1984	1986
Crop Research Division	1.0	1.3	1.0	0.9
Livestock and Pasture Division	1.8	1.3	0.7	0.6
Research Services Division	0.8	0.7	0.5	0.5
Farming Systems Research Unit	-	-	0.7	0.7
Total DR&SS	1.0	1.0	0.6	0.6

Source: ISNAR, 1987.

Table 20 shows resignations of research officers and technicians in the post-Independence period. The number of resignations for both was high in 1981 but has decreased, especially among research technicians. There are various reasons for this. Right after Independence, many experienced scientists resigned because they did not agree with the new government programs and priorities and/or they felt that DR&SS would not receive the support needed to maintain its high quality of scientific and technical standards. As a government institution, public service regulations for promotion and advancement apply to staff in DR&SS. By developing country standards, the level of salaries of DR&SS scientists and technicians is relatively high, but the declining value of incomes as a result of inflation, far in excess of public-sector salary increases, has resulted in a sizeable public/private-sector income differential. Consequently, DR&SS staff continue to leave for more lucrative appointments in the private sector. In January 1984, the pay award of 5% for all civil servants plus an additional 15% for civil

servants in designated highly skilled occupations, which included agricultural research scientists and technicians, improved the situation, but erosion of real incomes has accelerated since then.

Table 20: Number of Research Officer and Research Technician Resignations, 1981-1986

	1981	1982	1983	1984	1985	1986
Research Officer	30	27	22	20	10	16
Research Technician	37	9	16	5	10	12
Total	67	36	38	25	20	28

Source: ISNAR, 1987.

Filling vacancies has not been a major problem, because the university is now producing a considerable number of graduates each year. In fact, finding employment for them will soon become a problem. Student matriculation in the Faculty of Agriculture has more than doubled in the post-Independence period, and agriculture colleges are also producing a substantial number of technicians since the duration of the course was shortened from three to two years.

Table 21 provides a grade and experience profile of DR&SS professional staff in 1986. About 77% of the professional staff are in the lowest two grades: research officer and assistant research officer. The majority, 55%, have less than five years of research experience, particularly in the Agronomy Institute, the Horticulture and Coffee Research Institutes, and the Lowveld Research Station in the Crop Research Division, Henderson, Matopos, and Dairy Services in the Livestock and Pastures Division (though these have a few senior scientists in each), and the Plant Protection Research Institute and Biometrics in the Research Services Division. Thus DR&SS professional staff in the post-Independence period was largely made up of young scientists with limited research experience.

The disciplinary breakdown of DR&SS scientific staff and the number of research units to which they are assigned are presented in Table 22. In crop research the most represented disciplines are agronomy, soil chemistry, and crop breeding, and of these only the agronomists belong to more than one research unit. In livestock production, the most represented disciplines are animal production, dairying and animal breeding, and all these scientists are assigned to more than one research unit.

The absence of economists and other social scientists is particularly noteworthy. DR&SS has traditionally depended on MLARR and AGRITEX economists to provide such inputs into research decision-making. However, this linkage has never had any substantive effect on DR&SS programs.

Table 21: Grade and Experience Profiles of Research Officers in DR&SS, 1986

		Grade[1)]			Research Experience (years)				
	National	PRO	SRO	RO	0-5	6-10	11-15	16-20	20+
Crops									
Agronomy I	12	2	0	10	6	3	1	0	2
Cotton Research Institute	7	0	0	7	7	1	2	0	0
Crop Breeding Institute	8	1	1	6	4	1	1	0	2
Horticulture and Coffee Research Institute	5	0	1	4	2	1	1	0	1
Lowveld Research Institute	5	0	0	5	3	0	1	0	1
Subtotals	37	3	2	32	19	6	6	0	6
Livestock and Pastures									
Henderson Research Institute	6	0	1	5	1	1	1	3	1
Grasslands Research Institute	7	0	0	7	3	0	0	2	2
Matopos Research Institute	8	1	9	7	2	2	2	0	2
Makoholi Extension Supervisor	4	0	0	4	1	1	1	1	0
Dairy Services	5	0	0	5	3	2	0	0	0
Subtotals	30	1	1	28	10	6	4	6	5
Research Services									
Plant Protection Research Institute	11	0	0	11	5	3	2	0	0
Chemistry and Soils Research Institute	12	0	0	12	6	1	2	1	2
Biometrics Bureau	3	0	0	3	1	0	1	1	0
Herbarium and Botanic Garden	3	0	0	3	0	1	1	0	1
Seed Services	4	0	0	4	3	1	0	0	0
Information Services	1	0	0	1	1	0	0	0	0
Subtotals	34	0	0	34	16	6	6	2	3
Farming Systmes Research Unit	3	0	0	3	2	1	0	0	0
Totals	104	4	3	97	47	19	16	8	14

1) RO = Research Officer, PRO = Principal Research Officer, SRO = Senior Research Officer.
Source: ISNAR, 1987.

Table 22: Breakdown of National Researchers by Discipline early 1986

Discipline	Researchers No.	Researchers %	Number of units
Crop breeding	9	7	1
Agronomy	21	15	4
Soil Chemistry/Biochemistry	13	9	1
Soil Microbiology	3	2	1
Pedology/Soil Survey	5	4	1
Entomology	8	6	2
Pathology	6	4	3
Nematology	3	2	1
Horticulture	5	4	3
Botany/Ecology	6	4	1
Seed Testing	8	6	3
Animal Breeding	8	6	3
Animal Production/Systems	15	10	3
Animal Nutrition	5	4	2
Pastures	4	3	2
Veld and Range Management	3	2	1
Dairy	9	7	2
Statistics/Computer	6	4	1
Information Services	1	1	1
Total	138	100	-

Source: ISNAR, 1987.

In 1986 the distribution of academic qualifications among scientific staff was as follows: 8% had a PhD, 30% MSc, and 62% BSc. DR&SS has an active staff development program in which 10-15 scientists are sent each year for training, largely at the master's level. The support of the 16 expatriate scientists in DR&SS has been essential in providing continuity to the research programs of research officers on study leave and in-service training to the remaining younger staff. They are also expected to contribute to the evaluation of existing research programs and the setting of future research directions.

Besides providing training at the master's level, DR&SS gives its professional and technical staff opportunities to attend short courses such as those run by CIMMYT at the University of Zimbabwe on on-farm research, IITA and ICRISAT on research management, and others sponsored by various organizations.

Physical Resources

DR&SS has twelve research stations located in various parts of the country. The six research stations and the Cotton Research Institute are fully equipped with administrative offices, staff housing, and laboratory facilities.

Table 23 gives the geographical location of the stations. It is clear that on-station research programs are concentrated in high-potential areas, Natural Regions I and II, where there are eight stations, six for crop research and two for livestock research. The other four stations are in low-potential areas, Natural Regions IV and V, where major programs focus on extensive beef production systems (Matopos and Makoholi) and irrigated crop systems (Lowveld Research Station) which are largely characteristic of large-scale commercial-sector farming in those areas. In 1980, DR&SS was unable to assess whether and how past and current research programs and priorities on crop and livestock production could be applied or modified to fit communal-area farming systems. This deficiency and the fact that DR&SS had to demonstrate quickly that it was able to meet the challenge of communal-area development, were the key factors leading to the rapid development of on-farm research in communal areas.

In the section on financial resources, it was pointed out that investment funds for infrastructure were extremely limited, being as low as 0.5% of the total DR&SS budget in the 1985/86 financial year (Table 15). It was with the intention of developing infrastructure, especially staff housing and equipment, that the government negotiated the World Bank/IFAD loan in 1983. To date over 300 houses have been or are being built and field and laboratory equipment is being procured. The Ministry of Construction and National Housing, however, has not yet been able to build all the required houses due to other commitments.

DR&SS is highly centralized with regard to the major services it provides to its various stations, the farming community, and the agricultural industry. For example, the soil testing, seed certification, plant disease, and advisory services are all in the Harare research station. Because the demand for these services has increased substantially during the last five years, facilities are stretched to the limit. Their location in Harare also prohibits frequent use by clients in the low- potential areas, particularly in communal areas in Natural Regions III, IV, and V, because of high transport and other costs.

Each research unit manages its own fleet of vehicles. Most vehicles are maintained by the Central Mechanical and Engineering Department, a government department solely responsible for the purchase, maintenance, and repair of all government-owned equipment. This Department has shown serious weaknesses in timely delivery of vehicles taken for servicing and/or repairs, which can cause major problems if delays occur at critical periods of experimentation. For this reason the government allows research officers to use their personal vehicles for official duties, for which they are compensated at the same rate that this department charges all other departments. Most research officers, however, cannot afford to make the initial investment of ZWD 10,000 - ZWD 15,000 to buy a vehicle in reasonable condition. In 1985, DR&SS had a fleet of approximately 89 cars and pickups and 17 motorcycles. Since then, 15 pickups and 38 motorbikes have been obtained with the World Bank loan.

Table 23: Location of DR&SS Research Stations

Research/Experiment Station	Natural Region	Altitude (m)	Latitude S		Longitude E		Province
Rhodes Inyanga Experiment Station Nyanga	I	1070	10°	17"	32°	15"	Manicaland
Coffee Research Station Chipinge	I	1132	20°	12"	32°	37"	Manicaland
Grassland Research Station Marondera	IIa	1020	10°	11"	31°	20"	Mashonaland East
Harare Research Station	IIa	1500	17°	19"	31°	03"	Mashonaland Central
Variety Testing Center Gwebi	IIa	1110	17°	11"	30°	52"	Mashonaland West
Henderson Research Station	IIa	1292	17°	35"	29°	50"	Mashonaland Central
Cotton Research Institution Kadoma	IIb	1119	10°	19"	29°	53"	Mashonaland West
Panmure Experiment Station	IIb	001	17°	16"	31°	37"	Mashonaland Central
Matooos Research Station	IV	1330	20°	21"	20°	20"	Matebeleland South
Makoncii Experiment Station	IV	1201	19°	59"	30°	17"	Masvingo
Chredzi	V	429	21°	05"	31°	33"	
Chisumbanje Experiment Station	V	421	20°	48"	32°	14"	Manicaland

Source: Whingwiri et al., 1987.

Table 24: Comparison of Food Crop Production and Performance Trends in Three Farming Sectors of Zimbabwe, 1951-1955 and 1976-1980.

		Large-scale commercial sector			Small-scale commercial sector			Communal area sector		
		Area ha	Production tons	Yield Kg/ha	Area ha	Production tons	Yield Kg/ha	Area ha	Production tons	Yield Kg/ha
Maize	1951-55	145,000	207,068	1,421				628,751	217,103	342
	1976-80	212,450	1,008,136	4,726	29,825	53,263	1,786	738,400	514,800	695
Pearlmillet	1951-55							97,853	52,233	531
	1976-80				1,444	878	606	339,800	130,090	385
Sorghum	1951-55	3,017	1,678	568				149,673	45,995	307
	1976-80	6,476	16,124	2,499	1,282	861	682	152,400	77,400	493
Fingermillet	1951-55							91,347	55,368	605
	1976-80				2,995	2,288	762	116,500	60,340	493
Wheat	1951-55	494	634	1,235						
	1976-80	37,234	163,165	4,396	440	248	571	383	942	2,454
Barley	1951-55	291	352	1,202						
	1976-80	4,655	22,798	4,905				119	299	2,280
Sugarcane	1951-55	709	21,670	35						
	1976-80	25,091	2,583,306	103						
Potatoes	1951-55	1,789	12,018	6,709						
	1976-80	1,507	21,891	14,604	94	235	2,557			
Groundnuts	1951-55	2,908	1,562	560				175,604	45,462	258
	1976-80	3,394	7,980	2,335	11,811	6,559	551	250,000	123,400	481
Soyabeans	1951-55	231		97	470					
	1976-80	32,700	66,656	2,011	611	378	675	7,462	5,156	624
Edible Drybeans	1951-55	2,912	815	294				39,780	12,417	312
	1976-80	1,098	459	421	991	579	589	29,500	8,300	304
Sunflowers	1951-55	2,195	929	432						
	1976-80	3,074	1,688	545	4,733	2,593	530	29,400	11,800	401
Cotton	1951-55	5,102	1,428	256						
	1976-80	74,055	125,558	1,709	6,693	5,510	829	33,800	24,000	722

Source: Tattersfield, 1982.

Information Resources

The Information Services Unit is in the Research Services Division (Figure 2) and is responsible for the publication and distribution of annual reports of the various sections as well as two journals: Zimbabwe Agricultural Journal and the Zimbabwe Journal of Agricultural Research. The unit provides retrieval services from its extensive document collection. Most institutes have their own libraries and order journals and books according to the budget. The MLARR and University of Zimbabwe libraries can also be used by the research staff.

Each DR&SS unit publishes an annual technical report on past research projects. On average, however, these reports are running two to three years behind schedule, which means that it is not possible to obtain written results of research carried out after 1984. On the other hand, the two journals are up to date and mostly publish articles of DR&SS research staff. The most effective way to obtain results of recent research is through personal communication with the research officer concerned.

A computerized project identification index is kept by the Information Services Unit and the Biometrics Bureau, and it would be a good source at least for project topics and key descriptors, except that it is not current.

CONTRIBUTION OF RESEARCH TO AGRICULTURAL DEVELOPMENT

A comparison of food crop production and performance trends across sectors (large-scale and small-scale commercial and communal areas) is shown in Table 24. Since 1950 Zimbabwe has experienced a massive increase in the yields of many food crops. The most impressive increase has been in the large-scale commercial sector, where extension has been well organized, and farmers have had capital and managerial expertise to exploit research findings to their advantage. The example of maize yield increases, as a consequence of improved technology, is presented in Table 25.

Table 25: Estimated Percentage Improvement in Maize Yields from Improved Technologies since 1950

Factor	% increase in yield
Nitrogenous fertilizer	200
Hybrids	45
Increased populations	20
Early planting	15
Weed control	30
Pest control	10
Early reaping	5
Total	325

Source: Tattersfield, 1982.

It is evident that the large-scale commercial sector has made considerable use of research findings, but the small-scale commercial sector and the communal-area sectors in Natural Regions III, IV, and V have not. For communal-area farmers, fertilizer application and the use of hybrid seed (which requires fertilizers to achieve its full yield potential) are risky and require capital resources which are very scarce. The Agricultural Finance Corporation is aware of this, since it usually limits the credit available to these farmers. This was one problem faced in 1980 when DR&SS, like many other private and public institutions, shifted priority to this sector and on-farm research began on a large scale.

In spite of these problems, the changes in land allocated to principal crops and their performance in this sector in the post-Independence period are impressive (Table 26). In terms of area, maize and cotton have increased substantially, finger millet and sorghum have increased slightly, but groundnuts and pearl millet have decreased considerably. In terms of yield per ha, communal-area farmers have achieved favorable improvements in all crops, with spectacular yearly increases in pearl millet, maize, sorghum, and cotton.

Table 26: Estimated Area and Yield Increases of Principal Crops in Communal Areas, 1977-1985

	Area (000 ha) 1977	1985	Average Annual Growth %	Yield (kg/ha) 1977	1985	Average Annual Increase %
Maize	767	1160	5.2	754	1464	8.6
Sorghum	236	247	-0.6	544	895	6.4
Pearl millet	141	154	1.1	617	747	2.4
Groundnuts	325	149	-9.7	379	546	4.7
Cotton	39	146	16.9	564	893	5.9

Source: Farming Systems Research Unit, in press.

Crop sales from communal areas to the Grain Marketing Board and the Cotton Marketing Board depend on total production, which has a direct relationship to crop area and yield. In the case of maize, farmers' sales in the 1978/79 season totalled 33,300 tons, equalling 4% of total national sales. These figures in the 1980/81 season rose to 288,000 tonnes and 44%. Such a large increase was made possible by the high level of technical knowledge and experience with the crop as well as price incentives provided to the farmers. The impressive performance can be partially explained by relatively low levels in the base year, but due credit must be attributed to the concerted efforts of the government through its various agencies and to the progressive response of farmers. In all modesty, DR&SS should also take some credit for this success. The next important task set by the government's recent agricultural development policy and priorities is to improve oilseed and livestock production in communal areas. Improving agricultural production in Natural Regions IV and V poses a major challenge to DR&SS, and it will require an extension of research into those areas to develop the appropriate technologies.

CHAPTER THREE

ORGANIZATION AND MANAGEMENT OF ON-FARM RESEARCH

OVERVIEW OF ON-FARM RESEARCH IN THE DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES

The Department of Research and Specialist Services and the Organization of On-Farm Research

The Department of Research and Specialist Services (DR&SS), one of three departments under the MLARR, is organized into three divisions: Crop Research Division, Division of Livestock and Pastures, and Research Services Division (Figure 2). The Farming Systems Research Unit (FSRU) is directly responsible to the director. Each division is headed by an assistant director who is fully responsible to the director for the administrative and technical operation of all institutes, stations and units in the division. Decision-making is decentralized in that each institute, station, or unit head manages his/her resources independently, requiring only the approval of his/her respective assistant director. Thus each head has considerable discretionary power in defining research priorities, formulating programs, and allocating resources.

At Independence in 1980, the Government of Zimbabwe made a major policy shift in priorities towards the communal area sector, and political pressure was put on DR&SS to demonstrate its relevance and commitment to this sector. In response, several DR&SS institutes, stations, and units initiated independent on-farm research (OFR) programs as a means, first, of identifying research opportunities and, second, to test the impact of available technologies and demonstrate how they could contribute to the overall national development plan for communal areas. Since each institute or unit was already undertaking on-station research, on-farm research was generally integrated into the research program, which meant that some scientists were carrying out experiment station research and on-farm research simultaneously. The only exception was in the Farming Systems Research Unit.

A brief description of each on-farm research program, by division, is presented in Table 27. At present there are four on-farm research programs in the Crop Research Division, two in the Division of Livestock and Pastures, three in the Research Services Division, and the Farming Systems Research Unit. Except for the Lowveld

Table 27: Overview of the Department of Research and Specialist Services On-Farm Research Programs in Communal Areas

Research Unit/Divison	Mandate	On-farm Research Coverage in 1986	Year started	Farm Surveys to date	Number of: Trials (1986/87)	Number of: Sites (1986/87)	Disciplines Involved
CROP RESEARCH DIVISION							
Crop Breeding Institute	National	National	1982	0	6	48	Breeding
Agronomy Institute	National	National	1980	5	15	85	Agronomy
Cotton Research Institute	National	National	1982	1	3	77	Breeding, Agronomy, Entomology
Lowveld Research Station	Regional	Regional	1982	0	10	22	Agronomy
LIVESTOCK AND PASTURES DIVISION							
Henderson Research Station	National	Regional	1985	1	1	12	Animal Nutrition
Makoholi Research Station	National	Regional	1985	0	1	2	Animal Production
RESEARCH SERVICES DIVISION							
Chemistry and Soils Research Institute	National	Regional	1982	1	8	44	Soil Chemistry, Crop Nutrition
Plant Protection Research Institute	National	National	1982	2	12	28	Nematology, Entomology, Pathology
OTHER							
Farming Systems Research Unit	National	Regional	1984	8	18	109	Crop Agronomy, Forage Agronomy, Animal Nutrition, Economics

Research Station, which has a regional (Natural Region V) mandate, all on-farm research programs have a nationwide mandate. The emphasis on on-farm research on crops dates back to 1980 and 1982 when most programs were initiated and food production and security were key objectives of government policy. Livestock on-farm research was initiated by the Farming Systems Research Unit in 1984 and was taken up almost immediately by the Henderson Research Station and the Makoholi Experiment Station in 1985.

The largest trial programs, in order of size, are those of the Farming Systems Research Unit, the Agronomy Institute, the Cotton Research Institute, the Crop Breeding Institute, and the Lowveld Research Station. Only the Farming Systems Research Unit and the Agronomy Institute have given consistent attention to characterization studies.

Each unit gradually developed its on-farm research program independently. Due to the decentralized nature of DR&SS, on-farm research development was mainly a function of the professional interests and perspectives of the head and senior scientists of each institute, together with the resources they were willing to assign to on-farm research.

The Role of On-Farm Research Within the Department of Research and Specialist Services

During the three seasons 1984/85, 1985/86, and 1986/87, on-farm research programs in communal areas increased substantially (Tables 28 and 29). The institutes in the Crop Research Division, the Agronomy Institute, the Crop Breeding Institute, the Cotton Research Institute, and the Lowveld Research Station were very active, with as many as 292 trial sites in the 1985/86 season. In these institutes, on-farm research constitutes approximately 50% of the entire trial program and absorbs between 23% and 33% of research officers' time. In the Research Services Division, the Chemistry and Soil Research Institute, and the Plant Protection Research Institute in the 1986/87 season increased their trial programs in communal areas which account for approximately 12% of their research officers' time. In the Livestock and Pasture Division, only Henderson Research Station and Makoholi Experiment Station have on-farm research programs, but they are small compared to their experiment station research programs. However, research officers in Grasslands, the Livestock Nutrition Unit, and the Pasture and Veld Unit are participating directly in the Farming Systems Research Unit and Henderson Research Station programs. The Farming Systems Research Unit only does on-farm research on crops and livestock and has had a consistent level of activity since 1984. Overall, DR&SS averaged more than 400 trial sites per annum in communal areas covering representative environments and soil types in all natural regions. This occupied approximately 18% of its total research staff time.

Coordination of On-Farm Research across Institutes

Coordinating planning within DR&SS divisions is the responsibility of assistant directors, in consultation with the heads of institutes and stations. In 1984, the director assigned the task of coordinating on-farm research across divisions in DR&SS to the deputy director.

Table 28: Number of Communal Areas Trial Sites of Individual Research Units in DR&SS, 1984/85 - 1986/87

Division Unit	Trial Sites 1984/85	1985/86	1986/87
Crop Research Division			
Crop Breeding Institute	60	49	48
Agronomy Institute	99	128	85
Cotton Research Institute	60	85	77
Lowveld Research Station	29	30	22
Nyanga Experimental Station	0	0	0
Horticulture Research Center	0	0	0
Coffee Research Station	0	0	0
SUBTOTAL	248	292	232
Division of Livestock and Pastures			
Henderson Research Station	0	10	12
Grasslands	0	0	0
Matopos	0	0	0
Makoholi	0	1	2
Pasture and Veld	0	0	0
SUBTOTAL	0	11	14
Research Services Division			
Chemistry and Soils Research Institute	10	11	44
Plant Protection Research Research Institute	22	25	28
SUBTOTAL	32	36	72
Farming Systems Research Unit	108	125	109
TOTAL	388	464	427

Source: DR&SS records.

Only informal methods of coordination were employed prior to April 1986, when the director, on the advice of several on-farm research officers, sanctioned the establishment of the Committee for On-farm Research and Extension, comprising nine institute heads from DR&SS plus the assistant director of the Field Division of AGRITEX. Its original objective was to plan jointly the 1986/87 on-farm research programs and to offer AGRITEX provincial officers an opportunity to participate in and contribute to the research proposals and receive DR&SS assistance in the design of on-farm research demonstrations in their respective provinces. To achieve this, eight subcommittees of on-farm researchers themselves reviewed all proposals of DR&SS trials and AGRITEX demonstrations. Based on the first year's experience, the Committee for On-farm Research and Extension will remain active because its work is considered essential in order to assess the technical and farmer relevance of proposed on-farm research trials and surveys as well as AGRITEX recommendations. It will also be used to define appropriate site selection procedures, given the diversity of communal-area ecologies and logistical considerations, to monitor the implementation of on-farm research trials and demonstrations, and to review research and extension progress.

In spite of these new functions, the committee is still not performing optimally, due to the decentralized decision-making process and the lack of a clear policy statement on inter-program coordination in DR&SS. In other words, there are, at present, no incentives for research officers in a particular unit to coordinate their on-farm research program with others working on similar or related problems. This is due to the strictly vertical channels of communication and authority in DR&SS.

On-farm Research as a Link to Extension and Farmers

Every year there is a three-day meeting of senior officials in AGRITEX and DR&SS to review progress and proposed plans relating to the communal-area activities of both institutions. Usual participants include directors, heads of branches and institutes, official representatives of the three farmers' organizations (Commercial Farmers Union, National Farmers Association of Zimbabwe and Zimbabwe National Farmers Union), and invited guests from international agencies. There have been five such meetings in the past, the most recent being in June 1987, and each has been very successful in establishing an information linkage at the highest level of both organizations. They have been less successful as a coordination and/or planning mechanism.

The Committee for On-farm Research and Extension was established in 1986 to strengthen the on-farm research/AGRITEX linkage at all levels; i.e., to coordinate both trials and demonstrations in the communal areas. During the 1986/87 season, provincial-level planning meetings and monitoring tours were successfully implemented jointly, convincing both organizations that this exercise is a viable mechanism for coordination and collaboration. In future, the planning of these activities will be improved to enhance the committee's effectiveness. As the immediate client of on-farm research results, AGRITEX has a vested interest in promoting better linkages with DR&SS, which invariably means more frequent interaction with on-farm research programs.

At the grassroots level, on-farm research programs are one of the few visible mechanisms for providing updated research results to extension agents through trial work and field days. So far, the contribution of AGRITEX staff is confined mainly to helping with selection of research sites and farmers. AGRITEX may make suggestions, but these seem to have a limited effect, if any, on trial objectives and treatments. Researchers are generally better trained and have more experience than AGRITEX staff and believe AGRITEX cannot contribute much on technical matters. Besides, AGRITEX staff at the lower levels lack self-confidence and therefore do not press their case sufficiently.

Because researchers have direct contact with farmers through on-farm research, they tend to emphasize the technology communication and demonstration effect on farmers as a key function of on-farm research work. Farmers usually provide land and labor for non-treatment activities, as well as protection of trial sites, all free of charge. They may also contribute to the discussion on trial designs and evaluation. To date, farmers are extremely cooperative and very willing to host trials, probably because working with the "experts" gives them prestige in the community. Through its trial work and characterization studies, DR&SS at present has contact with more than 500 households in communal areas.

In most instances, the on-farm research-farmer linkage is arranged through AGRITEX. Because AGRITEX's extension strategy is to work with local leaders and "good" cooperators in pursuit of strong client participation and self-reliance objectives, the selection of OFCOR collaborators is biased toward the more interested, experienced, and resourceful farmers. Researchers support this approach as it should ensure a higher success rate of trial work.

Finally, some on-farm research programs, particularly those of the Agronomy Institute and Farming Systems Research Unit, have relationships with the National Farmers Association of Zimbabwe, the official communal-area farmer organization. The National Farmers Association of Zimbabwe officials strongly support the on-farm research activities and would like DR&SS to give more attention to their farmers, particularly on oil seeds, livestock production, and technology generation for the low-potential regions.

The Role of Donors and International Organizations

Donors to DR&SS on-farm research programs include the World Bank, the International Fund for Agricultural Development (IFAD), the Overseas Development Administration (ODA), and the International Development Research Centre (IDRC). In 1983, the World Bank and IFAD gave a loan of US$ 13.6 million for staff housing, vehicles and technical assistance to allow DR&SS to expand their communal-area program, particularly on-farm crop research. As counterpart funding, the government increased the number of professional and technical staff and the size of the operational budget to accommodate that expansion. Under the loan agreement, DR&SS is financing twelve expatriates, four of whom are directly involved in on-farm research. The World Bank/IFAD assistance has been instrumental in increasing the attention of On-farm Crop Research programs to communal areas.

The Overseas Development Administration has eight expatriates in DR&SS, two of whom are directly involved in on-farm research. In 1984, the International Development Research Centre provided a ZWD 253 530 grant to DR&SS for on-farm livestock research and an expatriate adviser to organize implementation of the project and the technical inputs from ILCA. This contribution covers approximately 50% of the total costs of the Farming Systems Research Unit. Previously IDRC had supported the Crop Breeding Institute's sorghum and millet on-farm research program.

On-farm research training, particularly for Farming Systems Research Unit staff, is provided by CIMMYT, ILCA, IDRC and, recently, ICRAF. The only other collaborator is IITA, which has posted a cowpea and soyabean agronomist in DR&SS who has some participation in on-farm cowpea and soyabean research trials.

Donor influence on on-farm research directions and priorities is negligible in DR&SS because:

a) The donor contributions are fully managed and integrated into the local administrative and technical structures.

b) They constitute only a minor proportion of the total resources allocated to on-farm research.

c) All the expatriate staff working in on-farm research are technically accountable to DR&SS, not to their financing organizations.

d) The senior management prefers them to play a strictly supportive role.

THE FOCUS OF THE CASE STUDY - FIVE ON-FARM RESEARCH PROGRAMS

Basis for Selection

For the present study, an in-depth analysis of five on-farm research programs was conducted: those of the Crop Breeding Institute, the Agronomy Institute, the Cotton Research Institute, the Lowveld Research Station, and the Farming Systems Research Unit. These units have the most experience and the largest on-farm research programs (Tables 27, 28 and 29). The programs permit a comparative examination of on-farm research organization and management using four distinct organizational models within the same institutional framework: a discipline-oriented research model (Crop Breeding Institute and Agronomy Institute), a commodity research model (Cotton Research Institute), a regional research model (Lowveld Research Station), and a farming systems research model (Farming Systems Research Unit). This analysis should provide useful insights for ISNAR's larger comparative analysis and for a review of DR&SS on-farm research organization.

Table 29: Number of Research Officers Involved and Percentage of their Time Allocated to On-Farm Research in Individual Research Units in DR&SS, 1987

Division Unit	Research Officers Number	% time spent in OFR
Crop Research Division		
Crop Breeding Institute	10	24
Agronomy Institute	15	33
Cotton Research Institute	7	33
Lowveld Research Station	6	23
Nyanga Experimental Station	1	0
Horticulture Research Center	3	0
Coffee Research Station	3	0
SUBTOTAL	45	25
Division of Livestock and Pastures		
Henderson Research Station	14	7
Grasslands	7	14
Matopos	13	14
Makoholi	2	25
Pasture and Veld	3	17
SUBTOTAL	39	8
Research Services Division		
Chemistry and Soils Research Institute	31	8
Plant Protection Research Research Institute	16	20
SUBTOTAL	47	12
Farming Systems Research Unit	5	100
TOTAL	142	18

Source: DR&SS records.

Profile of Each Institute and Its On-Farm Program

Although there is consensus on the general objectives of on-farm research in DR&SS, each institute designed and implemented its on-farm research program according to its own mandate. The following synopses describe the scope and importance of the on-farm research of each institute.

Crop Breeding Institute. The Crop Breeding Institute (CBI) is in the Harare Research Station and has ten research officers and 16 assistants. Its objective is to create, evaluate, and release new varieties in order to increase yields, improve stability of grain and oilseed crops, and ultimately to increase economic returns to all farmers in the country. To achieve this the Crop Breeding Institute tests its materials under a wide range of environmental conditions, bulks and distributes breeders' seed to the Seed Cooperative Company of Zimbabwe for multiplication and marketing, and makes varietal recommendations to farmers, either directly or through AGRITEX.

The on-farm research is used to test advanced breeding material under the agroecological conditions of the communal areas. Optimal management and input levels are used in order to evaluate growth, adaptability, maturity, and yield of new varieties and to demonstrate improved production technologies. Varietal recommendations for communal areas do not necessarily derive from these trials, however, since such results constitute only one source of information. At present, crops in the on-farm research program include maize, sorghum, millets, groundnuts, and sunflower, with each under the responsibility of a different research officer. From Harare, each research officer deputes his/her junior staff to carry out all on-farm research tasks, since no staff have been posted to research sites, and all trials are researcher-managed.

Agronomy Institute. The Agronomy Institute (AI) is in Harare; it has 15 research officers and 30 assistants. Its objective is to generate and/or adapt production technologies for all crops except cotton and tobacco. At present, the communal areas are the Agronomy Institute's priority target areas. It specifically aims:

a) to establish the yield potential of crops in the different natural regions under various management levels, so that communal-area farmers and policymakers can set realistic goals;

b) to define farmers' technical problems of crop production through field experience so that appropriate research trials can be planned. These aims are achieved through a combination of research carried out at an experiment station and on-farm, though on-farm research trials and surveys have greater emphasis.

The main thrust of the AI's on-farm research is to determine the effect of varieties, plant population and geometry, fertilizers (macro- and micronutrients, compounds, and cattle manure), and weed control methods to develop optimum management and input recommendations. The program presently includes maize, sorghum, pearlmillet, groundnut, soyabeans, sunflower, and some new crops (cassava and pigeonpeas).

Eight research officers are involved in on-farm research, each being responsible for a different commodity and a research cluster. From Harare, they must allocate time to plan their program with the head of the AI and implement and supervise their research responsibilities at several stations and at on-farm research sites covering all eight provinces in the country. Junior staff are organized into small teams who live next to their research areas during most of the growing season. Only two research field teams reside on the stations (Matopos). All on-farm research trials are researcher-managed.

Cotton Research Institute. The Cotton Research Institute (CRI) is located at Kadoma, 160 km southwest of Harare. It includes seven research officers and 13 assistants. It aims to improve production of cotton for all farming sectors to enable them to compete effectively in local and international markets. CRI's activities cover breeding, agronomy, entomology, and pathology, as well as monitoring of current recommended practices and training of AGRITEX staff and cotton-growers. It has an excellent record of collaboration with the Cotton Marketing Board and with the large-scale commercial sector, whose Commercial Cotton Growers' Association has active research and extension activities of its own.

The CRI's on-farm research has placed emphasis on:

a) comparing the effects of population and fertilizer regimes and moisture conservation techniques on growth and yield;

b) testing the pegboard pest-scouting as an alternative to the currently recommended technique which requires literate farmers;

c) screening breeding material as part of the overall national program.

Because of CRI's vast experience relative to present levels of cotton management and performance in communal areas, technology adaptation is the main thrust of its on-farm research.

At present, the institute has seven research clusters in three areas. Each cluster has a research hand who resides there during the growing season, carrying out all research operations with the support and supervision of three research officers: an agronomist, an entomologist, and a breeder. Since they also have experiment station research duties, each must present his/her whole proposed research program at the annual planning meeting in which participants include all CRI research officers, some Lowveld Research Station and the Agronomy Institute's Weed Research Unit representatives, AGRITEX specialists and the Commercial Cotton Growers Association's researchers. Though most trials are researcher-managed, there are some in which farmer collaborators participate in crop management in consultation with the field staff, in addition to the usual provision of land and pesticides for all trials.

Lowveld Research Station. The Lowveld Research Station (LRS) is located at Chiredzi, approximately 500 km southeast of Harare, with a staff of six research officers and eighteen assistants. It has

three programs: irrigation, rainfed agriculture, and horticulture. The rainfed agriculture program is the only one with an on-farm research component at present. Its main objective is to reduce the effect of low-rainfall seasons on the production of food, cash, and fodder crops in Natural Region V by:

a) perfecting rainwater conservation and concentration techniques;

b) searching for drought-tolerant varieties of traditional crops;

c) manipulating plant stand and crop sequences;

d) testing the yield potential of new crops.

LRS considers that one of its basic functions is to inform and advise farmers, large and small, and other interested organizations such as AGRITEX, on the potential of rainfed crop production in Natural Region V. So far the research program has emphasized testing landforms for water conservation, reducing plant populations, changing plant arrangements on various landforms, testing suitable maize, sorghum, and groundnut varieties, and testing the effects of fertilizers on crop yields. All these interventions are intended to stabilize crop yields.

The two research officers responsible for the on-farm research program, which includes experiment station research, work together on its design, in close consultation with the head and other research officers at the station. All decisions are made at the station, and farmers only provide land and some labor for the researcher-managed trials. All research staff reside on the station and travel together to each of the seven research areas to establish and monitor their trials.

Farming Systems Research Unit. The Farming Systems Research Unit (FSRU) has five research officers and seven assistants. The core team of five research officers, stationed at Harare Research Station, manages two small teams, one resident in a high-potential area and the other in a low-potential area. FSRU objectives are:

a) to improve the physical and economic performance of crop and livestock production systems in communal areas, in line with farmers' present resources, opportunities, and priorities;

b) to promote formal and informal collaboration among researchers (DR&SS and other agencies), extension workers, and farmers in the research and development process;

c) to contribute to the definition of priorities and design of programs for experiment station research so that appropriate technologies to solve communal-area farmers' problems can be developed.

In this respect, equal priority is given to characterization studies of communal-area farming systems and their production components, implementation of on-farm research trials to test proposed technologies and systems, and formal and informal planning and review meetings in DR&SS.

At present, the content of the unit's on-farm research trials includes:

a) evaluating varieties, populations, fertilizers (compounds and manure), and weed control methods, based on the most promising technologies for maize, sorghum, pearl millet, groundnuts, and soyabeans;

b) testing the application of draft-saving (ripper tine) and labor-saving implements (planters, groundnut lifter);

c) introducing herbaceous and tree perennial fodder legumes within the arable areas;

d) evaluating the plowing performance of draft oxen fed with stored crop residues plus protein supplementation;

e) comparing the reproductive and productive performance of indigenous and crossbred goats under local management conditions.

Depending on the stage of technology progress and confidence of the staff, FSRU designs researcher-managed, researcher/farmer-managed and/or farmer-managed trials in order to obtain the required degree of farmer participation in the management and evaluation of trial performance.

Comparative Approach

Each of the institutes described initiated and developed its on-farm research program in direct response to DR&SS's shift in priorities toward the communal areas. The Crop Breeding Institute does regional trials of advanced breeding material, a type of on-farm research which focuses particularly on agro-ecological conditions. Except for the different geographical scope, the on-farm research of the Agronomy Institute and the Lowveld Research Station have a similar orientation. Both emphasize technology generation to solve basic production problems and therefore have a strong technical agronomic focus. The Cotton Research Institute and FSRU are both interdisciplinary programs, and compared to the other three programs, appear to have a clearer farmer orientation.

It is important to emphasize that FSRU, the most recently established on-farm research program and still in its developmental phase, was set up with objectives and functions similar to those implicit in the "on-farm client-oriented research" approach, which is the subject of this case study. FSRU is the only on-farm research program with economists in the team. Although the stated objectives of the other on-farm research programs should require economic inputs, these are not presently obtained. Finally, all institutes except FSRU have experiment station research as their primary mandate and have added on-farm research as a major appendage of their programs. All programs, except that of the Farming Systems Research Unit, have had little, if any, input from the IARCs in terms of the organization and management of on-farm research activities.

While the study team admits that not all of the five on-farm research programs in this case study are -- strictly speaking -- on-farm, client-oriented research programs, a comparative analysis of these particular modes of conducting on-farm research will allow a better understanding of how each institute has performed in the seven explicit functions identified in the general study[1], how important each function is in terms of technology generation for the communal areas, and how specific policy, and organizational and managerial arrangements have contributed to the performance of these functions in each institute. It was for these reasons that the director of DR&SS suggested and supported the choice of these five programs for the Zimbabwe case study. The case study report will focus exclusively on the organization, management, and assessment of the five institutes, and reference to DR&SS will be made only when necessary.

DEVELOPMENT OF ON-FARM RESEARCH WITHIN DR&SS

This section is presented under four topics in order to explain the background, events, and trends resulting in the present status of on-farm research activities in DR&SS. First, there is a brief review of the pre- and post-Independence periods as they relate to the on-farm research programs in this case study. Second, the experience of the Agronomy Institute, with one of the consistently largest on-farm research programs, is reviewed in terms of the organizational and managerial modifications effected to solve specific problems arising in its development. Third, FSRU, which was established in 1984 to work exclusively in communal areas, represents a unique institutional model in DR&SS. Selected characteristics of its organization and methodology will be analyzed and justified in light of the objectives ascribed to the unit by the directorate. Fourth, the situation leading to the formation of the Committee for On-Farm Research and Extension, and progress achieved to date in coordinating DR&SS and AGRITEX on-farm activities, are summarized. Finally, the reasons for the delayed development of on-farm livestock research are briefly reviewed.

On-Farm Research in the Pre- and Post-Independence Periods

The tremendous success of agricultural development in the large-scale commercial sector of Zimbabwe can be attributed to the skillful implementation of appropriate government policies and, to a large extent, to the intensive interactions and effective communication between farmers, development and extension officers, and researchers from different institutions in the country.

On-farm research by DR&SS in the large-scale commercial sector has quite an established tradition. For example, as far back as 1909 trials were being implemented on farms because of the need to test crop varieties and husbandry practices under farmers' conditions,

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1) For definition of functions, see "Introduction to the ISNAR Study on Organization and Management of On-Farm, Client-Oriented Research", by D. Merrill-Sands, page iii.

and by 1922 more than 300 farmers were participating in this testing program. On cotton there was, and still is, a research and production committee comprising of representatives from the Commercial Cotton Growers Association, commercial companies, the Cotton Marketing Board, and the Cotton Research Institute. For over 30 years the Cotton Research Institute has performed planning and technical functions within the committee, including the design and implementation of on-farm research trials.

On the average, the Cotton Research Institute has had approximately eight on-farm research trials on breeding, twelve on agronomy, and seven on entomology every year. Although the institute designs all this work, since Independence, the research unit of the Commercial Cotton Growers Association has assisted with implementing the trials. Similar relationships with farmers existed at the Lowveld Research Station and the Agronomy Institute for evaluating crop husbandry practices on farms and generally responding to the problems of farmers, some of whom frequently visited the stations. The provision of specialist services, such as soil testing and pest management, directly to farmers, also created an effective complementary opportunity for researchers to learn at first hand the production problems and priorities of their principal clients.

When national development priorities shifted to the communal areas in 1980 and DR&SS was expected to define its strategy for this sector, it did not have any linkages and had limited technology testing experience in communal areas. There had been some on-farm research, such as the soil fertility management by the Soil Productive Research Laboratory and the introduction of forage legumes in rangelands by the Grasslands Research Station. But with the advent of Independence, political pressure led to the rapid proliferation of on-farm research activities.

Table 30 shows the evolution of the five case-study programs in selected key indicators (for details, see annexes 1 to 5). Since 1982/83, the Crop Breeding Institute's on-farm research has continuously expanded to the extent that in the 1986/87 season it was a major part of the institute's activities. Over the last seven years, the Agronomy Institute program has remained one of the largest, but through the course of its development there have been significant adjustments in the indicators presented. Together with the Agronomy Institute, the Cotton Research Institute was one of the first to initiate on-farm research, and since the 1983/84 season, when the number of research areas was drastically reduced, the size of the program has been fairly stable, increasing lately only in numbers of trial sites. The Lowveld Research Station initiated on-farm research in 1982/83, and there has been a continuous expansion every year, except in the number of trial sites. Since its inception in early 1984, FSRU has not changed much after the 1984/85 season.

During the last seven years, on-farm research within these institutes has expanded from an average of 15 trials on 60 sites during the first two seasons to an average of 52 trials on 380 sites in the last two seasons. Particularly relevant for communal areas has been the gradual shift of on-farm research trials from high-potential to low-potential regions, with special emphasis on the sandy light soils which are typical of communal-area arable lands.

Table 30: Evolution of Five On-Farm Research Programs in Terms of Number of Research Officers, Research Areas, Trials and Trials Sites, 1980-1987

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
Crop Breeding Institute							
Research Officers	-	-	3(9)*	4(8)	5(9)	6(9)	6(8)
Research Areas	-	-	8	13	21	20	24
Trials	-	-	3	4	5	6	6
Trial Sites	-	-	20	28	60	49	48
Agronomy Institute							
Research Officers	1	2(4)	2(7)	1(5)	1(11)	1(13)	8(14)
Research Areas	13	24	17	23	17	16	8
Trials	8	15	14	6	9	9	15
Trial Sites	28	82	42	37	99	128	85
Cotton Research Institute							
Research Officers	3	3(7)	3(7)	2(8)	2(7)	3(7)	3(7)
Research Areas	1	7	9	3	3	3	3
Trials	2	4	3	4	4	5	4
Trial Sites	5	40	21	65	60	85	77
Lowveld Research Station							
Research Officer	-	-	1(4)	1(6)	2(6)	2(6)	2(7)
Research Areas	-	-	2	6	7	8	7
Trials	-	-	1	5	6	9	10
Trial Sites	-	-	3	21	29	30	22
Farming Systems Research Unit							
Research Officer	-	-	-	4(4)	4(4)	5(5)	5(5)
Research Areas	-	-	-	2	2	2	2
Trials	-	-	-	8	20	20	18
Trial Sites	-	-	-	32	108	125	109

* In parenthesis, total number of officers in the institute or unit.
Source: OR&SS records.

It is important to note that on-farm research did not expand as part of a coherent DR&SS strategy but rather on an ad hoc basis in each institute in direct response to the political pressure of the new era.

Development of On-Farm Research Within the Agronomy Institute

Foundation for development of on-farm research. In the Agronomy Institute some on-farm research was conducted on large-scale commercial farms, but very little, if any, was undertaken in communal areas before 1980. When the government called for rebuilding the country after the war leading to Independence, and emphasized the communal-area sector which had not received the same attention as the large-scale commercial sector, the Agronomy Institute responded by initiating widespread on-farm research trials in that sector. This was the beginning of the Communal Area Research Trials program. The belief was that research station conditions were different from those in communal areas and that currently recommended practices based on station work should therefore be tested in communal areas.

In 1980, CIMMYT's regional office in Nairobi, Kenya sent a DR&SS letter advertising the farming systems research approach, and was subsequently invited to demonstrate the methodology in Zimbabwe. As a result, in 1981, another on-farm research program, Farming Systems Research, was initiated in the Agronomy Institute. Farming Systems Research was intended to identify and highlight crop production constraints through diagnostic surveys and conduct adaptive on-farm trials which, together with AGRITEX, would facilitate the flow of information to communal-area farmers. Communal Area Research Trials was to test the suitability of current recommendations on farms and generate appropriate technological packages for major crops by 1984. To strengthen Agronomy Institute capability, the research officer in charge of the farming systems research program and the head of the Agronomy Institute attended courses in farming systems research methodology.

In coordinating development of the two on-farm research programs, the head of the Agronomy Institute consulted with senior staff (research officers and research technicians) at annual planning meetings on any issues concerned with increasing the effectiveness of the Communal Area Research Trials. The key people involved in the development of farming systems research programs were the director, the assistant director (Crop Research Division), the head of the Agronomy Institute, the agronomist responsible for the program, and the regional CIMMYT economist.

The farming systems research program was initiated in Chivi District, a low-potential area in Natural Regions IV and V in Masvingo Province. A diagnostic survey was conducted under the supervision of Dr. M. Collinson, the CIMMYT regional economist, with the participation of the Agronomy Institute research officer who later became responsible for the program, the Department of Land Management of the University of Zimbabwe, and AGRITEX provincial and district staff.

The survey identified major production constraints, and a trial program, both adaptive and technical, was formulated and implemented in the 1981/82 season. In addition, parallel trials were run at Makoholi Experiment Station in Natural Region IV.

In 1982 another diagnostic survey was begun in Mangwende Communal Area, a high-potential area in Natural Region II, intentionally chosen to contrast with Chivi. Again, the CIMMYT regional office, AGRITEX, and the University of Zimbabwe participated, together with various DR&SS disciplinary specialists. The farming systems research officer led the survey. The results were used in designing an adaptive and technical trial research program. Technical trials were conducted whenever it was recognized that there was lack of adequate knowledge on a subject.

Researchers were trained by CIMMYT and included two research technicians. One left to work in the private sector, and the other was largely involved with the running of the Chivi project. The need for an economist in the program became apparent. Unfortunately, the Ministry would not support the appointment of such a professional in DR&SS, since it was felt that economists already in the Ministry could participate in the program. This never occurred.

At the inception of farming systems research, only one research officer was working in the program with the help of research technicians and agricultural assistants at Makoholi Experiment Station. They were also involved with Communal Area Research Trials in the Masvingo Province. The expansion of the farming systems research program to Mangwende necessitated employing an additional research technician and an agricultural assistant. Because Mangwende is a high-potential area, for which there are more "on-the-shelf" technologies which offer a higher probability of success in the short run, more research emphasis was placed in this area.

The officer in charge of the Communal Area Research Trials did not interact much with the farming systems research officer responsible for farming systems research because both operated in different areas, though at times they both used the same staff, particularly in the Chivi programs. Research officers and their staff participated in the Agronomy Institute's annual planning meetings. Similarities did exist, particularly in technical trials, which were very much alike. In both programs training of AGRITEX extension workers formed part of the activities.

In 1984 the Farming Systems Research program was separated from the Agronomy Institute to become FSRU dealing with crops and livestock. The head of the institute did not take part in this decision, which was made by the directorate. The transfer meant that there was more time for the head of the institute to concentrate on the Communal Area Research Trials program, but it also meant loss of control over integrating the technology generation, adaptation, and transfer processes. This may also account for the present weak linkage between the Farming Systems Research Unit and the Agronomy Institute, because the main link had been the institute's head, whose control of farming systems research and Communal Area Research Trials programs had been removed.

In the Communal Area Research Trials program, objectives could not be achieved on schedule, since too much was expected and promised. Developing recommendations or packages for various crops for all natural regions by 1984 was not possible and was not achieved due to a number of real problems. First, research results were highly variable due, in large measure, to the non-uniformity of trial sites, drought, and trial management problems. Second, the research officer attrition rate was high, and research officers, as fresh graduates from the University of Zimbabwe, lacked experience. This situation placed a strong technical and supervisory responsibility on the Agronomy Institute's head. Third, the trial program was too large and ambitious, and it was grossly inadequately staffed. Fourth, farmer and extension participation was poor, and this contributed to the high variability of results and the heavy trial losses. However, the large number of trial sites across the country ensured a relatively large number of successful trials.

Program content of on-farm research. On-farm research has been carried out on the basic staple foods of the communal areas - maize and pearl millet - and on groundnuts, sunflower, and soyabean since the 1980/81 season (Table 31). Research on sorghum began in 1982/83. Cowpea trials were initiated in 1983/84 as a potential drought-tolerant crop because the country was experiencing successive droughts. Although finger millet is the third most widely planted crop in the communal areas, its agronomy is the least studied, probably because there are few improved varieties. But finger millet does not seem to have as many problems as the other crops. Overall, the on-farm research program experienced a gradual broadening of crop coverage from 1983/84.

Table 31: Priority Crops in the Communal Area Research Trials Program of the Agronomy Institute, 1980-1987

Crop	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
Maize	*	*	*	*	*	*	*
Sorghum			*	*	*	*	*
Pearl millet	*	*	*	*	*	*	*
Finger millet		*			*		
Groundnuts	*	*		*	*	*	*
Sunflower	*	*	*		*	*	*
Soyabeans	*		*	*	*	*	*
Cowpeas				*	*	*	*
Total	5	5	5	6	8	7	7

Changes in the Agronomy Institute's on-farm research program are summarized in Table 30. There was a major reduction in the number of trial sites in the 1982/83 season, when the Institute stopped conducting variety trials because the Crop Breeding Institute had initiated its own on-farm research, and again in the 1983/84 season, when FSRU was established. Trial sites then increased as the result of clustering, an increase in the number of crops being studied, and an increase in the number of research staff. These changes have had

direct implications for the design of the on-farm research program: the number of trials, the quality of trial management, and linkages with AGRITEX, as discussed in the next section.

Development of communal-area research trials. The Communal Area Research Trials program has suffered many setbacks since its inception, but it has survived and progressed. Its development can be divided into three phases: an initiation phase from 1980 to 1984, a building phase from 1984 to 1986, and a consolidation phase which took place in 1986. Table 32 summarizes the main constraints identified in each phase and the actions taken to resolve them. Sometimes constraints were not resolved, primarily because they were not recognized. For example, the large number and spreading of trial sites over the whole country were not considered constraints until the absence of expected outputs and high costs of traveling and wear and tear made staff realize that the operations had to be streamlined.

Initiation phase, 1980-84. AGRITEX staff and farmer collaborators played a very active role in the Communal Area Research Trials program. To include as many different ecological zones as possible, trial sites were scattered all over the country, requiring the participation of many extension staff, most of whom were inexperienced. Because extension workers were expected to keep records, such as germination dates, rainfall figures, flowering, and date of fertilizer top dressing, while farmers were expected to prepare the field for the trial and weed it at the required time on the advice of the extension workers, it was decided that a four-day workshop on trial management, laying out, and data collection be organized for field extension staff each year. These workshops were held from 1981 to 1984. New researchers from assistant research officer level to agricultural assistants were required to attend. The workshops were organized and run by senior research technicians in the institute, and certificates of participation were awarded to participants.

From 1984 the workshops were no longer considered necessary for the Communal Area Research Trials program, as all trials were subsequently managed wholly by research staff. This change was necessitated by the poor attention given to the trials. The extension workers in AGRITEX had many other commitments, and trial management did not receive priority or much credit from their superiors. Farmers often gave poor sites to researchers for the trials, since good-quality land is scarce, and they were inclined to give less priority to trials. As a consequence, trials were left unattended, and in some cases were damaged by cattle. However, the involvement of extension workers and farmers for some of these operations could have been successful if there had been constant supervision by researchers. With the establishment of clusters and possibly greater appreciation of the usefulness of research trials, extension staff and farmers may gradually develop more commitment which could be extremely valuable in the future, particularly in reducing on-farm research operational costs.

Building phase, 1984-86. Because of widely scattered trial sites during the initiation phase, monitoring was difficult and in a given season not all trials were visited. To facilitate this work, trial sites were clustered from the 1984/85 season onward. Because trial success rate and reliability of data were poor, and the fact that

Table 32: Identification of Constraints and Actions Taken in Three Development Phases of Communal Area Research Trials

Constraint	Initiation phase 1980-1984	Building phase 1984-1986	Consolidation phase 1986-
Insufficient supervision of data collection and recording of trial performance by one research officer with help of the Agronomy Institute head	Program expanded intensifying problem	Constraint recognized hence clustering of trials but still too many clusters	Sharing responsibilities for supervising on-farm research at clusters among research officers
	Training of extension workers on trial layout and management	Last training for extension workers thereafter only research staff research staff managed trials	Only research staff manage trials
Trials too thinly spread across the country necessitating substantial travel	Program expanded	Clustering of trials initiated in 1984 season but 21 clusters were still too many	Cluster reduced to eight one per province
			Size of cluster reduced to a maximum radius of 2 km
Too many crops in Communal Area Research Trials for one research officer to deal with their technical information and problems	As many as six crop under one research officer	As many as eight crops under one research officer	Each research officer in the Agronomy Institute assigned on-farm and on-station research responsibility for one commodity
Insufficient time for one research officer to think of key on-farm research issues and adequate analysis	Second research officer employed but resigned after a short time	Clustering intended to leave more time for reading, analysing issues, but still too many clusters	Clusters reduced to eight
			Size of cluster reduced to a maximum radius of 2 km
Insufficient interaction of the Agricultural Institute with agricultural technical and extension services and farmers in all provinces	Committee for On-Farm Research and Extension formed for provincial officials to have inputs but proved ineffective due to large size of meetings	Coordination meetings and field days improved interaction	Coordination meetings now scheduled
			Field days
			Each research officer has developed strong linkages with his/her respective AGRITEX provincial staff

the emphasis in the program was shifting to technology generation instead of adaptation, it was decided that researchers would manage the trials throughout the season and that extension workers and farmers would play a minor role in laying and managing trials. Farmers and extension workers, however, played an important part at field days.

A cluster refers to a geographical area usually encompassing a number of villages within an approximately two-kilometer radius from the center of operations. A research team of four persons managed a cluster. Each team was generally led by an agricultural assistant and was provided with camping equipment. They stayed at the clusters from November to February or March, only returning for monthly pay. The institute considers that such a team can satisfactorily manage 12 to 14 trials per season, undertaking such operations as fertilizing, planting, germination counts, and weed sprayings.

Consolidation phase, 1986 to present. Clustering the trials improved monitoring to a certain extent. However, the research officer responsible for the Communal Area Research Trials program spent most of his time on the road, with little time to plan his program well. This was resolved by giving researchers responsibility for both on-farm and station-based research on their commodity, and having them manage one or two clusters each. In this phase researchers are expected to achieve better management and supervision of their trials. They are also expected to spend 25% of their time at clusters, learning more about the problems of growing crops in those communal areas, compared to research stations, and developing skills needed to conduct trials in harsh environments.

The new responsibilities for commodity researchers were not easily accepted when the head introduced the idea. Most expressed concern about time and transport problems, although most of them now appreciate the new responsibilities. The research officer who was previously in charge of the Communal Area Research Trials program became responsible for groundnut research and for one of the clusters. Unfortunately, his experience has not been fully exploited by his colleagues, because he went on study leave in 1986.

Table 33 shows that the number of clusters has declined in some provinces, except Matebeleland North and South Provinces, where there has been only one cluster since the 1984/85 season. This decrease was necessary because it was realized that there was a need to improve management and also to promote closer links with AGRITEX, which is organized on a provincial basis. It was considered that having a cluster in each province would facilitate closer links between the Agronomy Institute and AGRITEX. The need for stronger links with AGRITEX came about as researchers realized that the relevance of their work to the problems of farmers could be greatly improved, and that the transfer of developed technologies would be facilitated.

The reduction from 20 to eight clusters, one per province in 1986/87, meant a reduction in the number of research field staff allocated to clusters. Some staff were reassigned to station-based activities.

Table 33: Number of Clusters per Province Included in the Agronomy Institute's On-Farm Research Program 1984-1987

Province	1984/85	1985/86	1986/87
Matebeleland North	1	1	1
Matebeleland South	1	1	1
Masvingo	4	5	1
Manicaland	2	2	1
Mashonaland East	3	4	1
Mashonaland West	2	2	1
Mashonaland Central	2	2	1
Midlands	2	3	1
Total	17	20	8

Balance between on-farm and experiment station research. Before the 1986/87 season, all on-farm research trials were carried out by Communal Area Research Trials and the Farming Systems Research Program, before the latter was incorporated into FSRU (Table 34). Only the maize program had one trial on two sites in the communal areas in the 1985/86 season. In this season, the Agronomy Institute had 46 trials on 247 sites, of which 20% and 52%, respectively, pertained to communal-area on-farm research. In the following season, Communal Area Research Trials was eliminated, and each commodity program in the Agronomy Institute absorbed its share of previous on-farm research.

At present, a third of the Agronomy Institute's trials are on-farm research, which means that technologies will be generated in each program from a combined analysis of on-station and on-farm research results. This is rational, since researchers have more confidence in results obtained on stations than on farmer's fields, particularly with respect to investigations on new problems and crops.

In the limited experience of the Agronomy Institute, it is too early to precisely assess the correct balance and contribution of on-farm research to the development of appropriate technologies for communal areas. However, on-farm research has certainly resulted in a better appreciation and understanding by researchers of communal-area farmers' problems in all natural regions. It has also facilitated the adoption of appropriate technologies through interactions with farmers and field days.

Table 34: The Proportion of On-Farm Research Trials in the Agronomy Institute's Research Programs During Seasons 1985/86 and 1986/87

Program	1985/86 season				1986/87 season			
	Trials		Trial Sites		Trials		Trial Sites	
	No.	%	No.	%	No.	%	No.	%
Weed	13	-	17	-	13	8	14	7
Maize	4	25	14	14	6	33	31	48
Sorghum and millet	3	-	17	-	3	100	34	47
Groundnuts	-	-	-	-	3	66	18	66
Sunflower and castor	5	-	21	-	5	20	26	31
Soyabeans	-	-	-	-	3	100	12	75
Field beans and cowpeas	4	-	14	-	5	20	25	16
Wheat	5	-	14	-	2	-	10	-
New crops	4	-	9	-	5	20	24	23
Communal Area Research Trials	7	20	141	87	-	-	-	-
Total	46	20	247	52	45	33	194	42

Formation of the Farming Systems Research Unit

Because of the need to focus more explicitly on communal areas, farming systems research was initiated in 1981 under the Agronomy Institute mainly to improve crop productivity. CIMMYT provided technical guidance and support, staff training, and financial assistance. In 1982, with the assistance of the International Livestock Centre for Africa (ILCA), and following the example of the Crop Division, the Livestock and Pasture Division also designed a farming systems research project for livestock production in communal areas. The proposal was submitted to the International Development Research Centre (IDRC) and was approved for funding in 1983. The objectives were:

- to study mixed-crop and livestock production systems in two representative sites in the communal areas in order to identify opportunities for, and constraints to, improved crop and livestock production;

- to adapt, develop, and test on farms improved crop and livestock production technologies and systems;

- to develop and test a model of farming systems research acceptable to DR&SS and suitable for wide-scale application in Zimbabwe;

- to train DR&SS personnel in farming systems research methods;

- to provide information for the formulation of agricultural development policies for communal areas.

A component of the project was ILCA support in the form of an adviser, as well as technical assistance and staff training financed by IDRC. Although the project was scheduled to commence in March 1983, ILCA was unable to place the adviser due to delays in the negotiation of a formal agreement with the Zimbabwe government. IDRC finally decided to recruit the adviser directly and thus the project began in February 1984. This decision turned out to be crucial, because the adviser was neutral and completely free to act in the best interests of DR&SS.

Position and composition of the team. Several options were analyzed before organizing the unit. The first was to leave the crop farming systems research program in the Agronomy Institute and to set up a new project team under the Livestock and Pastures Division, perhaps at one of the research stations. This option obviously had the support of the respective heads, but effective planning to develop and implement an appropriate interdisciplinary on-farm research methodology would be difficult to coordinate. One team composed of crop, livestock, and social scientists was deemed desirable because:

a) opportunities to improve the farming systems should be assessed from a whole-farm perspective, which invariably involves crops and livestock;

b) team interaction, given a minimum critical number of researchers, was considered essential to developing the appropriate methodology.

In the course of discussion between the directorate and the IDRC project adviser, effective communication with the institute and station researchers was identified as a key factor for obtaining the necessary technical expertise for the farming systems research program and for influencing the direction of experiment station research programs. It became evident that if the farming systems research team was to have any impact, it should:

a) have a disciplinary mix covering the most critical subject areas;

b) have experience with agricultural research designs and analysis;

c) be as strong as the other station teams.

A real concern was that a technically weak team would do poor-quality work according to DR&SS standards and consequently would only discredit the potential value of this approach, and therefore the goal of promoting the farming systems research approach would certainly not be achieved.

A second option was that of having one national coordinator with several regional teams. This was a model being promoted in other countries in eastern and southern Africa. Its merits were a decentralized and location-specific research focus, which could be led in each region by at least one or two research officers and

coordinated well with AGRITEX staff. Such a model was also envisaged in the World Bank/IFAD agreement, with a view to expanding crop farming systems research to at least eight areas in the 1984/85 season. But because of the team's training objective, particularly in interdisciplinary research, the need to liaise closely with the stations and institutes, and the responsibility for developing an appropriate farming systems research methodology for DR&SS, this option was not considered appropriate and was discarded.

Following these deliberations, the directorate decided to form FSRU as an autonomous unit instead of placing it under one of the three divisions of DR&SS. It was agreed that there would be a core team of five research officers in Harare (two agronomists, two livestock scientists, and one economist) and two small field teams composed of one research technician and two agricultural assistants posted to each of the two areas. The deputy director, initially, and the director, now, is the coordinator of FSRU and the IDRC project adviser - an economist - is the team leader.

In a March 1984 memorandum to all directors and heads of institutes and stations, the director officially announced the formation of FSRU and the decisions made with respect to its organization, functions, and way of working. He clearly stated the complementarity foreseen between the work of the Farming Systems Research Unit and on-station work, and requested in the strongest terms the full cooperation of all experiment station research scientists.

It is essential to note that the research officers who joined FSRU in early 1984 were fairly experienced researchers. The farming systems research team (one research officer, one research technician, and one agricultural assistant inherited from the Agronomy Institute program) had experiment station and on-farm research experience. The two livestock scientists had more than fifteen years of experience combined, and the economist had about eight years of research experience.

Interaction with collaborators. The contribution of institute or station research scientists of DR&SS to the farming systems research program has been substantial in that they have provided reviews of past research on key topics or problem areas, have assisted in assessing farmer situations and identifying research opportunities *in situ*, have participated in designing research trials, and have initiated experiment station trials which have been identified as very urgent and relevant to solving communal-area production constraints. Because there is a fairly high level of technical knowledge on stations, some of which can be quickly adapted to communal area conditions, the more-experienced experiment station scientists have always been anxious to contribute strong technical support to FSRU.

Extension staff are actively involved. AGRITEX usually helps with designing and carrying out diagnostic studies, identifying farmer collaborators, managing some trials (e.g., farmer-managed trials), and discussing farmers' problems, research opportunities, and progress. Every year there is a formal two- to three-day workshop to review the previous year's results and plan the following year's program.

The international agricultural research centers (mainly CIMMYT and ILCA), IDRC, and the University of Zimbabwe have a special role in providing experienced scientists to assist, complement, and build on the farming systems research program. They provide expertise in methodological approaches, subject-matter training for the staff, and a documentation service. Their contribution has been coordinated to focus almost exclusively on the needs and priorities of FSRU. The unit's strategy has been to select specific methodological and research recommendations rather than the full package from any center, in order to meet with its own priorities and opportunities as part of DR&SS most effectively.

Research strategy. The Mangwende and Chivi communal areas, representing high- and low-potential areas, were inherited from the Agronomy Institute farming systems research program. These were selected for the work of the new unit from four communal areas on the basis of three sets of criteria: the ecological and physical conditions of communal areas in the country, the biological and economic potential for both crop and livestock production systems, and the managerial and logistic conditions for setting up an operational base. A high-potential area was required because of the availability of technological innovations to test with farmers and to show some results of the farming systems research approach in the short run. A low-potential area was also desired because 74% of communal areas are in such areas, although it was recognized that limited technical knowledge would slow the research progress.

No more than two research areas would have been manageable, taking into account the unit's multiple objectives. Subsequently, World Bank advisers, and even AGRITEX, requested the unit to expand to other communal areas, since eight areas had been envisaged in the World Bank proposal. This pressure was resisted by FSRU. Other DR&SS institutes, especially the Agronomy Institute did, however, expand their on-farm research programs.

Several aspects of FSRU research methodology are worth noting. First, teamwork and analysis are the basis of its work, particularly when reviewing past research, area selection, screening technologies, and analyzing results. Second, several diagnostic techniques (informal interactive surveys, formal surveys, use of key informants, and monitoring) have been sequentially employed to satisfy the immediate information requirements of the research team at each particular phase, the general guideline being to generate minimum data, do more analysis of collected data, and consequently extract more useful information. Third, most of the team's time has been spent on on-farm experimentation, ex ante evaluations, and research reviews, in that order of importance, because it is believed that technological intervention must be the main focus, since it is the best means to understand how a production system works and how it can be improved.

Coordination within DR&SS and with AGRITEX

The seven-year DR&SS experience with on-farm research programs has had two major outcomes. First, it brought to the forefront the problem of lack of technical coordination across institutes and stations and lack of effective institutional mechanisms to promote

such coordination of on-farm research. Second, the lack of coordination and the different way of working of each on-farm research unit was confusing to AGRITEX and demonstrated clearly the lack of a coherent DR&SS strategy which should have reflected agricultural development priorities as well as the degree of AGRITEX participation desired in the research process.

These two basic problems, lack of strategy and lack of coordination and linkage, would never have been paramount in the recent developments in DR&SS had it not been for the on-farm research experience. For this reason, this section will focus on coordination across institutes and stations within DR&SS and on linkages between DR&SS and AGRITEX.

Historical background. AGRITEX was formed in 1981 by uniting the Department of Conservation and Extension, the extension agency servicing the large-scale commercial sector, and the Department of Agricultural Development, the extension service dealing with the communal areas. The Department of Agricultural Development was established between 1920 and 1930 with a specific mandate for communal areas, but it was under the Ministry of Tribal Lands. In contrast to the high degree of integration which existed between DR&SS and the Department of Conservation and Extension in serving the large-scale commercial sector, the Department of Agricultural Development had virtually no linkages with research. At that time there was no research support for agriculture in communal areas, except for what could be adapted from research aimed at benefiting commercial farmers.

The Department of Conservation and Extension had two principal departments: communication and technical. The technical staff of subject-matter specialists were highly trained, with strong links with experiment station research, and were capable of developing research results into technical messages for farmers, for which they provided the critical link between research and communication or extension. They were also capable of performing adaptive research. Some subject-matter specialists in fact resided on research stations. For example, there were usually two at Harare Research Station, three at the Cotton Research Institute, and one at the Lowveld Research Station. Thus the close association between research, extension, and farmers through various mechanisms ensured identity of key production constraints and researchable problems, as well as quick feedback on the profitability and acceptance of technological innovations produced by DR&SS for the large-scale commercial sector. The formation of AGRITEX and the need to service a much larger and more heterogeneous communal-area sector, in terms of production systems and ecological potential, unfortunately coincided with a large turnover of experienced staff in both AGRITEX and DR&SS, right after Independence.

With the political emphasis on communal areas, government and nongovernmental agencies setting up activities, they usually called on AGRITEX for assistance because at that time AGRITEX was one of a few well-established organizations in the communal areas. DR&SS was no exception. As early as 1981 it recognized the importance of coordinating on-farm research in order to optimize use of the limited manpower resources available. Two-day on-farm research planning meetings were called at DR&SS head office, which were attended by 40-50 people representing all provinces, including

provincial AGRITEX officers and some of their staff, heads of institutes and their research officers in DR&SS, and private companies which promoted their business interests in communal areas. This continued until 1983, but with little success: the group was too large for discussing the country's research needs and was not even split into smaller groups for discussing specific topics; and there was poor coordination between DR&SS institutes, largely due to lack of experience and personality clashes.

In 1984 the deputy director of DR&SS was charged with coordinating on-farm research in DR&SS and with AGRITEX. Up to 1987 there have been at least four seminars at head office on research proposals for specific commodities and/or progress. The Agronomy Institute has organized workshops and FSRU one major workshop on communal-area research, to which several other research officers were invited. Owing to their proximity, there is constant interaction among institutes, particularly the Agronomy Institute, FSRU, and the Crop Breeding Institute at head office during tea breaks and casual meetings.

In addition, at the directorate's request, every year the FSRU team leader compiled information on on-farm research trials and surveys conducted by each unit during the previous season; i.e., title, researcher responsible, location, objectives, and brief summary of results. This information was presented at the DR&SS/AGRITEX Annual Review Conference in which senior research and extension managers participate but was never used explicitly for planning purposes in DR&SS.

Researchers in on-farm research programs liaised informally on what other units were doing and what progress was being made. However, there were no formal mechanisms or incentives for promoting inter-disciplinary interaction and coordination of programs. On departure of the deputy director in September 1985, it was evident that some degree of organized coordination was essential. The effectiveness of the previous informal approach was limited by the lack of concrete decisions, actions, and participation by the principal implementers in DR&SS and AGRITEX.

Committee for On-farm Research and Extension. The lack of formal coordination and its accompanying problems of duplication of efforts, wasteful use of resources, and lack of coherent communal area research strategy led some on-farm research heads to explore alternative mechanisms for rationalizing their communal-area programs and promoting effective planning with AGRITEX. On their advice, the DR&SS director established the Committee for On-farm Research and Extension (COFRE) in April 1986. It comprised eight heads of units whose participation was considered essential in on-farm research: the Crop Breeding Institute, the Agronomy Institute, the Lowveld Research Station, FSRU, the Grasslands Research Station, the Pastures and Veld Unit, Biometrics, and the assistant director of the Field Division of AGRITEX. The Cotton Research Institute was not included because no other unit at the time had on-farm cotton research trials. The AGRITEX assistant director was included because he had been designated coordinator of research/extension linkages from the extension side. COFRE's primary objective is to coordinate DR&SS on-farm research and to establish stronger ties with AGRITEX, both for planning trials and designing AGRITEX demonstrations.

To accomplish this objective, trial and demonstration proposals were submitted early in the season and were reviewed by commodity subcommittees on maize, sorghum and millets, sunflower, groundnut, soyabean, cowpea and fieldbeans, livestock and pastures, and diagnostic surveys. COFRE appointed a convener and research officers for each subcommittee, selecting the more experienced DR&SS on-farm research scientists working on those particular commodities or programs. Their terms of reference were:

a) to review and improve proposed trial designs, treatment levels, and trial site selection;

b) to identify opportunities for coordination or joint work between institutes on the proposed program;

c) to report the outcome of their deliberations to the committee.

DR&SS on-farm research teams held one-day provincial meetings in August 1986 with AGRITEX in two provinces at a time, to present and discuss on-farm research trials and demonstrations. These meetings were extremely successful, since they were the first of their kind, and interaction was good among the 20-30 participants of each. Each on-farm research unit had to present and defend its own program in each particular province.

Two months later, each commodity subcommittee presented its report at a meeting in which 17 researchers participated. It was discovered then that each subcommittee had met on several occasions and that some had even had to review previous research results. It was also decided at the same meeting that an on-farm research project directory of trials and demonstrations would be compiled and that COFRE would organize field monitoring tours. The document was produced four months later and was used to select sites for the monitoring tours.

For these tours, four teams were formed and four provinces selected for visits. Two teams were headed by DR&SS scientists and two by senior AGRITEX officials. Each team comprised about eight members drawn equally from both organizations and visited about twelve trial and demonstration sites during a three-day trip. Their mission was to assess trial and demonstration designs, management, and performance using a standard format for each trial, to assess farmer, extension, and researcher relationships, and to identify opportunities for technical coordination and follow-up. These tours were extremely useful in that they permitted each team to interact and discuss the observed directions, strengths, and weaknesses of the research and demonstration trials.

In April 1987 each team presented a tour report. From a synthesis of the reports, five key areas were identified as requiring urgent attention: coordination among DR&SS units, farming systems diagnosis in AGRITEX, on-farm research methodologies (area selection, field designs, and systems approaches to research), definition of DR&SS/AGRITEX responsibilities and functions, and the development of a natural region research and extension strategy. Because of the urgency of the latter for planning the following year's program, the Committee for On-farm Research and Extension agreed to convene a two-day workshop in May to define research and

extension priorities for Natural Regions III, IV, and V. Approximately 20 senior officers from both DR&SS and AGRITEX were invited. The outcome will serve as guidelines for DR&SS and AGRITEX crop and livestock staff in preparing more coherent and relevant on-farm research proposals which will again be reviewed by the subcommittees. It was also agreed that the subcommittees would be strengthened by incorporating more-experienced experiment station scientists from DR&SS and subject-matter specialists from AGRITEX.

The committee has made good progress, to which three major factors contribute. The first was the appointment of the head of the Agronomy Institute, the chairman of the committee, and the assistant director of AGRITEX as coordinators of research-extension linkages. With the full support of their respective superiors they have given this responsibility their highest priority. The second was that they developed appropriate mechanisms with active participation from middle- and lower-level officers who have come to realize that some degree of coordination is essential at this stage of on-farm research development. Many officers in both organizations have on-farm research experience and can make constructive suggestions. The third was that neither organization had logistic resource constraints to implement coordination activities because of flexibility in the administrative and technical procedures of both departments.

The main difficulty is the ad hoc nature of the process being followed by COFRE. There are no institutional mechanisms or agreements to ensure intra- and interdepartmental coordination. COFRE has no authority to sanction its recommendations, which leaves any head or research officer to decide whether to accept or reject them. It will be essential in the near future to lay down a formal institutional coordination policy and the necessary responsibility or incentives to support it.

Linkages between the DR&SS and AGRITEX. Under the present organizational structure of the Ministry of Lands, Agriculture and Rural Resettlement, DR&SS has a mandate to generate and develop technologies, and AGRITEX to disseminate them. To carry out its mandate, DR&SS is organized into broad disciplinary and specialist units, whereas AGRITEX is organized into a Technical and a Field Division[2]. The Technical Division comprises seven specialized branches in crop production, animal production, engineering, irrigation, planning, training, and soil conservation. Their main function is, with their subject matter specialists, to synthesize research results, adapt technical messages to suit farmer target groups, and to provide technical support to the "army of communicators" in the Field Division. The presence of such a large Technical Division in AGRITEX and the expansion of on-farm research programs in DR&SS have raised serious questions about where responsibility for adaptive research lies and about the degree of coordination required. In fact, because on-farm research programs invariably require AGRITEX assistance, the lack of coordination within DR&SS was becoming a serious problem for AGRITEX.

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2) An Irrigation Division in AGRITEX was created recently to deal with this area of high priority to government.

Except for a few cases, the linkages of DR&SS on-farm research programs with the Technical Division are relatively weak. There are few opportunities to interact with subject-matter specialists who have to synthesize research results and draft production recommendations for farmers. The lack of interaction is due in part to the rather limited experience of this division at present.

All senior managers in DR&SS and AGRITEX agree that on-farm research linkages should be strengthened. However, there are problems in achieving this. First, the organization of the departments is not compatible. AGRITEX is organized on a provincial basis, in line with the political and development organization within the country. In contrast, DR&SS is organized by discipline, and its research is oriented towards natural regions. Since a province may cover several natural regions or vice versa, these diverse organizational boundaries complicate the process of developing effective linkages. For example, if a research unit working on critical production problems in Natural Region V is not in a particular province, AGRITEX staff in that province tend not to consult with that unit, despite the fact that it is also trying to develop messages and demonstrations for Natural Region V. In the past this was not a problem, but the new generation of less-experienced staff have not yet developed the mechanisms for informal contacts with researchers.

There is also the need to strengthen collaboration at the field level by involving extension workers directly in on-farm research. The advantages of this are, first, that extension supervisors and extension workers could contribute by helping researchers to understand farming systems and priority problems of specific regions; and, second, extension officers would become much more knowledgeable about and confident in research.

Stronger collaboration at the field level would accelerate the process of technology development and dissemination. It is also a logical training mechanism for developing the capacities of AGRITEX staff to assume fuller responsibilities for location-specific adaptive research. This is the direction envisaged in the AGRITEX development strategy and would drastically modify the image DR&SS has of AGRITEX as strictly a consumer of research results.

As government officials, especially in the Ministry of Lands, Agriculture and Rural Resettlement, have become more aware of on-farm research, DR&SS is receiving increased pressure to expand the program to all provinces (since the province is the development unit). One of the benefits of having AGRITEX take on more responsibility of on-farm research is that it is organized on a provincial basis and will be able to satisfy these political demands. This is a clear advantage in developing stronger research-extension linkages, and on-farm research appears to be the most appropriate means to achieve it.

AGRITEX supports this view, and its directorate is moving to strengthen its technical capacity and develop a farming systems research approach. The farming system is the logical unit of analysis for defining target groups and their respective priority problems. Under the training plan, subject-matter specialists would use a systems perspective to carry out the functions of:

a) characterizing farming systems;

b) diagnosing major constraints or determining leverage points for intervention;

c) adaptation and design of appropriate technology;

d) testing and monitoring of alternative technologies;

e) developing appropriate technical messages.

This would be done in conjunction with agricultural extension officers working at the field level, and the subject-matter specialists would be the primary link between extension and research. Agricultural extension officers would be relieved of their administrative responsibilities and would assume a fully technical role. They would be trained in the systems approach and would have responsibility for adapting messages for their client groups. Some agricultural extension workers are now being assigned to work part-time in FSRU.

It should be noted that this is the training plan envisaged. Currently, AGRITEX has a limited capacity to carry it out. Two staff members were sent on a CIMMYT/University of Zimbabwe regional on-farm research training course. AGRITEX plans to seek CIMMYT and FAO assistance to develop, together with their training branch and FSRU in DR&SS, an in-service training program for extension staff.

The recent emphasis on farming systems research in AGRITEX is not surprising, since its director was previously deputy director of DR&SS and coordinator of FSRU. He has considerable experience of farming systems research and has studied alternative models for organizing farming systems research and on-farm research. His assistant director, who is clearly committed to this direction, has extensive field experience with farmer-participatory approaches to extension work at regional and provincial levels, has a good conceptual background on holistic systems analysis, and has had previous contacts with FSRU. There is therefore strong high-level support for the farming systems research. The deputy director also believes that the development of FSRU in DR&SS has been the motivating force in bringing AGRITEX and DR&SS together in a joint effort to strengthen linkages.

Livestock On-Farm Research

The predominant farming systems in the communal areas are mixed crop/livestock systems, in which livestock, either as an input into the crop component or independently, is an important and strategic component, especially in Natural Regions III, IV, and V. The on-farm research programs of the crop-related institutes in DR&SS are impressive, and tremendous progress has been made; yet livestock on-farm research is only conducted by FSRU (introduction of forage legumes, supplementation of oxen, and goat crossbreeding), Henderson Research Station (improved feeding for milk production), and Makoholi Experiment Station (forage legumes for seed production). This is a very small fraction of the total DR&SS on-farm research program. The reasons for the very slow development of on-farm

livestock research in response to the government's high priority on communal-area development follow.

First, the professional staff of the Livestock and Pastures Division have been seriously depleted in recent years, to the extent that they have problems in maintaining their experiment station research projects. Unlike the Crop Research Division, which was fairly well supplied with fresh graduates from the University of Zimbabwe, the Livestock and Pastures Division did not draw such resources, particularly on rangeland management and forage agronomy, which are highly relevant to communal areas. Furthermore, the inability to hire young African research officers in sufficient numbers meant that there was less technical and political commitment to initiating on-farm research activities in communal areas.

Second, the Livestock and Pastures Division was excluded from the World Bank/IFAD project, because the project related to food production and security in communal areas was interpreted as being crop-related. This meant that the division did not have access to resources for rebuilding its staff and infrastructure after Independence. Furthermore, because of the crop bias, more political pressure for communal-area work was applied in the Crop Research Division.

Third, the difference between the livestock systems in communal areas (multiple uses of livestock and overgrazed lands) and the large-scale commodity sector (highly specialized and sophisticated systems) does not allow easy transfer or adaptation of technologies developed for the latter sector, as in the case of crop production. In other words, the technical expertise of DR&SS, particularly in the field of beef and dairy production, cannot be extrapolated to the communal area systems unless drastic changes in the functions of cattle, the land tenure system, and infrastructural and service conditions are made to accommodate technologies currently available. For example, the fact that the present stocking rates are already twice the potential carrying capacity of livestock in most communal area rangeland discourages technical experts from testing innovations to increase productivity, which would be translated into larger numbers of cattle, a common objective of farmers, thereby exacerbating the ecological problem.

Finally, as far back as 1982, the assistant director of the Livestock and Pastures Division intended to initiate on-farm livestock research; which was why he had personally developed and submitted the IDRC proposal. Subsequently, the IDRC support was used to establish FSRU, a decision which was not originally favored but was reluctantly supported by the then new assistant director. FSRU was justified on the grounds of being an extension of and feedback link for their experiment station research programs. To date, the more experienced on-station livestock research scientists look at participation in Farming Systems Research Unit activities as a means of having their technologies tested within a systems context; to define relevant priorities for experiment station research that will make them more effective consultants to FSRU; and to interact with other disciplines in livestock and crop research in designing improved technologies for livestock and crop systems.

In spite of substantial technical inputs into FSRU, the present assistant director and scientists of the Livestock and Pastures Division perceive the need to participate directly in on-farm research, a view that the case study team fully affirms. This need is supported by some recent projects.

The first is on the screening of annual and perennial multi-purpose legumes and trees with the Pasture and Veld Branch at Grasslands and with the Forestry Commission. The objective is to develop management options (spatial and chronological arrangements) for introducing these legumes in various systems in the arable (intercropping, rotations, alley-cropping, hedgerows) and grazing areas (agroforestry techniques). The basic functions of these legumes would be forage production, soil fertility improvement, wood fuel production, household food production, construction materials, and protective fencing, with the overall objective of stabilizing the productivity of whole farming systems which are presently too dependent on annual grain crops and therefore risk-prone.

The second project is on the upgrading of crop residues and byproducts for ruminants with Grasslands, the Henderson Research Station, and the University of Zimbabwe. The objective is to develop physical and chemical methods for optimizing the utilization of low-nutritive feedstuffs. These methods are an essential component of efforts to improve the efficiency of draft use, fattening of cows and old oxen for culling, and to promote small-scale milk production systems.

The third project is on goat production, with the livestock stations. Goats are the main species in the communal areas, particularly in low-potential areas, supplying meat and generating cash; yet to date they have attracted very limited research. Research on crossbreeding with indigenous breeds, management of semi-arid range types, food supplementation, and health management could have high pay-offs.

Most of the four livestock research stations are participating in the above-mentioned projects, which have both on-station and on-farm research components; thus effective coordination in the Division has begun well. If the staff situation improves and operational funds continue to be available, the strategy is to transfer promising experiment station research results as soon as possible to on-farm research.

MANAGEMENT OF ON-FARM RESEARCH: KEY ISSUES

Management of the Research Process: Planning, Programming, and Review

The basic responsibility for these functions rests directly with the head of the institute, in consultation with the corresponding assistant director. On-farm research is not treated differently because it is considered to be an integral component of the institute's total research program. In all institutes the research officer draws up the research proposals, but the process followed in each on-farm research program varies according to who is consulted

and the degree of their participation in the research process (Table 35). A brief description of the planning, programming, and review process in each institute follows.

In the Crop Breeding Institute the process is informal, depending on research officers to seek assistance or to circulate their research proposals. Some inputs from AGRITEX and collaborating farmers are obtained in the problem identification and review phases, primarily through field days and informal discussions at trial sites.

In the Agronomy Institute, priority setting and program formulation are strongly influenced by the head through informal discussion with individual research officers. Once the research officer has prepared his/her proposals, which incidentally include on-farm and experiment station research, the head and his assistant director review them together in a more formal meeting with each research officer. Research officers receive informal guidance on data analysis and evaluation of results from the biometrician and the head. Because on-farm research staff are relatively inexperienced, the planning function depends considerably on the head. Research technicians with considerable field experience participate informally in trial analysis, discussion of results, and planning future trials. The Agronomy Institute also uses technical seminars as a means of conveying feedback in DR&SS. As an example, the sunflower program was presented to approximately 25 research officers in a one-hour seminar, with time for discussion. The institute has also sponsored field days and monitoring tours to assess technical problems with on-farm research implementation and to identify areas of future collaboration with other institutes. Participants in these events have included breeders, soil scientists, plant pathologists, entomologists, statisticians, and farming systems research and AGRITEX specialists.

At the Cotton Research Institute the major event is an annual planning meeting attended by all its research officers, AGRITEX representatives, the research officer from the Commercial Cotton Growers Association (CCGA), research officers from the Lowveld Research Station (one research officer there is a Cotton Research Institute entomologist), and the Agronomy Institute Weed Research Team. At the meeting, each research officer must present his/her on-station and on-farm research proposals, including projects discontinued, new projects, modification of ongoing projects and demonstrations to be carried out. AGRITEX attends principally to assess the relevance of these proposals to communal-area farmers. The on-farm research officers and AGRITEX regional staff also contribute to the planning phase, as they are informally consulted on trial results of previous seasons and on new proposals. Trial data analysis is done at the Cotton Research Institute by the responsible research officer, and there are frequent informal consultations and constructive criticisms. Field days and training programs at the CCGA Training Centre offer an opportunity for farmers and AGRITEX staff to contribute to the early and late phases of the research process.

In the Lowveld Research Station the two on-farm research officers work together to identify problems, set priorities and formulate trial programs. These proposals are circulated to other research

Table 35: Level of Participation by Different Actors in Five Stages of the Research Process in the Five On-Farm Research Programs

Stage in Research Process	Crop Breeding Institute	The Agronomy Institute	Cotton Research Institute	Lowveld Research Station	Farming Systems Research Unit
Problem identification					
Head	1*	3	3	3	3
Research officers within institute	1	1	2	3	3
Other Research officers within DR&SS		2	1		2
On-farm research field staff					1
AGRITEX	1	2	2	1	3
Farmers	1	1	2	1	3
Priority Setting					
Head	1	3	3	3	3
Research officers within institute	2	1	3	3	3
Other research officers within DR&SS		1	1		1
On-farm research field staff					2
AGRITEX					2
Farmers					2
Program Formulation					
Head		3	3	3	2
Research officers within institute	1		2	3	2
Other research officers within DR&SS		2	2	1	3
On-farm research field staff		2	1		2
AGRITEX		2	3		2
Farmers		1	2		
Data Analysis					
Head		2		3	2
Research officers within institute	1		3	3	2
Other research officers within DR&SS	3	2		1	2
On-farm research field staff		2			2
AGRITEX					1
Farmers					
Review/Evaluation					
Head	3	2	2	2	3
Research officers within institute	1	2	3	3	3
Other Research Officers within DR&SS	1				2
On-farm research field staff			1		2
AGRITEX	2	1	3	2	3
Farmers	2	1	2	2	3

* 1 = weak, 2 = moderate, 3 = strong. Blank means there is no participation

officers at the station for ammendment and suggestions. There is one annual planning meeting, and there is a high degree of continuous interaction, particularly on the evaluation and planning of trials. To these activities, however, the research assistants make little contribution. Lowveld Research Station staff organize field days and meetings for AGRITEX at the station and field days for AGRITEX and farmers on research sites, in order to obtain feedback and to discuss the farmers' priorities and problems to be investigated.

FSRU has adopted planning and review mechanisms that ensure effective interaction among experienced researchers, extension personnel, and farmers. For example, in 1984, it conducted a one-week workshop in each study area in which about 20 crop and livestock specialists from DR&SS and AGRITEX participated. Small-group discussions were held with a wide diversity of farmers to better understand their farming systems and production constraints. The workshop resulted in a list of potential innovations which were subsequently evaluated by the farming systems research team for their technical and economic feasibility.

This was the basis on which the 1984/85 program was formulated. Since then, the planning procedure has been stepwise.

1) The core team meets to highlight the results of the previous season. This takes at least a day and the objective is to identify research priorities and opportunities and to define major project objectives and titles.

2) Each component of the program (i.e., crops, livestock, socioeconomics) is drawn up as a formal proposal by specific research officers in consultation with DR&SS scientists and others, such as international agricultural research centers, AGRITEX, and the University of Zimbabwe collaborators. This may last weeks, as consultations take time to arrange, and experienced on-station research scientists usually have "clear" ideas of their own. The process at this stage also requires close consultations among the farming systems research team and field staff as alterations of original directions may be necessary.

3) The farming systems research team, together with research technicians, one in charge of each area, meet to review the detailed proposals for justification, hypotheses, experimental designs, and (ex ante) analysis.

4) Formal meetings are arranged with AGRITEX staff, usually a two-day exercise in both study regions, to analyze the previous year's results, to discuss farmers' and AGRITEX priorities, and to assess the appropriateness of the research proposals for the next season. An average of 25 extension officers, supervisors, and workers attend these meetings.

5) The revised program is discussed at a planning meeting with DR&SS and international agricultural research center collaborators. These meetings are usually informal, with DR&SS research officers participating, except in September 1984 when a formal four-day meeting was held. At that meeting, about 28

scientists from DR&SS, CIMMYT, ILCA, and the University of Zimbabwe reviewed farming systems research proposals to improve their design, identify complementary experiment station research required, and identify relevant previous and current research work in Zimbabwe or elsewhere.

6) The research proposals are demonstrated and discussed with farmers in every cluster to obtain feedback and to prepare them to assist in quick trial establishment as soon as the rains start. Even at this last stage, changes in trial designs have been made at the suggestion of farmers.

The formal annual planning meeting is the most important event for the Cotton Research Institute, the Lowveld Research Station, and FSRU, being more elaborate and extended in the case of the latter. All five programs make considerable use of informal interactions at planning meetings. AGRITEX participation is much stronger in FSRU, the Cotton Research Institute, and the Agronomy Institute, but the Lowveld Research Station and the Crop Breeding Institute make some effort to obtain AGRITEX inputs, usually at the review stage. Farmer input is much stronger in FSRU and the Cotton Research Institute. All programs use experiment station research to obtain feedback to a greater or lesser extent in the review phase.

At present the Committee for On-Farm Research and Extension is the most effective means of inter-program coordination; it attempts to define on-farm research, design appropriate programs, and monitor and evaluate trial progress. Finally, it should be emphasized that daily informal discussions at tea breaks at the head office strengthen coordination among the Crop Breeding Institute, the Agronomy Institute, and FSRU research officers.

Management of Surveys, Trials, and Field Operations

Surveys. The degree of interest in and use of diagnostic surveys varies much across programs. The only example of a formal survey in the Crop Breeding Institute was with participation of the Agronomy Institute and help of FSRU: a short national survey on cowpea in 1985 to determine its role and utilization patterns in communal areas, with a view to developing its on-station and on-farm research strategy for this crop.

Before 1984 the Agronomy Institute's farming systems research program was responsible for studying production systems in communal areas. Following formal and informal surveys out at the major research sites, the information on communal-area system management and constraints was used to plan farming systems research, Communal Area Research Trials, and experiment station research in the Agronomy Institute. After 1984, when farming systems research became a separate unit, the Agronomy Institute felt that FSRU's should continue its studies and provide feedback to the Agronomy Institute and others in DR&SS. For this reason institute research officers have advised and even participated to some extent in Farming Systems Research Unit diagnostic activities. They also felt the need to complement such work with surveys of their own, in which other institutes, including FSRU, contributed to the design of questionnaires and analysis of results. Surveys included sunflower

production in 1984, one on cowpea in 1985, both having national coverage, a weed survey in 1983, and a soyabean production survey in the Hurungwe District in 1986. The objective was to assess the role, agronomic management and general performance of these crops or problems, but little attention was paid to the socioeconomic aspects of the production system other than analyzing farmers' practices.

In 1984/85 the Cotton Research Institute entomology section surveyed 200 farmers in their research areas to assess the appropriateness of existing pest management recommendations for communal areas. It was found that they were not readily understood or followed, since many farmers are illiterate, and a study of alternative methods then followed.

The diagnostic function is important in FSRU, and it has made use of a combination of diagnostic techniques to meet specific needs at each stage of research. Since 1984 it has carried out various surveys (Annex 5):

a) an informal survey to define farmers' problems and research priorities;

b) a formal survey to define farmers' resources, farming practices and attitudes towards proposed innovations;

c) a technology assessment formal survey to determine how farmers will accept and adopt maize reduced-tillage, fertilizer, and herbicide technology;

d) a livestock census to determine population and ownership distribution;

e) livestock production monitoring to generate data for cattle, goats, and donkeys;

f) a key informant study on household decision-making to characterize gender and age divisions of labor and responsibilities for crop and livestock management and distribution of outputs;

g) an informal goat production survey to determine their role, management, constraints, and research needs in communal-area systems;

h) an economic analysis of crop systems, with emphasis on maize and groundnut (University of Zimbabwe/MSU Project);

i) a study of livestock grazing schemes (University of Zimbabwe/International Development Research Centre Project).

The Lowveld Research Station on-farm research program has not done any formal surveys in communal areas, because its research officers do their diagnostic work informally by means of direct interactions with farmers and extension personnel in the various phases of the trial program. All other on-farm research programs also make use of these informal methods.

Area and farmer selection. There are some differences among on-farm research programs in the mechanisms and criteria for communal area, site, and farmer selection. The Crop Breeding Institute, the Agronomy Institute, and the Lowveld Research Station select their research areas on the basis of agro-ecological (natural regions and soil types) and logistic (human and financial requirements and accessibility) considerations. AGRITEX then helps them to select farmers willing to collaborate, whereupon research officers negotiate for sites that conform to experimental requirements (i.e., within-site uniformity, drainage, etc.).

The Cotton Research Institute's method of defining specific or representative farmer target groups was as follows. First, communal areas with the largest cotton production were identified by their seed purchases from the Cotton Marketing Board. Then, a meeting was held with AGRITEX to identify key areas where research would have the most value, and then AGRITEX was asked to identify farmers on the basis of willingness and accessibility. Third, sites were selected from these farms by Cotton Research Institute staff on the basis of site uniformity, drainage, etc.

FSRU has been working in only two communal areas since 1984. Within each area there is a formal procedure, invariably involving AGRITEX, for site and farmer selection, depending on the type of trial. Trial sites are first clustered according to the geographical area covered by an extension worker and his/her farmer groups. The objectives and design requirements (soil, climate, and farmer characteristics) of each trial are provided to the extension workers and supervisors who explain the selection criteria to the farmers. Since farmers are usually organized in groups, their committees identify potential collaborators (a larger number than required) who are then visited by AGRITEX and Farming Systems Research Unit staff to make the final choice. For researcher-managed trials, representativeness in terms of agro-ecological factors would be important, whereas for a farmer-managed trial, representativeness in terms of productive resources, particularly management levels, would be imperative. Finally, two or three sites in each research area are selected for establishing all trials, one of which will subsequently be used for the major field day.

At present the Agronomy Institute, the Cotton Research Institute, and FSRU use cluster trial sites within an area. Although there are other objectives, such as promoting linkages with farmers and AGRITEX, clustering is necessary to rationalize resource use, because the long distances and poor-quality roads within communal areas are serious problems. Clustering does not compromise research program design; a more scattered selection of sites would not necessarily cover a greater diversity of agro-ecological conditions which are relatively homogeneous within a given communal area.

Table 36 presents information on the logistical aspects of the five on-farm research programs. The Crop Breeding Institute and the Agronomy Institute research officers have to travel most in terms of the number of areas and the average distance from base, but once they are in the area, moving among sites is minimized. FSRU and the Cotton Research Institute have an advantage in having the least number of sites, even though FSRUs are quite distant from each other. There is no overlap of area among the Agronomy Institute, the Cotton Research Institute, the Lowveld Research Station, and

FSRU, but the Crop Breeding Institute does overlap in some areas with the Agronomy Institute, the Cotton Research Institute, and FSRU (see Annexes 1 to 5).

Table 36: Distances of Research Areas for Five On-Farm Research Programs During the 1986/87 Season

Variable	Crop Breeding Institute	Agronomy Institute	Cotton Research Institute	Lowveld Research Station	Farming Systems Research Unit
No. of research areas	24	8	3	7	2
Average distance from headquarters (km)	190	280	110	120	220
Average travel time from base (hrs)	2.1	3.1	1.5	1.6	2.4
Distance between areas farthest apart (km)	500	500	120	250	450
Average distance within research area (km)	1	3	5	15	20

There are two basic problems in area and farmer selection. The first, mentioned by on-farm researchers, especially in the Agronomy Institute, is on-farm site selection: farmers tend not to offer the best or most uniform sites for trial work. The need to have the "best" is open to debate, but the uniformity issue needs to be analyzed in terms of appropriate statistical designs and "blocking" methodologies. The second problem is that since AGRITEX tends to work with farmers, who have received formal training from AGRITEX and may constitute less than 5% of the total farmer population, and with local leaders, on-farm research units normally end up with more resourceful or progressive farmers participating in trials. FSRU does look for more representative farmers for trials where farmers have some degree of managerial participation. However, the bias toward more resourceful farmers is not viewed as a problem by research officers because better farmers are usually better collaborators.

Trial management and operations. Details of the trials of each on-farm research program are provided in Annexes 1 to 5. According to the summary presented in Table 37, the Cotton Research Institute works with one commodity, and FSRU with nine (seven crops, cattle, and goats). The number of trials on crops or livestock varies. The Crop Breeding Institute is the only unit with one trial per crop.

Farmers do not participate in trial management in the Crop Breeding Institute, the Agronomy Institute, and the Lowveld Research Station, as these have only researcher-managed trials, whereas the Cotton Research Institute and FSRU have some degree of farmer participation in about a third of the trials in which ability of farmers to use and manage technologies (e.g., pest-scouting, use of implements, and supplementing draft oxen) is an integral component. It should be

noted that field assistants of FSRU also carry out characterization and monitoring studies which require on-farm research all year round. In the other units, field staff either have other duties on-station (Crop Breeding Institute, Agronomy Institute, and Lowveld Research Station) or are posted only for the duration of the crop season; i.e., five months of the year.

Table 37: Distribution of Trials for Five On-Farm Research Programs During the 1986/87 Season

Variable	Crop Breeding Institute	Agronomy Institute	Cotton Research Institute	Lowveld Research Station	Farming Systems Research Unit
No. trial crop and livestock enterprises	6	9	1	4	9
No. trials	6	15	4	10	18
No. trial sites	48	84	77	22	109
% researcher-managed	100	100	74	100	65
% researcher/ farmer-managed	0	0	26	0	35
No. trial sites per research assistant	8	4	15	4	15

From the preceding analysis, it seems that a smaller number of research areas and farmer participation in trial management can increase the output of the field staff, as evidenced by the Cotton Research Institute and FSRU trial sites to research assistant ratios. However, a larger number of research areas and too much farmer participation, particularly in researcher-managed trials (the Agronomy Institute's experience) can reduce trial success and reliability of results. These problems basically depend on the size, organization, and management of the field teams.

The organization of the field staff for each program is as follows. The Crop Breeding Institute and the Lowveld Research Station do not outpost any staff to the research areas. The Cotton Research Institute outposts one research hand per cluster, whereas the Agronomy Institute has a team of one agricultural assistant and three research hands per cluster. In each area FSRU has a small team of one research technician, two agricultural assistants, and two research hands. The field teams and assistants are highly experienced in research activities and assume full responsibility for on-farm research implementation. In the case of the Lowveld Research Station and FSRU, field staff (research technicians and agricultural assistants) are also required to explain a trial program's justification, objectives, and design to farmers, visitors, and AGRITEX staff at any time. Data collection is also the responsibility of the staff, and is organized by the research technicians, except in the Crop Breeding Institute, where it is done by the research officers.

Supervision of field staff is not a problem because research technicians can work independently, but agricultural assistants and research hands often require constant supervision, except in the Cotton Research Institute and FSRU, where they too work well independently and require only casual monitoring visits by superiors. According to field staff, research officers always come to the field when needed, and it is fairly easy to contact. In the Crop Breeding Institute, the Lowveld Research Station, and one area of FSRU, field staff reside with research officers on the same station and therefore frequency of meeting is as often as necessary, whereas in the Agronomy Institute, the Crop Breeding Institute, and the other area of FSRU, it is once per month, once per week, and twice per month during the season, respectively. Most field staff seem to be satisfied with this level of supervision by research officers, but the less-experienced field staff in the Crop Breeding Institute, the Agronomy Institute, and the Lowveld Research Station were not satisfied. A Crop Breeding Institute research officer was the only one to complain that the large number and distances of research areas led to supervision problems.

The 1986/87 season was harsher than average. There were problems with late establishment of trials for the Crop Breeding Institute. Estimates of trial site losses at this time were about 50% for the Crop Breeding Institute (due to drought), 10% for the Agronomy Institute (due to bird damage and pests), 5% for the Cotton Research Institute (due to the farmer being arrested for killing his son), 60% for the Lowveld Research Station (due to drought and destruction of sites by farmers and animals), and 20% for FSRU (mainly due to drought). These percentages were determined mainly by the types of crops and natural regions involved. Not much can be done about drought, but with the others the on-farm research staff believe they must provide more explanations to farmers and be flexible in dealing with them. The proportion of trials with reliable results were estimated at 80% for the Crop Breeding Institute, 85% for the Agronomy Institute, 75% for the Cotton Research Institute, 55% for the Lowveld Research Station, and 90% for FSRU. There was consensus in the Crop Breeding Institute, the Agronomy Institute, and FSRU on acceptable coefficients of variance levels, a maximum of 30%, whereas the Cotton Research Institute put it at 25%, and the Lowveld Research Station at 20%, basically for researcher-managed trials.

Communications. Instructions for on-farm research work are provided on project sheets and are reinforced verbally by research officers when visiting research areas. Since most staff have experience with experiment station trials, they have no problems in understanding such instructions.

Communicating with junior staff in the Crop Breeding Institute is easy because each research officer resides and usually travels with them from the Harare Station. In the Agronomy Institute, the on-station Crop Production Unit serves as the center of communication. The research technicians there communicate with the agricultural assistants and research hands as often as necessary, and weekly reports are made by the on-farm research field staff. From the Crop Production Unit to Harare, the telephone works very well. The Cotton Research Institute has all its on-farm research staff at the station except for research hands. Each has access to the AGRITEX radio system and can therefore contact the Cotton

Research Institute station directly. The Lowveld Research Station was included in the AGRITEX radio system in September 1986, and although there are no staff posted out, there are good communications with AGRITEX supervisors in each area. The field staff for one Farming Systems Research Unit area operate from the Harare Station, as does the research officer team, and therefore communication is excellent. The other field team's research technician operates from the AGRITEX provincial office, and there is no problem in contacting him through that office. However, if he is in the field with his agricultural assistants and research hands, telephone or radio communication has to be there. On occasions communication may take as much as a day or two, but such delays have not been known to cause problems with the trial program, except in one case when army worm attacked a trial and the responsible research officer could not be contacted.

Communication between researchers and farmers is very good. With the exception of a few research officers (expatriates and Europeans), all speak the local language. Farmers are also highly interested and cooperative in on-farm research trials, as mentioned before.

Management of Data Analysis, Reporting, and Dissemination of Results

The analysis and interpretation of on-farm research data is fairly centralized for all units and is the duty of research officers, whose research technicians usually organize and code the data for computer entry and processing. After analysis, research technicians may be consulted on interpretation or asked to prepare summary tables of trial results. Except for the Cotton Research Institute, which has a terminal to the mainframe computer of the Scientific Computing Center of central government, all others use the Biometrics Bureau or may do some of the simple analysis on hand calculators. FSRU recently acquired a microcomputer with data management, statistical analysis, and wordprocessing software. There are no major problems with on-farm research data analysis because the Biometrics Bureau can manage most analysis. For more sophisticated types of analyses, it also has direct access to the government's mainframe computer. The Agronomy Institute and the Lowveld Research Station have already ordered microcomputers. Microcomputer data management capability should be extremely useful, particularly for survey and monitoring data, and without doubt the wordprocessing package will help expedite the preparation of annual and other reports.

One of the main problems raised by research officers is that everyone brings data for analysis simultaneously. Furthermore, the Crop Breeding Institute mentioned the problem of inconsistency of results across sites, the Cotton Research Institute mentioned the complexity of experimental designs used, the Lowveld Research Station the high coefficent of variance, and FSRU high seasonal variations. These create serious problems for data interpretation and statistical inference. Survey work is seldom undertaken by the Crop Breeding Institute, the Agronomy Institute, the Cotton Research Institute, and the Lowveld Research Station, and when it is, the information is immediately used in formulating their trial programs; so there are no problems of data analysis. FSRU has published some of its survey results, but it normally presents results in the

context of the projects being developed and discusses them with experiment station research groups in order to develop research projects.

Monthly and annual reports and scientific articles are the usual reporting mechanisms. The monthly reports of each on-farm research program are up-to-date, but they do not have much technical content. All research officers must prepare draft technical reports on their trials during the year (a reporting year is from October to September) which the head of the institute edits and integrates into the institute's annual report. The latest report for some institutes is the 1983/84 season; this was published in 1985 for FSRU and the Cotton Research Institute, and in 1987 for the Agronomy Institute and Crop Breeding Institute. The Lowveld Research Station's 1981/83 report was still with the printer at the end of 1987. It seems that they were held up at the final editing and review stages as all research officers have handed in their reports up to and including the 1985/86 season's results. The main problems of heads are over-commitment to administrative duties (more time is spent on cumbersome bureaucratic procedures) and highly ambitious research programs, both on-station and on-farm. There are also delays of up to five months at the government printers.

The usefulness of the institute's annual reports has been seriously challenged by on-farm research and AGRITEX staff because the reporting period is too short for long-term trials, and although numerous institutes are doing research on the same commodity, there is no integrative analysis of results.

The DR&SS has its own scientific journals, Zimbabwe Journal of Agriculture Research and Zimbabwe Agriculture Journal, which publish most research results. The editors of these journals maintain scientific excellence in DR&SS, and they ensure that there is a continuous stream of publishable articles from research officers. Research officers agree that the opportunities for publishing on-farm and on-station results are the same. However, because of higher coefficients of variance on on-farm research, data over more years may be needed to produce articles of an adequate scientific standard.

Because reporting mechanisms are slow in disseminating research results, the Agronomy Institute organizes formal symposia and field days to brief fellow researchers, AGRITEX staff, and other interested professionals. In September 1986, approximately 25 technical papers, mostly on-farm research, were presented at a three-day workshop attended by more than 35 research and extension officers. Prizes donated by the assistant director of the Crop Research Division were awarded to the three best presentations. The Cotton Research Institute was the only institute with an on-farm research program that did not present a paper. A small committee of the Crop Breeding Institute, the Agronomy Institute, and FSRU planned a symposium which was held in September.

It should also be mentioned that the Committee for On-farm Research and Extension is contributing to immediate dissemination of results and that on-farm research officers can have access to results in tabular form at any time. The Crop Breeding Institute research officers usually make yield performance data for varieties and locations available very quickly after the season.

Integration of On-Farm and Experiment Station Research

Within an institute, the head is mainly responsible for ensuring integration of on-farm and on-station research. All heads acknowledge that this is very important and, therefore, they favor scientists' participation. Thus it is common practice in the case study units, except FSRU, for the same research officers to have both on-station and on-farm research programs. In the Crop Breeding Institute each commodity breeder has an experiment station research program, and depending on his/her interest, stage of progress in the program, and priority attributed to the commodity in communal-area development, the research officer and the head decide whether to initiate an on-farm research program as an extension of on-station research. However, breeders recognize that their critical research is done on-station and that it therefore has priority.

In the Agronomy Institute the main thrust is on-farm research, but every on-farm research officer also has on-station trials, and the planning and discussion of proposals of both is done simultaneously. Some trials are both on-station and on-farm, and others are one or the other. The balance depends on the experience and interest of the researchers and in particular on the priority and potential assigned to the commodity. Although experimental designs for similar on-station and on-farm research trials are usually the same, independent and dependent variables may be different. For example, all on-farm moisture conservation trials are also being done on-station. The on-station research work will enable the researcher to control and measure some factors, such as water-holding capacity, which cannot be done on farms. Another example is the manure trial on maize being carried out on-station because long-term and detailed measurements are required which cannot be achieved through on-farm research.

Until recently in the Agronomy Institute, information flow was essentially from experiment station to on-farm research. The objective was to develop crop packages for farmers by adapting available technologies to communal-area conditions. From on-farm research experience eleven new projects have been designed, both for on-farm and on-station research, to develop new technologies. The new on-farm research trials include intercropping of maize and sorghum with cowpeas, manure and inorganic fertilizer combinations on maize, fertilizer-limiting factor analysis on soyabeans, comparison of grain cereals under different soil types and planting dates and testing of three mixed or rotational crop and cattle production systems. All these new trials are being carried out because of the problems encountered with previous on-farm research trials, the need to look at new approaches to old problems (e.g., natural soil fertility generation and pest and disease control), or questions posed by farmers (e.g., on the best grain or legume to grow). In order to make best use of resources, both on-station and on-farm research are considered in the overall strategy to develop appropriate technologies.

At the Cotton Research Institute the yearly planning meeting is the main mechanism for this integration because every research officer at the institute presents on-station and on-farm research proposals for critical review and suggestions. Experiment station to on-farm

research flow of information is very strong, as evidenced by the agronomic and entomological on-farm research. However, some useful feedback on soil moisture conservation in communal areas has been obtained from on-farm research, which suggests further experiment station research with fertilizer trials for adaptation to the large-scale commercial sector.

At the Lowveld Research Station there is also a yearly meeting and there are joint visits to on-station and on-farm research sites to assess trial progress and problems. On-farm research has served the Lowveld Research Station well in the sense of confirming emphasis on key problems. For example, there was a higher proportion of maize (variety, water harvesting, and manure by inorganic fertilizer application), and cotton and sorghum trials on-station because farmers have expressed a strong interest in these crops. Inter- and relay-cropping work (maize with cowpeas, pigeon peas, pearl millet or sorghum) arose because farmers practice them as a risk-minimizing strategy. Trials have included low plant population treatments, a common strategy among some farmers, with water-harvesting techniques in maize, sorghum, and cotton production. It is now planned to develop and test appropriate ox-driven equipment for land-forming and weed control, because these operations are prohibitively labor-intensive. This project will be done in conjunction with the Soil Productivity Research Laboratory, the University of Zimbabwe, and the Institute of Agricultural Engineering.

FSRU is not formally obliged to do on-station research, but each biological scientist has or has had an on-station research trial in order to give him or her an opportunity to interact with experiment station scientists and to pursue well-controlled experimentation in their own professional interests; e.g., working for a post-graduate degree, which is important also for gaining credibility with experiment station scientists. The team solicits and receives technical inputs for its research from other institutes in DR&SS. Specialized researchers have provided reviews of their past research on key topics or problems (e.g., water-harvesting techniques, range management, and crop fertilization with cattle manure), have assisted in assessing farmer situations and identifying research opportunities (e.g., interactive informal survey on goat production in 1984), and have participated in designing and monitoring on-farm research trials (e.g., forage legumes, livestock nutrition, and manure utilization).

The institutes that have been consulted often are: the Crop Breeding Institute, for results on the performance of promising cultivars of crops that are already in the farming systems research program; the Agronomy Institute, on technical management packages; the Soil Productivity Research Laboratory, for improved soil fertility management on sandy soils (with manures, legumes, and/or rotations); the Institute of Agricultural Engineering, for information on tillage systems and labor-saving implements for crop cultivation; the Grasslands Research Station, for information on forage production (herbaceous and tree legumes, range management) and livestock feeding systems (physical and chemical methods to improve cereal stovers), and Makoholi and Matopos Stations on goat breeds and management.

Discussions between FSRU and other scientist have resulted in the following on-station research projects. First, a study of soil fertility management, with the Soil Productivity Research Laboratory and the Crop Nutrition Unit of the Chemistry and Soils Research Institute, was carried out to find appropriate levels for nitrogen, phosphorus, potassium, sulfur, lime, and micro-nutrients for grain and oilseed crops grown under management systems involving manure, legumes, or various tillage methods (reduced tillage, ridges, basins, etc.). Second, attention will be increasingly given to cropping systems particularly suited to low-potential areas under the Agronomy Institute; present management and inputs to traditional crops (bambara nuts, cowpeas, sweet potato) will be introduced. Another three projects are related to livestock: screening of forage legumes, upgrading of crop residues, and goat production, as described previously.

Basically the five on-farm research programs were initiated as extensions of on-station research programs on the assumption that there are technologies on the station or in the large-scale commercial sector which are appropriate or which can be quickly adapted to communal-area conditions. On-farm research programs have gradually shifted to put more emphasis on technology generation, but the on-farm research experience is also beginning to have a marked effect on the development of new experiment station research projects aiming to resolve communal-area farmers' problems with technologies that should be more technically feasible and economically viable than the high-input solutions normally applied in the large-scale commercial sector. For this reason, perhaps with the possible exception of the Crop Breeding Institute, on-station research officers readily admit that on-farm research has a very important role in their programs.

The Committee for On-Farm Research and Extension is strengthening its subcommittees with experienced on-station research scientists for the review of the 1987/88 trial and demonstration proposals, and this should definitely improve the on-station/on-farm research integration.

Management of Farmer Collaboration

In the 1986/87 season the Crop Breeding Institute had trials with approximately 40 farmers, the Agronomy Institute with 66, the Cotton Research Institute with 38, the Lowveld Research Station with 30, and FSRU with 90. Field staff, research technicians, and agricultural assistants (research hands in the case of the Cotton Research Institute) have the most contact with farmers. The research officers in the Crop Breeding Institute, the Lowveld Research Station, and FSRU also have contact with farmers, since they are out with their research assistants at least once a month.

In all programs, farmers are selected as collaborators with the assistance of AGRITEX, except in the Crop Breeding Institute, which just consults with AGRITEX and then selects its own farmers. The Agronomy Institute depends on AGRITEX, in discussion with farmer groups, to select farmers, which means that farmers hosting trials have a feeling of community consciousness and respect. The Cotton Research Institute interviews prospective candidates recommended by AGRITEX. The Lowveld Research Station lets AGRITEX select for them. FSRU holds meetings with farmer groups and AGRITEX to explain

the objectives and requirements of each trial for the area, and volunteer farmers are then screened. The research staff claim that collaborating farmers are typical, in terms of climate, soils, and crops. Socioeconomic considerations are not considered important; for example, the Agronomy Institute and the Farming Systems Research Unit have women collaborators, with a ratio of about one to seven, even though approximately one third of all farming households are headed by women. FSRU also has a range of farmers from the poor to the best, depending on the type of trials. Where an institute depends on AGRITEX, influential farmers or local leaders are likely to be selected. FSRU uses its surveys to better analyze farming in order to define specific target groups and achieve greater representativeness for its trial work.

Usually, when on-farm research units remain in the same locality year after year, research officers prefer to work with the same farmers for two or three years because their knowledge of research work enhances the probability of trial success. The Farming Systems Research Unit has had some collaborators since 1984, particularly in work on forage legumes and livestock production monitoring, which are multi-season studies.

For the trial program, farmers are expected to provide land plowed in preparation for planting and to protect sites during the course of the season. For the Crop Breeding Institute and the Agronomy Institute, they do not have any other responsibility, but they may help with weeding. In the Cotton Research Institute, as a regular practice, all farmers are involved in trial management, since the Institute's on-farm research consists of researcher/farmer-managed trials. The farmers run the entire trial, providing and preparing land, providing labor and all inputs except seed and fertilizer, with research staff advising and helping with the implementation of treatments. It is felt that through this hands-on experience, farmers can make better judgements and can contribute more to the research process. In the Lowveld Research Station, farmers prepare the land and weed, and some may participate in planting and harvesting, if trusted. In FSRU, farmers are not expected to do much on researcher-managed trials, but on trials in which some degree of farmer management is involved, they are responsible for all operational tasks. According to field staff, farmers cannot be expected to do more because they are already overloaded with their own work. However, staff believe that farmers should be more involved in the management and assessment of their trials.

In exchange for collaboration, farmers are provided with all cash inputs for trials (the Cotton Research Institute does not provide insecticides) and are given the trial outputs (research officers only take small samples for analysis). In addition, the Lowveld Research Station compensates them for good collaboration with a bag of maize (90 kg), or one bale of cotton (180 kg) for those hosting cotton variety trials. The Cotton Research Institute gives them half a bale of cotton, because yields of new varieties cannot be purchased by the Cotton Marketing Board. The Crop Breeding Institute, the Agronomy Institute, and FSRU do not provide any additional compensation. In 1986, a large number of goats died in the on-station phase of Farming Systems Research Unit crossbreeding trials, and farmers had to be paid the market value of the lost stock. Government treasury regulations do not allow for such compensation; so it had to be done in kind or unofficially.

On-farm research officers indicated that farmer decision-making, following informal discussions, should be in the problem identification and trial assessment phases. The Agronomy Institute's field team is always in contact with collaborating farmers and informs research officers of any issues of interest to the program. Collaborating farmers always receive an explanation of trial objectives and requirements and a description of the trial treatments from research officers. At the Cotton Research Institute, research officers visit their trial sites at least once a month, usually in the company of research hands, and interact with farmers who are expected to keep some records. Record-keeping has, incidentally, been a useful experience for farmers, particularly in economizing on use of chemicals.

Flexibility for modifying trial designs to take advantage of farmer participation and indigenous knowledge is normally limited. This is justified on the basis that trials must be consistent across seasons and years and be well-controlled and managed to have reliable results. Therefore, research officers do not really desire any additional responsibilities for farmers. However, FSRU is more flexible. For example, a randomized block design for a crop trial had to be re-designed into a type of strip design because farmers suggested that the comparison of treatments would be easier with a simpler design.

To monitor feedback, the Crop Breeding Institute, the Cotton Research Institute, and FSRU keep formal trial record books in which farmers' opinions are recorded. However, when asked for specific examples of how farmers' feedback had influenced on-farm research trials, research officers in the Crop Breeding Institute, the Agronomy Institute, and the Cotton Research Institute did not have any, whereas research officers in the Lowveld Research Station gave two examples: inclusion of the local farmer's sorghum variety, Chitichi, in their trials; and the cutting of sorghum shoots when the drought is severe, thereby leaving the base to ratoon when the late rains come - an idea learned directly from farmers. A Farming Systems Research Unit research officer indicated that time-of-planting trials are now based on farmers' advice. The Lowveld Research Station research officers claim that they encourage farmers to observe the effects of trial work because, if after a number of seasons these farmers do not volunteer to adopt the proposed system, then the on-farm research program has failed to improve production or provide a practical means to do so, and research officers "go back to the drawing board".

All on-farm research programs have field days for farmers every year at their research sites, provided there is something worth demonstrating and learning. Most units hold them towards the end of the season, when yield differences can be observed. The Crop Breeding Institute holds field days on the day of harvest to allow farmers to see for themselves the actual yield differences. As many as 100 farmers from surrounding villages attend these field days, usually arranged by AGRITEX, at which DR&SS staff explain the trial program. Because farmer feedback is not effective at such field days, FSRU holds much smaller "internal" field days, strictly for farmers and AGRITEX staff, at which the host farmer explains trial justification, management, and performance. Farmers also play a key role in field days of the Agronomy Institute.

Political and development leaders are usually invited as guest speakers at field days. For example, the Agronomy Institute invites National Farmers Association of Zimbabwe officials and the Farming Systems Research Unit invites high-level ministry officials (the Deputy Prime Minister in 1985) and provincial governors. The major field day of FSRU, one yearly in each area, attracts as many as 500 farmers, and at these, on-farm research receives substantial political visibility.

There are no communication problems with farmers because research officers and staff, except the Crop Breeding Institute head and FSRU adviser, speak the local language, and most research officers come from the same cultural background. Of problems experienced with farmers, one is the failure of some farmers to fulfill their commitment, manifested in offering poor sites, late plowing, mixing up treatments, or not protecting sites. A problem for the Cotton Research Institute is that collaborating farmers always want grade A cotton for their bonuses.

Because of this, the Agronomy Institute modified its operation by making a research officer responsible for each cluster; he/she could then spend more time in the field, with farmers. FSRU, together with AGRITEX, has experimented with various methods of encouraging farmer interest and participation. One is to use organized farmer groups, group development areas, and local administrative structures - village development committees - to organize meetings and field days at which farmers' problems and priorities are analyzed, trial plans are screened, and research results are discussed. Some group development areas have even added research to their activities, mainly because FSRU program complements, and caters to, their principal concerns.

Another method, also being implemented through the group development area system, is awarding prizes to individual farmers and farmer groups for best trial management. This is very effective in promoting strong farmer participation, since prizes include inputs and equipment being tested and have prestige in the community. All Farming Systems Research Unit equipment used in its trial work remains with the farmer or farmer group during the whole year, which permits farmers to experiment with the equipment on their own.

It should be emphasized that experience with farmer organizations in the large-scale commercial sector, having a constructive input in DR&SS programs, has convinced on-farm research workers of the important role of the National Farmers Association of Zimbabwe as representative of the communal-area sector. For this reason, the Agronomy Institute, in particular, invites them to participate in field days. At present, the National Farmers Association of Zimbabwe does not have the grassroots organization to fulfill its role effectively. Its task is made difficult because the communal areas form a very large and heterogeneous sector, and many farmers are too poor to support the organization financially. Furthermore, it does not have the technical capacity to influence on-farm research priorities and programs, as its president readily admits, but it has good contacts with DR&SS and believes that research should be expanded, particularly on livestock production and crops for low-potential areas.

Management of Collaboration with Extension

On-farm research experience in DR&SS has contributed greatly to building and strengthening linkages with AGRITEX. As shown in Table 35, AGRITEX contributes to the problem-identification and evaluation phases of most on-farm research programs, but not to priority-setting and data analysis, except in FSRU.

The Crop Breeding Institute and Lowveld Research Station do not receive much input from AGRITEX. They see it as a necessary link with farmers, but they feel that it does not have the technical ability to make constructive inputs to on-farm research. They do, however, have regular contacts with local extension staff, and the Lowveld Research Station even provides some inputs to AGRITEX for its demonstrations. The most common method of interaction is through on-farm research field days, in which AGRITEX participates. The Lowveld Research Station also invites AGRITEX staff to visit on-farm research sites and to discuss on-farm and and on-station research results, as well as the next season's plans.

The Agronomy Institute is presently consulting very closely with provincial and district AGRITEX staff in the planning of trial work because of the need to assist AGRITEX in the development of appropriate recommendations and to design more appropriate trials. The recent changes in the institute's on-farm research program (one cluster per province, designation of one research officer per province, participation in AGRITEX planning, and running training workshops for AGRITEX staff) were effected in order to improve collaboration with AGRITEX, even though AGRITEX does not have any specific responsibilities in trial management.

The Cotton Research Institute receives a substantial contribution from AGRITEX, whose cotton specialists are housed at the institute and participate directly in the annual research planning meeting. In conjunction with the Commercial Cotton Growers Association and the Cotton Research Institute, they organize training programs for AGRITEX staff and communal-area farmers so that the senior extension staff participate in priority setting, progress evaluation and project planning. On-farm research field activities are coordinated directly and informally with the research assistant in the area. AGRITEX field staff also arrange for communal-area farmers to attend cotton production courses at the Commercial Cotton Growers Association Training Center and help to organize meetings and field days for farmers at which the researchers explain their trials and results. On-farm research officers visit trials in the company of local staff whenever possible.

AGRITEX has a prominent role in various phases of FSRU program. In particular, its officers have participated in diagnostic studies, discussion of trial designs, and evaluation of results. Within each research area, which corresponds to an administrative region for AGRITEX, extension workers participate in annual workshops on trial designs, discussion of trial results, analysis of technical and operational problems encountered during the previous season, and discussion of possible future trials and studies. Participants include FSRU staff for that area and 20-40 AGRITEX field staff. The function of these workshops has improved since they have recently really begun to make substantive comments and suggestions.

Extension supervisors and extension workers participate in trial site and farmer selection, depending on the objectives and requirements of each trial.

Other Farming Systems Research Unit activities in which AGRITEX staff participate are pre-planting demonstrations to explain trials and results to farmers, soil sampling, helping farmers to keep sensitive records (rainfall, critical operations), and running field days. AGRITEX staff usually accept total responsibility for establishing and monitoring farmer-managed trials and assessing and discussing such trials with farmers. Because AGRITEX uses the group approach, such as the group development area, quite effectively, on-farm research trials have a wider direct audience.

The working relationship with AGRITEX has not always been very successful, according to the experiences of the Agronomy Institute, the Lowveld Research Station, and FSRU. Efforts were made to involve senior AGRITEX specialists at national and provincial levels, but they have not been able to participate as much as desired. Nor were extension supervisors and extension workers able to participate effectively, such as when they neglect their agreed responsibility on the trial program at the most critical period; e.g., the application of fertilizer or herbicide. These problems arose principally because of the lack of a defined responsibility and priority in the on-farm research program, the lack of research capability, and logistic problems.

Senior managers in AGRITEX believe that their staff should share responsibility in the on-farm research program for it to function effectively, because they are in direct contact with farmers, local development and planning organizations; however, for this, strong research/extension linkages are a prerequisite. AGRITEX could play the current role of FSRU (diagnosis and adaptive research) nationally, but as experience of FSRU shows, the success of developing a two-way flow between on-station and on-farm research depends on the on-farm research team demonstrating strong research capacities, and on the station-based researchers viewing them as colleagues. Furthermore, unless the on-farm research staff is well-trained and competent, they will not be able to draw effectively on the knowledge and findings from experiment station research as inputs for adaptive research and design of alternative technologies for client-farmer groups.

The problem of experiment station/on-farm research linkages being weakened by the disparities in the strength of teams involved has, unfortunately, been common in the experiences of developing on-farm research programs in other countries. There is a precedent for this in the DR&SS/Department of Conservation and Extension service in the large-scale commercial sector before Independence, but the success of this arrangement was clearly dependent on the high-quality technical capabilities of both departments.

The need to establish strong collaboration with AGRITEX was one of the main justifications of the Committee for On-Farm Research and Extension. Coordination with AGRITEX and across on-farm research programs will be necessary if DR&SS is to successfully tackle the key problems of farming systems in their areas, i.e. low rainfall in some areas, lack of draft power, lack of timely availability of inputs (especially fertilizers), low soil fertility, lack of

varieties for low-potential areas, and poor cattle condition. Priorities differ according to natural region: not all require the same degree of research effort; and, admittedly, none of the on-farm research program by itself can systematically tackle all these constraints in an effective manner.

Development and Management of Human Resources

Profile of staff. All on-farm research units have teams comprising professional, technical (research technicians and agricultural assistants), and operational staff (research hands or casual laborers). Table 38 shows a profile of professional staff of five on-farm research programs. The Agronomy Institute and the Crop Breeding Institute have the biggest staff contingent, but the Agronomy Institute staff, on average, have less on-farm research experience. The Lowveld Research Station and the Cotton Research Institute have the smallest units, but staff, particularly their heads, have fairly good research experience. Farming Systems Research Unit staff have comparable academic qualifications, research, and on-farm research experience. However, its staff have participated in a larger number of on-farm research workshops. Of the five, only the Cotton Research Institute and FSRU have staff with more than one discipline. FSRU has a vacant post for forage agronomy and grazing management and currently counts on the direct participation of the Pastures and Veld Unit for this input. On-farm research professional staff have good academic qualifications (15% with PhD and 44% with MSc) and research experience (26% with more than ten years and 26% with five to ten years), in comparison to DR&SS as a whole (8% with PhD and 30% with MSc; 23% with more than 10 years and 22% with 5-10 years of experience).

Technical staff involved in on-farm research are numerous, and many work part-time or only for part of the year. All on-farm research units have between six and seven research technicians and agricultural assistants, except the Agronomy Institute, which has 21. In addition, all units have a labor pool of research hands whose numbers vary, depending on the tasks at hand. The only unit that gives research hands a considerable responsibility and consequently provides trial and technology management training is the Cotton Research Institute. Its research hands, who have on-station research experience, mark out trials and establish and manage the crop with occasional assistance from research officers. In other programs this is usually the responsibility of research technicians and agricultural assistants. Most research assistants have at least three or four years of research experience, and a few research technicians have as many as ten or fifteen years.

Some experienced research technicians design their own trials and publish scientific articles. Thus research technicians, and agricultural assistants, can implement on-farm research trials simply with the provision of project sheets and some supervision from research officers.

Table 39 summarizes the degree of participation in on-farm research according to technical staff category. For all categories, the Agronomy Institute and FSRU have the largest staff in on-farm research. For FSRU it is almost its full staff complement, whereas for the Agronomy Institute it represents about a third of

Table 38: Profile of Professional Staff for Five On-Farm Research Programs, 1987

Name and grade	Sex	Age	Last Degree Institution	Discipline	Years of Research	Experience of On-Farm Research	Year Joined DR&SS	Previous Work	Training in On-Farm Research
Crop Breeding Institute									
R.C. Olver, Head	M	40	BSc Agriculture	Breeding	17	4	1970	Student	None
Z.A. Chiteka	M	33	BSc Hons, UZ	Breeding	8	4	1979		None
J.M. Mushonga, SRO	M	44	Purdue University	Breeding	8	5	1979		None
J.M. Muza	M	24	BSc Agriculture UZ	Breeding	3	3	1984	Student	None
H. Gridley (expatriate)	M	42	PhD Cambridge	Breeding	10	1	1985	Researcher	None
K. Mtindi, SRO	F		MSc India		5	3		Researcher	None
The Agricultural Institute									
E.E. Whingwiri, Head	M	37	PhD Australia	Agronomy/Physiology	7	7	1980		CIMMYT workshop
G.E. Zharare, ARO	M	29	BSc Hons, UZ	Agronomy	3	3	1984	Student	CIMMYT workshop
D. Hikwa, RO	F	30	MSc P. Lumumba	Agronomy	4	2	1983	Student	None
L.T. Gono	M	30	BSc Hons, UZ	Agronomy	3	2	1984	Student	None
T.M. Nleya	F	27	BSc Hons, UZ	Agronomy	3	2	1984	Student	None
P.L. Mafongoya, ARO	M	26	BSc Hons, UZ	Agronomy	3	2	1984	Student	None
S. Mabasa, ARO	M	28	BSc Hons, UZ	Agronomy	3	2	1984	Planner	None
D. Mataruka, RO	M		MSc U.K.	Agronomy	3	2		Student	None
H. Natarajan (expatriate)	M	40	PhD India ARI	Agronomy/Physiology	10	1	1985	Researcher	None
Cotton Research Institute									
G. Rabey, Head	M	38	MSc	Agronomy	17	7	1970	Student	None
T.T. Mashavira, ARO	M	26	BSc Hons, UZ	Agronomy	3	4	1984	Student	CIMMYT workshop
P. Jowah, RO	M	35	MSc	Entomology	7	2	1980	Teacher	None
G.B. Jones (expatriate)	M	48	P.G. Cambridge	Breeding	25	4	1982	Researcher	None
Lowveld Research Station									
E. Jones (expatriate), Head	M	53	MSc UK	Agronomy	26	21	1982	Researcher	None
C. Nyati, RO	M	33	MSc degree		4	3	1983	Student	None
P. Nyanmudeza, ARO	M	29	MSc degree		4	4	1983	Student	CIMMYT workshop
Farming Systems Research									
B.G. Mombeshora, Leader	M	37	MSc New Castle Upon Tyne	Animal Nutrition	7	3	1980		4 workshops
E. Shumba, RO	M	31	PhD candidate, UZ	Agronomy	6	6	1981	Student	7 workshops
S. Dendere, RO	M	26	BSc Hons, UZ	Agronomy	3	3	1984	Student	3 workshops
G. Makombe, ARO	M	27	MSc candidates, UZ	Economics	5	0	1987	Researcher	1 workshops
M. Avila (expatriate adviser)	M	48	PhD University of Missouri	Economics	10	10	1984	Researcher	Many workshops

ARO: assistant research officer
RO : research officer
SRO: senior research officer.

Table 39: Degree of Participation in Five On-Farm Research Programs, 1986/87

Unit	Research Officers			Research Technicians			Agricultural Assistants			Overall % of Person/years On-Farm Research[1]
	Total	Number in On-Farm Research	Person/years	Total	Number in On-Farm Research	Person/years	Total	Number in On-Farm Research	Person/years	
Crop Breeding Institute	10	6	2,4	7	2	0,6	13	4	1,2	14
Agronomy Institute	15	8	5,7	16	9	4,5	26	12	6,0	28
Cotton Research Institute	7	4	2,4	6	3	1,5	6	2	1,0	26
Lowveld Research Station	6	2	1,0	3	2	1,0	16	4	2,0	16
Farming Systems Research Unit	5	5	4,5	3	3	3,0	4	4	4,0	95

1 Calculated by summing person/year in on-farm research for all grades divided by total number or person/year institute. Person/years in on-farm research is estimated, based on proportion of year and proportion of time spent in on-farm research.

professional staff and a fourth of total staff. For the Crop Breeding Institute, the Cotton Research Institute, and the Lowveld Research Station a third or less of professional staff and about a quarter of technical straff (research technicians and agricultural assistants) are directly allocated to on-farm research.

Each unit has an expatriate researcher attached (Table 38). In the Crop Breeding Institute and the Cotton Research Institute the expatriate scientists have a specific research program addressing priorities of their respective institutes. In the Agronomy Institute an expatriate is managing the research programs of a research officer on postgraduate study leave, as well as assisting the head with the preparation of a crop production handbook. In the Lowveld Research Station the expatriate was brought in to develop the research team and, as in the case of the Cotton Research Institute expatriate, was instrumental in initiating on-farm research in soil moisture conservation techniques. In FSRU the expatriate was the team leader responsible for developing the team and a suitable farming systems research model for DR&SS. In September 1987, a local leader was appointed. The Crop Breeding Institute and he Agronomy Institute expatriates are paid from the World Bank loan, those of the Cotton Research Institute and the Lowveld Research Station by the Overseas Development Administration, and FSRU expatriate is an International Development Research Centre project advisor. However, operational expenses of their research programs are administered similarly to those of any other research officer.

Recruiting mechanisms. Recruiting mechanisms for on-farm research programs are the same as those of DR&SS. The main source of professional staff is the University of Zimbabwe Faculty of Agriculture. Vacant posts are usually advertised there and in the Harare daily newspaper. There is no problem recruiting technical staff because there is a surplus of graduates from agricultural colleges.

Because DR&SS salaries are not very attractive, being as much as 40% lower than the University of Zimbabwe, the Agricultural Finance Corporation, the Agricultural and Rural Development Authority, or the private sector, DR&SS cannot attract experienced professional staff. It has to rely on fresh graduates from the University of Zimbabwe.

To attract the best graduates, FSRU team leader gives a few lectures every year to third-year students on the farming systems research approach and program. Good graduates have been recruited but have then left to take up postgraduate fellowships by the university. There is, however, now an adequate supply of graduates from the university with the required discipline, except for pasture agronomy and grazing management. Graduates from the university may have some exposure to on-farm research but usually do not have any training in it.

DR&SS often hires young research officers and research technicians and trains them in research methodologies and technology management, which makes them highly marketable to agricultural development agencies. If their commitment to research is not strong, they leave for $200-300 more per month and some fringe benefits. Of course,

this could be viewed as a direct and effective technology transfer process to other sectors, but it does not contribute to building DR&SS technical capability.

Training and team building. Only a few research officers from the Agronomy Institute, the Cotton Research Institute, and the Lowveld Research Station have attended any training events in on-farm research. In contrast, the staff of FSRU have attended more than a dozen workshops in Zimbabwe or in the region. CIMMYT is by far the most active IARC in providing training.

An important effect of on-farm research is that research officers, especially the less-experienced ones, have become aware of the limitations of available on-station research technologies and have identified research priorities more in line with farmers' problems. Accordingly, some research officers have or are pursuing advanced studies, either overseas or at the University of Zimbabwe. One from the Crop Breeding Institute, two from the Agronomy Institute, and one from FSRU are overseas taking master's degrees. Another research officer from the Agronomy Institute and two others from FSRU are also enrolled for higher degrees with the local university. Another from the Crop Breeding Institute is finalizing his dissertation research in the country. Since there is no real distinction between on-station and on-farm research duties, on-farm research officers have as much opportunity as any other professional staff member to pursue advanced studies. On-farm research officers may have better opportunities of receiving local or international support, especially if they relate their future areas of specialization to communal-area production systems.

When heads of on-farm research units were requested to identify on-farm research training needs for professional staff, statistical and experimental analysis, the CIMMYT-University of Zimbabwe regional on-farm research course, public speaking, and driving lessons were mentioned. Three heads emphasized the need for subject-matter training. For the technical staff, neither heads nor research officers identified any special training requirements other than more on-the-job and informal training on trial layout and management, which is already happening. FSRU identified the need for statistics and data analysis training to increase their participation in trial assessment, which was supported by the Lowveld Research Station team. Research assistants were also requested to identify their own training needs. Invariably they mentioned trial design, management, and data analysis. The only research technicians who have attended any formal on-farm research training are one from the Lowveld Research Station and two from FSRU. However, all units have some form of internal and in-service training for junior staff, usually consisting of informal presentations by senior staff and hands-on field demonstrations.

In 1986 there was a formal DR&SS training workshop for about 30 research assistants, with presentations by senior researchers on experimental designs and trial management for on-station research. This was organized by a temporary training officer appointed to liaise with directors and heads in order to develop a consistent training policy according to needs of the different staff categories. In the past, training needs had been identified by the head in consultation with his staff, but funding was not always

available. During the short time she was with DR&SS, the training officer was attempting to standardize selection criteria and rationalize the use of funding opportunities across all units. At present the post is vacant.

Since the establishment of FSRU, one of the most important tasks has been the development of capacities for systems research and teamwork. The initial strategy was to expose researchers as quickly as possible to the various approaches of farming systems research/on-farm research, as suggested by CIMMYT, ILCA, CATIE, or other organizations. Then the team proceeded to review secondary information under the following specific topics: national development policies and goals, technical and economic potential of communal areas in different natural regions, the role and ownership patterns of livestock, communal grazing practices and schemes, livestock nutrition and supplementation, as well as health conditions and management, genetic potential of local breeds and crosses, and livestock marketing and markets.

Although livestock production systems were particularly emphasized, previous experience on crop productivity and constraints in high- and low-potential areas were reviewed, particularly previous farming systems research work under the Agronomy Institute. The next step was to analyze the objectives of FSRU and determine how they could be achieved through a production systems framework. This exercise resulted in outlining steps that the team would follow in designing its 1984/85 on-farm research program: organization of available secondary information on communal-area systems and constraints, an informal interactive survey in June, ex ante analysis of proposed innovations from June to August, and a formal workshop to review key technical problem areas and the proposed Farming Systems Research Unit program in September. It was agreed that the team would seek maximum participation of experienced on-station scientists and international agricultural research center collaborators in every step of the process.

The initial interactive process of the team lasted from February to May and used round-table discussions on topics defined and assigned beforehand to specific members of the team to organize and lead. The key outcome of this interaction was that the team members knew each other better and understood the technical justification of proposals. Furthermore, they all worked together better after this intensive encounter. The issue of who had final responsibility for acceptance or rejection of proposals was repeatedly raised. It was finally established that the team could require further justification for any proposal, but the final decision rested with the proposing officer.

The change of leadership of FSRU from an expatriate to a local research officer was planned from the beginning as part of the institutionalization process. The former leader now serves as adviser to the team, complementing the present leader to ensure a smooth transition in the administrative and technical management of the program.

Staff incentives. It is the policy of the case study units to carry out on-farm research in communal areas because communal-area development has been given top priority by the government. Thus all

research officers are doing on-farm research because of assignment, but research officers with both on-farm and on-station research, except those in the Crop Breeding Institute, expressed the opinion that the optimal balance should be about 50% of their time on each. Research officers in the Crop Breeding Institute indicated that about 20% on-farm research would be optimal because breeding is more appropriate and effective on stations. This response is interesting because the actual proportion is significantly less in the case of the Cotton Research Institute and the Lowveld Research Station. All research officers consider on-farm research to be a genuine obligation to demonstrate what DR&SS can and should do for communal-area development; thus some heads stressed this motivation to young staff.

The technical staff interviewed also expressed preference for on-farm research, since it provides the opportunity to test and evaluate technologies for communal-area farmers under a wide range of environmental conditions and to develop more appropriate programs based on a better understanding of farmers and their priorities. Research assistants in the Crop Breeding Institute, the Agronomy Institute, and FSRU prefer on-farm research, and those in the Cotton Research Institute and the Lowveld Research Station have a similar preference.

No special fringe benefits, distinctions, or conditions are granted to on-farm research staff. Daily and transportation allowances are the same for everyone in DR&SS, including the directorate. There was a big difference between the daily rates for professional staff and junior staff, but it was eliminated in 1986; thus it is financially advantageous for junior assistants to do on-farm research, because daily allowances could easily cover their costs in the field and be more than their salary. Supplementing income through university teaching or private consultancy is not a common practice among research officers and therefore is not relevant in this case.

In professional opportunities, there is no distinction between on-station and on-farm research staff. Formal evaluation in DR&SS applies to all staff, and no special weight is given to on-farm research. Since most research officers do some on-station research, they have research findings to prepare publishable papers if scientific quality was the critical issue. FSRU research officers have not encountered any objections to the publication of on-farm research results.

Staff attrition. The rate of attrition of professional research staff working in on-farm research has not been higher than the norm for DR&SS as a whole.

In the Cotton Research Institute, one research officer left on-farm research after two years because he was transferred to a more senior position in DR&SS. In the Agronomy Institute, one of the research officers responsible for initiating on-farm research in the communal areas transferred to the Crop Breeding Institute. There have been problems finding a stable replacement. There have been two successors, both of whom have left DR&SS after one year. One left for an alternative job and one was asked to leave.

The Cotton Research Institute has had no problem in keeping its professional staff in on-farm research, and the Lowveld Research Station has lost only one on-farm researcher. He left to join a private sugar research organization for a much higher salary.

FSRU lost an expatriate animal scientist in early 1985 at the end of her contract and has had problems filling that post since. Two recent graduates from the University of Zimbabwe were hired in sequence, but both left after six months of service to pursue postgraduate studies on university fellowships. Up to the end of 1987 the leadership of the units had not changed, apart from the change in FSRU. This has meant good continuity for on-farm research programs.

The five case study institution units have faced difficulties in keeping trained research technicians because after some research experience they can easily find attractive salaries elsewhere. The rate of attrition for on-farm technicians is not higher than that for DR&SS as whole, however.

Management of Financial Resources

Funding trends and share for on-farm research. In nominal terms, the total budget of each unit has increased continuously between 1981 and 1986 (Table 41). The change in operational expenditure was notable between the 1983/84 and the 1984/85 financial years, increasing by 44%, 24%, 39%, 71%, and 184% for the Crop Breeding Institute, the Agronomy Institute, the Cotton Research Institute, the Lowveld Research Station, and FSRU, respectively. These increases were much larger than the 21% increase of the total DR&SS budget. Investment budget values are extremely variable from year to year and usually represent a very low proportion of the total budget. However, investment figures do not include the additional Central Mechanical and Engineering Department vehicles made available since 1986 to each unit and houses which have been built on the stations, all financed from the World Bank/IFAD loan. These are as follows:

	Pickups	Motorbikes	Houses
Crop Breeding Institute	4	2	15
Agronomy Institute	10	13	10
Lowveld Research Station	2	5	44
Cotton Research Institute	3	2	138*

* Under construction.

Research equipment was purchased with the loan funds. The only investments that have a direct bearing on on-farm research are the pickups; only the Agronomy Institute uses motorbikes; and housing and equipment have been for stations except for some minor investment in tents and caravans for the Agronomy Institute and the Cotton Research Institute. The International Development Research Centre (IDRC) donated a pickup in 1983 and provided funds for some of the sorghum and millet on-farm research from 1983 to 1985. The Overseas Development Organization also made available one landrover each to the Lowveld Research Station and the Cotton Research Institute.

Since early 1984 IDRC has provided approximately 50% of FSRU staff and operational budget and 100% of the investment budget through the Animal Production Systems Project. It gradually reduces its contribution to the staff budget so that by the end of the project staff will be fully funded by DR&SS. Other contributions were a small one by CIMMYT of about $2000 annually to FSRU for farmer field days, which ended in 1986, and another by the Food and Agriculture Organization (FAO) of $8000 to DR&SS per year since 1985 for on-farm crop demonstrations. During the first year, the FAO funds were used by the Agronomy Institute and the Farming Systems Research Unit for on-farm research field tours by experiment station research scientists and for farmer field days. In the 1986/87 season the FAO contribution was shared among all on-farm research programs for farmer field days.

Table 40: Distribution Between Operations and Investment Funds of Total Yearly Budgets for Five On-Farm Research Programs, 1981-1986

	1981/82	1982/83	1983/84	1984/85	1985/86
Crop Breeding Institute					
Operational	96,807	116,894	139,399	201,313	232,424
Investment	20,447	17,301	0	4,998	0
Agronomy Institute					
Operational	93,457	103,925	159,931	198,718	260,333
Investment	9,691	11,210	581	21,573	5,748
Cotton Research Institute					
Operational		115,874	143,493	199,862	226,717
Investment		3,134	44,083	17,880	18,246
Lowveld Research Station					
Operational	88,800	93,991	136,778	233,593	238,639
Investment	6,377	0	0	16,181	8,366
Farming Systems Research Unit					
Operational	-	-	11,000	31,192	42,957
Investment	-	-	60,000	4,000	5,000
DR&SS total (millions ZWD)	7.73	8.24	8.98	10.85	13.22

Source: Government Treasury Reports.

The on-farm research share of the total budget of these units, apart from FSRU, is virtually impossible to calculate, since there is no separate accounting for on-station or on-farm research. FSRU employs all its resources for on-farm research, except for a few on-station research activities to which some research officers contribute time, transport, and some inputs not surpassing 5% of researcher time and operational expenses. For the others, only approximations can be made. Crop on-farm research does not require much material and input costs, but it does require substantial

investments in transport and daily allowances. Table 41 presents the yearly expenditure on two DR&SS budget items likely to be seriously affected by the increase in on-farm research in the number of research areas and trial sites. These are the traction and travel budget and subsistence and travel budget.

In the Crop Breeding Institute and the Cotton Research Institute, there does not seem to be a clear effect of on-farm research-related indicators on the level and/or size of the expenditure items. In the Agronomy Institute, there was almost a 100% increase in both budget items in 1984/85, and although the number of on-farm research areas was reduced by one third in that year, the number of on-farm research sites more than doubled. In 1985/86, the Subsistence and Travel expenditures increased approximately in proportion to trial sites. There was also a large increase in Traction and Transport and Subsistence and Travel in the Lowveld Research Station budget in 1984/85 also, but obviously the major increase in trial sites with the addition of just one research area cannot account for it.

Overall these trends imply that the level of on-farm research cannot be directly related to these expenditure items. However, it is obvious that over the last five years on-farm research has increased and was made possible because of the favorable budget increases, particularly after 1983/84. Since the stations of these units have fairly large maintenance and overhead costs, it is expected that only a small portion of the total operational budget can be used for discretionary purposes.

For estimates of operational expenditure allocated to on-farm research, heads' responses were 40%, 50%, 40%, 17%, and 95% for the Crop Breeding Institute, the Agronomy Institute, the Cotton Research Institute, the Lowveld Research Station, and FSRU, respectively, as a proportion of the total (see Table 40). These estimates appear to be too high in the case of the Crop Breeding Institute, the Agronomy Institute, and the Cotton Research Institute, but they may be more realistic estimates of the proportion of their trial inputs, transport costs, and subsistence costs after overhead and maintenance costs of the station are deducted.

In real terms, the budgets of all units increased substantially up to 1987, but in the last two years only those of the Crop Breeding Institute and FSRU have increased. Yet daily allowance rates were increased for the professional staff and the rates of all junior staff were increased to the same level in 1986. This increase in operational costs will have a strong adverse effect on on-farm research if the trend continues. Alternatively, the budget reduction in real terms will force these units to reduce their on-farm research programs in joint site selection, trial design and implementation, and AGRITEX collaboration.

Budgeting system. The disbursement of funds follows regular government instructions. Each unit has its yearly allocation, and its head controls all expenditures. There is considerable flexibility within the financial year to make any necessary

Table 41: Yearly Expenditure on Traction and Transport and Subsistence and Travel Costs with Number of Research Areas and Trial Sites in Five On-Farm Research Programs, 1981-1986

	1981/82	1982/83	1983/84	1984/85	1985/86
	ZWD[1] (% of total operational expenditure)				
Crop Beeding Institute					
Traction and transport	15 650 (20)	10 822 (14)	15 117 (20)	29 741 (31)	37 394 (40)
Subsistence and travel	4 859 (6)	4 986 (6)	4 643 (6)	4 501 (5)	3 491 (3)
Number of research areas	8	13	21	20	24
Number of trial sites	20	28	60	49	48
The Agronomy Institute					
Traction and transport	26 264 (35)	34 624 (51)	32 958 (38)	53 469 (54)	51 283 (42)
Subsistence and travel	7 810 (10)	5 884 (9)	6 913 (8)	14 479 (15)	16 515 (13)
Number of research areas	24	17	23	17	16
Number of trial sites	82	42	37	99	128
Cotton Research Institute					
Traction and transport		17 572 (23)	22 939 (30)	51 424 (49)	28 172 (26)
Subsistence and travel		2 932 (4)	5 778 (7)	4 961 (5)	3 998 (4)
Number of research areas	7	9	3	3	3
Number of trial sites	40	21	65	60	85
Lowveld Research Station					
Traction and transport	26 510 (38)	22 830 (37)	25 123 (34)	53 286 (46)	44 349 (39)
Subsistence and travel	2 719 (4)	2 858 (5)	3 131 (4)	4 141 (3)	4 977 (4)
Number of research areas	-	2	6	7	8
Number of trial sites	-	3	12	34	51
Farming Systems Research Unit					
Traction and transport	-	-	1 620 (27)	4 659 (30)	6 347 (31)
Subsistence and travel	-	-	2 160 (35)	6 428 (39)	8 333 (41)
Number of research areas	-	-	2	2	2
Number of trial sites	-	-	32	108	125

1) ZWD at 1980 rate

Note: Traction and Transport includes use of Central Mechanical and Engineering Department or hired vehicles, and Subsistence and Travel includes daily allowances and official use of research officer-owned vehicles.

adjustments across budget line items or across research programs within a unit.

With respect to the procurement of chemicals, fertilizers, and other inputs, the government's Tender Board approves all requisitions, a process which may take up to a month, which means that in cases of emergency the trial program may be seriously affected. The Tender Board must also approve all expenditure exceeding $750. Tender Board approval is often more of a constraint than budget allocations, since some units do not always spend their yearly allocations.

For subsistence and travel expenses, staff are allowed to apply for advance payment and submit claims later. Because travel advances not cleared by the end of the month are automatically subtracted from their salary, research staff prefer to cover trip expenses from their own pockets. Recently, however, payment delays of up to two months have caused financial difficulties for staff, especially junior staff on lower incomes. This definitely reduces the incentives for on-farm research, the frequency of field visits, and the quality of supervision.

Heads of on-farm research units spend 40% to 60% of their time on administrative duties, depending on the size of their experiment station research and on-farm research programs. Research officers spend less than 10% of their time on administration.

Costs of running an on-farm research program. FSRU is undertaking research in two communal areas - a high-potential area 90 km from Harare, and a low-potential area 350 km from Harare. The core team resides in Harare and comprises five research officers, one research technician, one agricultural assistant, and a secretary. In each area there is a small field team of one research technician, two agricultural assistants, and two research hands who are permanently in the area, carrying out survey and trial work. Since the 1984/85 season FSRU has been fully staffed and operational, and a detailed financial statement is presented in Table 42 for its first two seasons. A brief summary of its on-farm research activities is also presented.

There was an original investment of approximately $60,000 for a station wagon, two four-wheel-drive pickups, four motorbikes, and an electric typewriter. Subsequently, some small equipment items and office furniture were purchased under investments. Approximately 75% of the total budget was spent on staff, and about 22% on operational expenditure.

There have been no budgetary problems in running the on-farm research program. During the first year, approximately 20% of the research resources were employed on diagnostic studies, about 50% on crop trials, and the rest on livestock-related trials. The proportion on characterization studies increased in the second year to about 25% or 30% because of the large demands of the bimonthly livestock monitoring study. Crop trials accounted for about 40% and livestock related trials for the rest. For specifics of FSRU program in these two seasons see Annex 5.

Table 42: Budget Distribution of the Farming Systems Research Unit and Summary of On-Farm Research Activities During the 1984/85 and 1985/86 Seasons

	1984/85		1985/86	
	ZWD (=0.67 US$)	% of total	ZWD (=1.60 US$)	% of total
Total budget	160,990	100	187,927	100
Staff[1)]				
Research officers	54,383 (4.5)	34	67,140 (4.5)	35
Research technicians	34,195 (3)	21	37,944 (3)	20
Agricultural assistants	24,340 (5)	15	21,636 (4)	12
Research hands	7,776 (4)	5	8,640 (1)	5
Secretary	4,104 (1)	3	4,560 (1)	2
Subtotal	124,789	77	139,970	74
Operations				
Vehicle operation and maintenance	6,582	4	9,358	5
Experimental supplies	8,500	5	11,254	6
Subsistence	10,914	7	9,309	5
Casual laborers	3,800	2	5,560	3
Others	2,396	1	7,476	4
Subtotal	32,192	20	42,957	23
Investments (initial investment: $60 000)	4,000	3	5,000	3
On-Farm Research	Area 1	Area 2	Area 1	Area 2
Crop trial sites	81	21	49	44
Forage/livestock trial sites	5	7	25	5
Livestock monitoring and weighing	-	-	1 (16)[2)]	1(19)
Farm surveys: informal	1 (50)	1 (50)	1 (0)	2(38)
formal	2 (108)	1 (131)	1 (103)	1(105)

Notes: 1) No. of staff in parentheses (Expatriates are included as local research officers).
2) No. of farmers or households in each study.

Source: FSRU records.

According to the above budget estimates and distribution of resources among on-farm research activities, the average cost of researcher time per trial site is estimated at ZWD 868 and ZWD 853 in 1984/85 and 1985/86, respectively. The average operational cost per trial site is estimated at ZWD 224 and ZWD 262.

In the Agronomy Institute, which operates differently, each research officer stationed in Harare manages an area individually and has some junior staff, one agricultural assistant and three research hands permanently located there. Selecting an area of average distance from Harare, the direct cost at 1985/86 prices is estimated at ZWD 13,566 (Table 43).

Table 43: Estimated Annual Cost of a Trial Area of the Agronomy Institute, 1985/86

	ZWD	%
Staff		
1 Research officer for 40% of time	5,960	44
1 Agricultural assistant for 50% of time	2,700	20
2 Research hand for 50% of time	2,160	16
Subtotal	10,820	80
Operation		
Transport for six trips (180 km from Harare at $0.35/km)	756	6
Bicycles, field staff	300	2
Daily allowances for agricultural assistant and three research hands ($3,50/day for 85 days)	1,190	9
Input costs (ZWD 50/trial site)	500	4
Subtotal	2,746	21
Total	13,566	100

Source: An Agronomy Institute research officer, personal communication.

Taking an average of ten trial sites per research area, the average staff cost per trial site is about ZWD 1,082 and the average operational cost about ZWD 275. These estimates are higher than those of FSRU, due primarily to the lower number of trials the Agronomy Institute has in any one area. It could therefore be argued that ten trial sites per area for a field team of four may be less than optimal, and the team could manage additional trials with very low additional costs.

Of the five research units, Farming Systems Research Unit and Agronomy Institute costs would probably be the highest, as the other teams have not outposted research staff in the field. However, this probably requires ten to twelve visits to each area per season.

Management of Logistic Support

Transportation. Each unit has its own fleet of vehicles for on-farm research and other activities, and there is no problem of access to them for on-farm research. Only the Farming Systems Research Unit uses motorbikes on its on-farm research program, for its agricultural assistants, because there are safety problems to be considered. One agricultural assistant died in an accident one year after he started to ride. Although it was not his fault, lack of experience was probably the main cause of his death. Research hands and agricultural assistants in the Agronomy Institute stationed in research areas are provided with bicycles.

Larger vehicles for the use of research officers and research technicians are government-owned and are usually in good condition. Refuelling is done at any DR&SS research station, Central Mechanical and Engineering Department depot, or police station. Since every vehicle must have an up-to-date logbook, without which no fuel can be drawn, it serves as the most effective mechanism for controlling the use of vehicles. Maintenance and repairs of most vehicles must be done by the Central Mechanical and Engineering Department, whose workshops are usually overcommitted and do not have the necessary spares. Delay in maintenance and repair is the major transport problem for on-farm research.

Some government-owned vehicles are serviced in the private sector using government requisitions. For FSRU, this arrangement has worked well, and transport costs have been low.

The head is responsible for the vehicles assigned to his unit, and he may delegate the responsibility to monitor their use to one of his staff. As long as the logbook is up-to-date, there are no legal constraints on the use of government vehicles, other than those which would apply to any other vehicle. Research officers and research technicians owning their own vehicles are allowed to use them on official business, upon approval by the head; however, such vehicles must be properly insured and registered with government authorities. At present, all heads and a few research officers and research technicians use their personal vehicles for official use and for on-farm research. They are compensated at the same rates, depending on size of vehicle and quality of road, as the Central Mechanical and Engineering Department charges its users.

Housing. DR&SS has no permanent facilities in communal areas, as AGRITEX has, and there are no houses to rent that would be suitable for professional or junior staff. Only junior staff, who are mostly single, in the case of the Agronomy Institute (agricultural assistants and research hands) and the Cotton Research Institute (research hands only), are posted to research areas from October to April and are housed in tents or caravans, which are not appropriate

for family accommodation. Other staff share accomodation or commute. In one area - the farthest from Harare - FSRU has borrowed two houses from AGRITEX, one for each of the agricultural assistants. Since the research hands are bachelors, each boards with his corresponding agricultural assistants. The research technician lives in the nearest city, 60 km away, and commutes in his pickup. For the other area, the FSRU field team resides in Harare because of lack of accommodation in the communal area. This team travels in a pickup for two to three days at a time every week, or daily if necessary. Research officers overnighting in the communal areas usually stay at hotels in the nearest towns. During major operations, professional staff stay in the field for three to five days, but for supervisory visits they commute if distances involved are less than 150 km.

The desirability of having field teams live at research sites depends on the volume of work and the degree of clustering it would be useful for the Agronomy Institute and the Cotton Research Institute, which have about ten trial sites each per area. For the Crop Breeding Institute and the Lowveld Research Station it would probably be more expensive. Farming Systems Research Unit staff who participate in characterization and monitoring studies need to live on sites; otherwise, transport and daily allowances would be exorbitant. The Lowveld Research Station plans to have some staff, agricultural assistants and research hands, posted to their research areas.

FSRU has a core team centrally located and a field team posted to each area, an arrangement which seems to be adequate in achieving good linkages with experiment station research programs, AGRITEX senior managers and field staff, and farmers. However, there is little probability of DR&SS solving the housing shortage in the near future, and FSRU is likely to shift most of the responsibility of management and supervision of trials to extension staff, as envisaged in the new AGRITEX plan. An alternative would be to select research areas within commuting distance of experiment stations, although at present there is a housing shortage at most stations.

Input and material supply. On-farm research field teams are supplied with inputs from their station when needed. FSRU uses the Harare Station for inputs and materials for on-farm research, but in the more distant areas, some equipment is kept by agricultural assistants in their homes or at the nearby research station.

Farmers are not expected to provide any equipment or inputs for trial work other than plowed land and, in the case of the Cotton Research Institute, the expensive pesticides. Farmers appreciate the cash input contribution of on-farm research programs.

Financial management of field teams. There is a standard daily allowance that applies to all staff on official duty travel. These rates were increased in 1986, and for meals and basic accomodation, there is no need to submit receipts. Higher claims, within limits, are reimbursed if supported with receipts. This arrangement is very attractive for agricultural assistants and research hands on stations, who consider it a substantial fringe benefit. However,

staff posted to the research area do not receive the daily allowance, except when they leave their area for assignments elsewhere. Because the Agronomy Institute and the Cotton Research Institute outpost staff for only part of the year, a subsistence allowance is provided; for example, the Agronomy Institute pays its field staff ZWD 7.50 per day. The recent increase in allowances has meant close monitoring of field trips of the junior staff, but this has not affected the quality of supervision.

All on-farm research staff complained about the long delays (up to two months) in the settlement of subsistence claims. Since all claims must be reimbursed by the Ministry of Lands, Agricultural and Rural Settlement head office in Harare, there is an administrative bottleneck. This service definitely needs to be decentralized. Some research officers still complained of the low levels of subsistence provided.

Research support personnel. The hiring of casual laborers for peak periods (e.g., planting and weeding) is not usually done by on-farm research units. When they need helpers at field sites, they bring them in for one or two days from their research station. FSRU, which does not have such a labor pool, hires them at the sites. These workers are well known to FSRU field team, have some experience with on-farm research trials, and are hired on a day-to-day basis for specific tasks. The procedure for payment is to request an advance through the Harare office, where cash is issued to FSRU to make these payments directly. At first this process was efficient, but recently it has been taking up to two months to receive payments for casuals in the more distant research area. Thus since March 1987, payments have been made directly from one of the nearest stations.

Since casual workers are hired only for specific tasks and supervised by the farming systems research field staff, there is no need for job descriptions and/or performance evaluation.

TECHNOLOGY VIGNETTES

Tine/Herbicide Technology in Maize Production

Diagnostic surveys conducted by FSRU in Mangwende communal area identified draft power shortages which led to delayed crop establishment as a major constraint to high crop yields, particularly for non-cattle owners in the area. This constraint resulted in the increasing use of cows and two-animal draft teams, instead of the traditional four-oxen teams. To reduce power requirements, as well as to enable timely draft availability to non-draft owners, reduced tillage through tine use was identified and screened as a possible intervention to be tested with farmers. The Institute of Agricultural Engineering of AGRITEX provided the necessary technical expertise. However, during the *ex ante* evaluation of this technology and subsequent discussions with farmers, the importance of addressing the weed burden associated with reduced tillage was recognized, and a herbicide treatment was incorporated. This was tested with farmers in farmer-managed trials. To ensure full farmer participation, the trial design was simplified to a split plot arranged in a 2 x 2 factorial with two replications per site. The trial was planted at

several sites over a number of seasons to enable an assessment of the adaptability of the technologies over a wide range of farmer management capabilities and physical conditions.

AGRITEX involvement, at both the provincial and field levels, was achieved through annual training workshops in which trial objectives, design, field layout, recording procedures, and the previous season's results were presented and discussed. Such workshops formed the basis on which subsequent meetings to plan the following season's program with participating Group Development Areas and host farmers were conducted. Farmer participation in trial execution and evaluation was enhanced by conducting pre-planting demonstrations on farmers' fields. Farming Systems Research Unit field staff in conjunction with AGRITEX personnel illustrated the use of the tine and herbicide technology in maize production to farmers. Furthermore, the participation of host farmers as speakers helped them feel more confident to ask questions. The awarding of a tine and herbicide prize to the best Group Development Area encouraged competition among Group Development Areas and hence the incentive for more farmers to experiment with the new technology. Valuable feedback was also obtained from station-based engineering and weed science specialists at such field days, as well as during special field trips arranged by research officers.

The tine and herbicide technology was subjected to three sets of analysis - agronomic, economic, and farmer assessment. The agronomic analysis concentrated on assessing the stability of the technologies across sites and years, using variance, multiple regression, and stability analysis techniques. These analyses showed that tine technology had a significant maize grain yield advantage over conventional tillage in a poor rainfall season. No significant yield difference between these treatments was observed in a good rainfall season. With respect to weed control, there was no significant grain yield difference between hand-weeding and herbicide use. Economic analysis showed that it was profitable for farmers to change their current practice (mouldboard-plowing and hand-weeding) to the new technology, even in the absence of a significant yield increase. This result was confirmed by the 1984 Farming Systems Research Unit farmer assessment survey, which showed that, of the 75 surveyed farmers, most were interested in the new technology.

However, after several years of testing this technology, questions have been raised about its use. First, to obtain maximum yield benefit from early planting through tine use, basal fertilizer has to be applied at planting, despite the shortage of labor for this. The possibility of testing planters and fertilizer applicators with a tine attachment is being explored as a mechanism to reduce this constraint. Further, a trial to quantify the likely benefits from applying basal fertilizer at planting, compared to three weeks after emergence (the current farmer practice), is being investigated at Henderson Research Station and in an on-farm trial. Problems that have arisen will require further research. They include manure incorporation in a tine-based system, the lack of information on the optimal period of continuous tine use before adverse effects on soil structure and fertility set in, and how best to organize tine

technology, given that the primary beneficiaries are non-draft-animal owners who rely on others for this service. It is hoped that introducing the tine-and-herbicide technology through Group Development Areas will solve this problem.

Moisture Conservation Technology

Low and unreliable rainfall resulting in total crop failure in some years was identified as a major constraint to increased food crop (maize and sorghum) production in the southeast lowveld from an agro-ecological review and from one research officer's personal knowledge of the area. Although no formal socioeconomic criteria were used in problem identification, research officer participation in field days and training workshops organized by AGRITEX, and informal discussions with farmers, facilitated better problem definition. To stabilize crop yields, landforms (ridges and tied ridges) aimed to improve harvesting and concentrate rainfall around the root zone were designed and initially tested on heavy soils at Chiredzi Research Station. Based on successful on-station results, this trial was replicated on farmers fields, on both heavy and sandy soils, using ox-drawn equipment.

Given the lack of experience of local farmers in the use of these land forms and the need to obtain more precise information, the trial is managed by the researcher, with the farmer participating only in the weeding and protection of the trial. AGRITEX involvement has been largely confined to selection of farmers, monitoring, and informal evaluation of trials. However, the apparent lack of familiarity with the trial program appeared to limit AGRITEX staff's ability to monitor and evaluate it. Other on-station researchers have been involved through annual planning and review meetings and joint research staff visits to on-farm research trials.

Because of limited farmer and AGRITEX participation in the design and implementation of this trial, and the disciplinary composition of the team, it was only subjected to biological analysis. Emphasis on farmer and AGRITEX assessment has been minimal and on an informal basis. Although no formal recommendations have been made so far, three seasons of on-farm testing showed that water conservation in ridges increased maize and sorghum yields by up to 30% in dry years, compared to flat-planting. No significant yield differences were observed between ridge and flat-planting treatments in a good rainfall season. These on-farm results have been consistent with those obtained at Chiredzi Research Station. The responsible research officers claimed that some farmers had started planting on ridges.

Although there is little feedback from farmers to researchers through farmer assessment, the program has apparently evolved through time in response to results of previous seasons and a better appreciation of farm conditions by the researchers. For example, fertility and plant population components have been incorporated into the trial as the team gained knowledge on soils and the need for population adjustments to suit the rainfall regimes from previous trials. Furthermore, given the problem of water retention on sandy soils, a manure treatment to reduce the degree of fertilizer leaching and increase water retention capacity of the soil has been included.

CHAPTER FOUR

FUNCTIONAL ASSESSMENT OF ON-FARM RESEARCH PROGRAMS

INTRODUCTION

This chapter examines the five case study on-farm research programs in terms of their performance of seven research functions the ISNAR study considers to be central to most on-farm, client-oriented research programs. Chapter 5 then analyzes the organizational and managerial factors which have either facilitated or impeded the performance of the various functions. All the country studies in the ISNAR study conducted this type of analysis in order to provide a basis for systematic comparative analysis across institutions. The seven functions reviewed are listed below.

Function 1: support a problem-solving approach within research which is fundamentally oriented to farmers as the primary clients of research.

Function 2: contribute to the application of an interdisciplinary systems perspective within research.

Function 3: characterize major farming systems and client groups, using agroecological and socioeconomic criteria, in order to diagnose priority production problems and identify key opportunities for research, with the objective of improving the productivity and/or stability of those systems.

Function 4: adapt existing technologies and/or contribute to the development of alternative technologies for targeted groups of farmers sharing common production problems by conducting experiments under farmers' conditions.

Function 5: promote farmer participation in research as collaborators, experimenters, testers, evaluators, and disseminators of alternative technologies.

Function 6: provide feedback to the research priority-setting, planning, and programming process so that experiment station and on-farm research are integrated into a coherent program focused on farmers' needs.

Function 7: promote collaboration with extension and development agencies in order to improve efficiency in the processes of technology generation and diffusion.

The assessments presented reflect the analysis of the study team based on information gathered from primary data collected across the case studies; from interviews with research managers, scientists, technicians, extensionists, and farmers (see Annex 7); as well as the experience and knowledge of the case study research team who prepared this report. Such an evaluation is clearly somewhat subjective, but the analysis has been reviewed by representatives of the respective programs.

It is also stressed that functions are not all equally important in the institutes reviewed due to differences in mandate, state of technical knowledge, and the research objectives and methods of their on-farm research programs. The objective of the analysis has not been to evaluate one program against another, but to systematically examine the factors affecting the performance of the functions within diverse on-farm research programs of a single research institution.

THE CROP BREEDING INSTITUTE

1. Supporting a Problem-solving, Client-oriented Approach within Research

The function of supporting a problem-solving approach focused on farmers as clients has been performed moderately well in the Crop Breeding Institute. On-farm researchers realize that appropriate varieties or hybrids for farmers in communal-area conditions can contribute to solving production problems.

On-farm research staff are also well aware of the farming systems and basic problems of production. They are not so aware, however, of farmers' priority problems.

They identified the main problems in crop production as poor crop management, fertility, erosion, and poor seed quality, but collaborating farmers gave more importance to pests (weevils in maize, borers in sorghum, and boll worm in cotton), and feed deficiency and parasites in livestock production. AGRITEX staff interviewed agreed with farmers but added unreliable rainfall and lack of draft power and labor to the list.

All variety trials are conducted under optimal management conditions (early planting, adequate population and fertilization, etc.) to achieve potential yields. The basic criteria used for varietal performance are crop establishment, yield levels, and stability. The sorghum breeder also mentioned food quality.

As a consequence of its on-farm experience, the Crop Breeding Institute has placed more emphasis on short season, drought tolerance, and pest and disease resistance characteristics in its breeding program. Thus it has expanded its on-station and on-farm research program to focus on crops which should be more suitable to low-potential areas (sorghum, millets, beans, etc.).

2. Contributing to the Application of an Interdisciplinary Systems Perspective

In practice, researchers of the Crop Breeding Institute participate in the planning, implementation, and evaluation activities of other on-farm research programs, especially those of the Agronomy Institute and Farming Systems Research Unit. This interaction is relatively easy to arrange because of proximity to the head office. However, researchers in the Crop Breeding Institute do not readily involve others in their own program, probably because they sense no need. Accordingly, the contribution to the application of an interdisciplinary systems perspective is assessed as weak.

The six commodity sections of the Crop Breeding Institute's on-farm research program carry out their field work autonomously, coordinating only logistic and support aspects. There is little interaction on problem identification, trial designs and management, and analysis of results, since every crop has its own peculiarities.

There is no evidence of teams systematically seeking technical inputs from other disciplines to help define on-farm research priorities or formulate programs. However, when they experience management problems with their crops, especially phytosanitary problems, they may call in the plant protection specialists. There is no social science input; the only example of evaluation beyond the purely technical area was food quality analysis of sorghum varieties. One research officer expressed the opinion that interdisciplinary research was very important for on-farm research, that it has high priority in DR&SS, and that more training in its methods was required. However, the Crop Breeding Institute leader thought that no specific training was required for on-farm research, except through experience gained from participation.

3. Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

The Crop Breeding Institute's on-farm research teams do not give much importance to characterizing major farming systems and client groups. Through their experience in the field with farmers, knowledge of areas and farming practices has automatically improved, but it has not had any observable effect on their research program. Consequently, the performance of this function is assessed as weak.

According to the farmers interviewed, researchers understand and are knowledgeable about farming practices and problems. Researchers acknowledged that they knew more about the agroecological and socioeconomic factors and other constraints to production, but they did not make any distinctions among client groups, as they felt that all farmers in the area shared the same problems. They do not, therefore, make any changes in their variety recommendations or management levels to reflect farmers' specific socioeconomic circumstances.

The procedure for selecting trial sites and farmers is not systematic. One research officer uses AGRITEX to select collaborators in the regions desired, and he then selects the plot

appropriate for his requirements. Another research officer does not use AGRITEX, but relies on personal contacts of his research assistant. Since a wide range of agroecological conditions is a key criterion for achieving maximum potential in the overall testing program, a farmer could, and usually does, host many trials.

4. Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

During the 1985/86 season, the Crop Breeding Institute had approximately 60 on-farm research trial sites, 80% of which were in low-potential areas (Natural Regions III, IV and V). This program is a component of the advanced testing phase, which is carried out on stations. Since most stations are in high-potential areas, on-farm research trials a) provide a wide range of environmental conditions to test germplasm and b) demonstrate "good technologies" under farmers' agroecological conditions. The performance of the function of adapting existing technologies and contributing to the development of alternative technologies is therefore assessed as good.

The design and choice of on-farm research trials are not really based on previous on-farm research results. Varieties and hybrids developed by the Crop Breeding Institute on-station or from other sources are evaluated, in comparison to the standard varieties used by farmers, under farmers' agroecological conditions but not their management conditions. Site selection is based on agroecological representation, and the optimal management package is determined for each site. Breeders may consult other disciplines in DR&SS if they suspect that the management package needs refinement, but they do not systematically seek inputs on any other aspects.

The Crop Breeding Institute researchers are aware of other design and evaluation criteria that could be used in variety testing (e.g., nutritive quality of biomass, economic costs, and benefits), but they are not inclined to expand their assessment criteria for fear that progress on current activities would become slower.

Up to the end of 1987, the most important achievements of their advanced testing, both on-station and on-farm, were as follows: a three-way maize hybrid; high-yielding white sorghum varieties for staple food (three to four tons/ha); improved millet varieties (up to two tons/ha), and a high-yielding and early-maturing sunflower hybrid (two to three tons/ha). All these achievements, except for the maize hybrid, have particular relevance to the low-potential communal areas.

According to farmers, the Crop Breeding Institute trials have taught them how to plant sorghum in straight lines and how to grow the new varieties of sorghum and sunflower. AGRITEX staff highlighted planting in lines, appropriate varieties, appropriate fertilization, and weed control with herbicides as being highly relevant technologies. Most of these are also addressed by other DR&SS on-farm research programs.

5. Promoting Farmer Participation

The involvement of farmers in this program consists of providing land (sometimes prepared), weeding, and protecting trial sites. Researchers interact informally with farmers, explaining objectives of trials and obtaining the views and opinions about the trials. Field days are the only formal mechanism for interaction; thus the performance of the function of promoting farmer participation is assessed as moderate.

On-farm research staff believe that the principal contribution of farmers is to provide feedback on trial work. Farmers are not usually involved in the problem-identification phase, and no *ex ante* analysis is carried out to assess the appropriateness of the trials. Researchers explain trial objectives to farmers, who appear to understand them well. One farmer was even able to speak about trial objectives at a field day. AGRITEX staff believe that farmers understand the Crop Breeding Institute trials because they are simple and farmers can participate in all operations, not just weeding. One researcher, however, thought farmers did not always understand the purpose of the trial because extension staff used unfamiliar "terminology" or gave unclear explanations.

When researchers visit trial sites they talk to farmers about the trials and ask for comments. This was confirmed by farmers and indicates that there are no communication barriers. From responses of on-farm research staff, there is some indication that they are drawing on farmers' knowledge and informal assessment of their varieties to improve their research program. One research officer commented that he had learned through his work on-farm that "farmers are keen to use new ideas and varieties".

Farmers have not been asked to improve trials or encouraged to experiment on their own, although the Crop Breeding Institute leader said he encourages them to try new varieties. It is obvious that the researcher-to-farmer information flow is strong. Farmers' assessment reactions to trials do also carry some weight in researchers' analysis of trial results and their planning of future research, however.

6. Providing Feedback so that Experiment Station Research and On-Farm Research are a Coherent Program

Within each on-farm commodity research program of the Crop Breeding Institute, there are strong linkages between on-farm and on-station research because the same research officer carries out both. Experiment station research is directly related to on-farm research because the materials developed in the early breeding phases are tried on farmer fields. However, the linkage from on-farm to experiment station research appears to be weak. Overall, the performance of the feedback function is assessed as moderate.

On-farm research is not really given much credibility as a source of information for setting research priorities or directions in breeding work. Researchers are dedicated to varietal development under optimal conditions, which is basically an experiment station activity, and some research officers think that on-farm research should be done only if a separate team can be established.

There are a few examples of how on-farm research has affected experiment station research. It has confirmed the need to develop very short-duration, drought-tolerant, and pest/insect-resistant varieties for the erratic and low-rainfall regimes in most communal areas. Also, better emergence of some varieties through communal area soils has made them record and select for this trait on experiment station research trials. On the other hand, staff working on-farm believe that the added responsibilities have adversely affected their on-station research. They argue that it is difficult to do both types of research effectively and efficiently.

With respect to influencing other experiment station research programs, Crop Breeding Institute research officers have been somewhat successful in drawing attention to urgent problems needing further research. For example, the Plant Protection Research Institute has undertaken new trials on termite and stem borer control in response to suggestion from the Crop Breeding Institute.

The information flow from experiment station research to on-farm research is strong, since on-farm research is planned as an extension of experiment station research. The planning of both components is done simultaneously by each commodity section in the Crop Breeding Institute, but no other section in the institute or other institutes of DR&SS participate in this process. No specific changes are made to experiment station research trial designs or management levels (uniform treatments) for application under on-farm research conditions. Because of the lack of adequate supervision and researcher time to take precise measurements, only yield data are collected from on-farm research trials for statistical analysis.

7. Promoting Collaboration with AGRITEX

The on-farm research officers in the Crop Breeding Institute perceive AGRITEX as the necessary linkage to farmers. They are interested in having AGRITEX workers involved, particularly in research activities directly relating to farmers and implementation of on-farm research, such as selection of sites and farmers, monitoring trials, and field days. According to his experience, the on-farm research leader thinks that AGRITEX staff are technically weak and that DR&SS on-farm research programs have been compensating for their deficiency. Overall, the performance of the function of promoting collaboration with extension is assessed as moderate.

In the on-farm research program dealing with small grains, extension staff have a moderate level of participation in problem identification, a high level in site and farmer selection (basically selecting the better farmers and collaborators), in trial implementation and monitoring (one extension worker kept rainfall, crop-flowering, and maturity records), in organizing farmers' field days, and even judging the performance of trials. They have not participated in the evaluation of results and formulation of recommendations (no formal recommendations have yet been prepared). In the maize program, AGRITEX has not volunteered its services, and has therefore not been involved.

AGRITEX staff are fully aware of the objectives of the variety-testing program and have benefited from it. They indicated

that new recommended crops are being planted in the area and extension teachings are being supported by breeders. They believe that on-farm research will solve the farmers' problems more quickly in the particular areas where they are working. One extension worker suggested that researchers should improve the coordination of visits so that he did not miss them due to other duties.

The on-farm research staff think that the linkage with AGRITEX is necessary because of its closeness to farmers, but at present they perceive AGRITEX as less than competent to transfer technical information to farmers. For this reason, researchers are usually the key speakers at field days which are held at successful trial sites to demonstrate improved husbandry practices and results.

Researchers have participated in other AGRITEX activities (e.g., field days, demonstrations) upon invitation. Researchers are not involved with any other development agency at their research sites.

On-farm research staff are very much aware of AGRITEX's current varietal recommendations for research sites and do include them in germplasm entries as experimental controls. They are also aware of crop "package" recommendations (planting dates, population, and fertilizer levels), which roughly correspond to the levels used in their testing program, although researchers tend to be more exact, compared to usual communal area practices.

8. Synthesis of Assessment

The Crop Breeding Institute's on-farm research program first and foremost provides an opportunity to test breeding materials under a wide range of environmental conditions representative of the communal areas, particularly those in low-potential areas. This explains why the performance of its function of adapting existing technologies and contributing to the development of alternative technologies is good. This assessment should not be interpreted strictly in the adaptive research sense, however, because the Crop Breeding Institute is not "adapting" its varieties and hybrids to farmers' conditions. This is a function that the institute cedes to the Agronomy Institute, the Farming Systems Research Unit, and AGRITEX.

Because of the definition of the Crop Breeding Institute's breeding objectives, support of the interdisciplinary systems research and characterization of local farming systems and client groups are logically weak. The consigned responsibilities for work on-farm as well as on-station draws researchers' time and resources away from the central breeding work that can be done most efficiently on experiment stations. Consequently, research officers are not able to spend sufficient time on-farm to develop stronger farmer participation or feedback of farm-level information to the station. In the future, if funds became more limited and/or breeding mini-stations are established in the low-potential areas, the Crop Breeding Institute is likely to withdraw from on-farm research.

THE AGRONOMY INSTITUTE

1. Supporting a Problem-solving, Client-Oriented Approach Within Research

Both senior and junior scientists in the Agronomy Institute contend that their on-farm research program should give high priority to the function of supporting a problem-solving, client-oriented approach within research. They also indicate that, in fact, their performance is not at the level desired. However, given the recent adjustments of focus and direction in the institute and the positive response of AGRITEX staff and farmers, the performance of this function is assessed as good.

First of all, research staff recognize that on-farm research is an essential component of the research program. They indicate that "everybody wants to grow maize" and that the major production constraints for maize are "poor soil fertility and rainfall".

They arrived at this diagnosis from literature reviews, past on-station research, and from farming systems research diagnostic studies carried out while farming systems research was still in the Agronomy Institute. In research protocols they often mention farmers' practices and problems related to the use of different varieties, fertilizer levels, and other management options, as well as the economic aspects of their use. In reports, yield response is the main criterion used to screen and evaluate technology, but there is some evidence of economic analyses as well. Since each officer plans and implements both on-station station and on-farm research, there is a high degree of complementarity, and on-farm research is perceived as distinctly advantageous. One research officer commented that with on-farm research "you work in the right environment and are exposed to the real situation".

Second, although research staff are well informed on farmers' predominant crop and livestock enterprises and farming system interactions, there seems to be some difference of opinion on critical production problems. Farmers have identified inadequate rainfall, lack of draft power, lack of cash, and weed problems as general constraints, as well as a number of specific problems with particular enterprises. They did not mention soil fertility specifically, but this is regarded as a major constraint by researchers. AGRITEX staff agreed with farmers in highlighting lack of draft power and lack of cash as the main problems, but they also cited soil fertility, transport, and lack of availability of inputs as additional problems, thus being in agreement to some extent with researchers. Because most trial treatment combinations of the Agronomy Institute's on-farm research program are related to variety, population, and fertility factors, researchers believe that their trials are particularly relevant for adapting technologies to solve farmers' problems (e.g., drought-tolerant varieties for different levels of management and input costs). This belief is realistic, as it was confirmed by farmers and extension agents when they expressed strong support and interest in the results of the trial program.

2. Contributing to the Application of an Interdisciplinary Systems Perspective

The head of the Agronomy Institute is extremely keen on promoting interdisciplinary collaboration in planning and reviewing research programs of all DR&SS on-farm research programs. Given the present levels of interaction across disciplinary boundaries, i.e., beyond the Agronomy Institute, this function is assessed as being good.

The institute's research officers are basically agronomists in practice, although by training they may have some capability in other disciplines, such as physiology and breeding. They consult widely in DR&SS to seek materials and technical inputs from other staff (breeders, soil scientists, statisticians, plant pathologists). This is done largely informally at head office during technical seminars, tea breaks, or office visits and more formally through the recent activities of the Committee for On-Farm Research and Extension. For the Agronomy Institute, interdisciplinarity is important to ensure efficiency in the design and management of the on-farm research trial program.

At present, socioeconomic analysis is used only in ex post evaluations of trial results and only by a few research officers. This is the weakest aspect of the interdisciplinary perspective, especially for the Agronomy Institute. However, the on-farm leader, as well as researchers, clearly recognizes the need for such analysis.

3. Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

At present, the Agronomy Institute's on-farm research does not systematically carry out characterization studies. Staff have drawn on experience with the farming systems research program (which was in the Agronomy Institute before 1984) and have done some survey work on specific crops, e.g., sunflower and cowpeas, to define researchable problems. At present, their characterization studies focus mainly on climatic and soil factors. Their performance on this function is assessed as moderate.

Before 1984, the Agronomy Institute had its Farming Systems Research program to characterize production systems and identify constraints. The institute depends on and supports the Farming Systems Research Unit to carry out this type of research for the benefit of DR&SS as a whole, although research officers have done their own surveys, particularly on technical aspects of crop production.

The Agronomy Institute depends largely on AGRITEX for selecting trial sites and farmers for on-farm research, but it provides instructions to AGRITEX on selection criteria, usually biotechnical considerations. The type of farmer is not one of the selection criteria. AGRITEX introduces researchers to potential farmer collaborators, and researchers negotiate with them for appropriate sites.

Through direct interaction with farmers and analysis of trial and survey data, the Agronomy Institute researchers' understanding of crop production systems and constraints has improved, and the on-farm research program has thus been modified and expanded. New trials include manure and inorganic fertilizer combinations for groundnuts, fertilizer limiting factors for maize, groundnuts, and soyabeans, dual-purpose crops such as pigeon peas and cassava on contour ridges, intercropping of maize and sorghum with cowpeas, and ox-drawn implements for weed control. These subjects demonstrate a keener awareness of priority problems of farmers.

4. Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

Conducting on-farm research trials to develop technologies for the particular circumstances of communal-area farmers is the central thrust of the Agronomy Institute's program, and the performance of this function is assessed as good.

The institute's research officers use their research on climate and soil types to define target groups of farmers. Thus research areas and trial sites are selected using agroecological potential (areas in Natural Regions II to IV) and soil texture types (mainly sandy areas). Logistic and accessibility considerations are then added to make best use of manpower and operational resources. The latter is important because the network of on-farm research trial sites is large, with 100 sites distributed over all eight provinces of the country.

Trial planning is meticulously done using previous on-farm research, recent experiment station research results, and the expertise of other relevant experienced researchers, both within and outside DR&SS. In many respects this approach probably runs the risk of being too "top-heavy" and thus obscuring the direct relevance to farmers' priorities and conditions. Specific mechanisms have not been instituted for AGRITEX and farmers to contribute effectively to trial design prior to, and/or during, establishment. However, on-site analysis of farmers' practices, as well as current extension recommendations, are usually the basis for defining treatment levels and combinations.

The institute's on-farm research trials are strictly researcher-managed and have so far been fairly successful. The on-farm research team has considerably enhanced its knowledge on the potential of crop enterprises in all regions of the country. This has been accomplished through several means: trials have been replicated over a wide range of agroecological conditions; the program has concentrated on a narrow range of technical problems, coupled with very detailed site-specific data: and research officers spend much more time in the field now, as they combine research on experiment stations with that carried out on farms. However, highly variable weather patterns and poor fertility in areas where trials were sited has caused serious problems and setbacks. Nevertheless researchers have gained the expertise to be able to set yield limits for the different agroecological zones under specific management practices, such as population and fertilizer levels.

Although most collaborating farmers have been with the program for less than three years, they indicated that they had learned from the trials about the application of appropriate fertilizer levels, row planting, and thinning out after germination as a means to ensure appropriate plant rows and population. They also claimed to have adjusted plant rows and populations on their own crop systems, but five out of six farmers interviewed had not increased fertilizer use to the appropriate levels due to a shortage of cash.

Although there is no evidence of formal recommendations drawn up as a result of these trials, a group of senior researchers and extension officers used the results, as well as those of other on-farm and on-station research programs, to update in 1986 the Agricultural Finance Corporation crop package specifications which are used for credit purposes.

The main reasons for less-than-desired progress in the Agronomy Institute, especially in the low-potential areas of the country, are 1) the initial lack of technical and research experience of its young staff, 2) the quick acceleration of the on-farm research programs, both in number of commodities and in geographical coverage, which resulted in poor management of trials and a consequent loss in reliability of results, and 3) the misleading assumption that on-the-shelf technologies were appropriate and only required adaptation. That the institute's on-farm research has been a learning experience for the staff is evident from an analysis of the new range of problems which have been identified.

5. Promoting Farmer Participation

Given the state of technology development and the specific trial objectives of the Agronomy Institute, farmers do not participate much in the planning and management of trials; thus performance of this function is assessed as weak. The institute is satisfied with this level of participation because it feels that more farmer involvement at this stage would probably result in a reduced success rate, as measured by a reduction in the proportion of trials analyzed to trials planted.

In the beginning, farmer participation was important to the on-farm research program. Researchers now do not favor much participation because of serious problems encountered, namely farmers' failure to carry out specific operations, such as weeding and top-dressing, on time. However, farmers still actively discuss local problems and proposed trials with the field team and with the research officers during site visits. Research staff feel that farmers understand the on-farm work, whereas AGRITEX staff believe that they do not, due to a low level of understanding of research, researchers' inability to communicate, and the lack of names for certain varieties used. One research officer said that he had not learned anything directly from farmers; on the other hand, farmers reported being impressed with how well research officers knew their problems.

Collaborating farmers do not participate in trial implementation and most do not even provide prepared land. Some used to help with weeding when research staff could not keep up, but even this

contribution is being reduced. Farmers admitted that they do not know enough about how to contribute to the program, but AGRITEX staff believe that farmers should be more involved in operations and field days (explaining to other farmers), as one "learns by doing". Researchers do not favor more participation because they have had problems with farmer-managed trials.

The yearly field day and clustering of trials have been the main mechanisms used to improve relations with farmers as they become more aware of the research being carried out and it is easier to work with farmers' groups. There is no evidence, however, indicating that these mechanisms have been effective in obtaining feedback from farmers.

In spite of the limited involvement of farmers in the research process, most neighbors of collaborating farmers would like to host trials. They preferred to work with researchers rather than AGRITEX officers because the latter "tell", but the former "show" how to cultivate crops. On-farm researchers do their work more neatly, even though the content of the message did not differ much. They expressed the opinion that research would be useful in the future, even though it was too early to obtain specific recommendations from the present trials.

6. Providing Feedback so that Experiment Station Research and On-Farm Research Are a Coherent Program

There are two components of the function of providing feedback for a more coherent on-station and on-farm research program for the Agronomy Institute. First, within the institute on-station and on-farm research programs are being designed and implemented by the same researchers and these efforts are themselves well-integrated. Second, on-station research programs in other institutes should be integrated with the Agronomy Institute on-farm research. Overall, the performance of this function is assessed as good.

Complementarity between on-station and on-farm research within the Agronomy Institute is well-established because of the internal planning process. The information flow from on-station to on-farm research was definitely strong, because initially it was assumed that adaptive research was all that was needed to produce relevant technologies for the communal areas. This assumption has now changed, and applied research through on-station and on-farm work is now the institute's basic thrust.

Outside the Agronomy Institute, only informal mechanisms are available to promote integration of on-station and on-farm research programs. To define on-farm research in the Agronomy Institute, inputs of other experiment station scientists have been sought through informal personal consultations or seminars. The recognition that there are others to take on on-station research to follow up technical problems identified in on-farm research trials has been the reason for forging better linkages with the Cotton Research Institute, the Soil Productivity Research Laboratory, the Plant Production Research Institute, and the University of Zimbabwe. These linkages are beginning to generate some

inter-institute projects; e.g., nitrogen fixation with the Soil Productivity Research Laboratory and the University of Zimbabwe, and soil fertility improvement with different tillage systems for grain and legume crops with the Chemistry and Soils Research Institute and the Soil Productive Research Institute. The on-farm research leader believes that the Committee for On-Farm Research and Extension will also facilitate better cooperation with on-station research.

7. Promoting Collaboration with AGRITEX

At present the performance of this function is assessed as good. Research staff at all levels definitely want to improve this function, since AGRITEX staff "live with the farmers and have a more advanced insight and interpretation of their problems, which is essential for successful on-farm research".

Previously, AGRITEX was expected to contribute substantially to on-farm research in the Agronomy Institute. This contribution never really materialized, and now the involvement of AGRITEX staff extends primarily to site and farmer selection and field days, where their participation is strong, and secondarily to trial implementation and evaluation, where it is weak. Trial objectives and designs are explained to them, but they are not consulted about them. Basically they agree with the content of the institute's on-farm research program, since it supports their own "message and teachings" and are in favor of expanding on-farm research trials. They have requested, however, that the research staff improve communication and coordination with AGRITEX and define how both can best contribute to the research and development effort in communal areas.

Participation of on-farm research staff in extension activities is not formally established. Requests by AGRITEX are fitted in, when possible, at the farm level, but researchers have no responsibility in extension activities and only give advice or answer farmers' questions occasionally.

The Agronomy Institute has initiated a number of activities to strengthen research/extension linkages. For example, it holds workshops for AGRITEX on trial management, with the objective of involving extension officers and workers in implementation and evaluation of trials. Research officers now attend almost all AGRITEX review meetings. It is thought that clustering of trials will facilitate the development of effective links with AGRITEX. The present plan is for each research officer in charge of a research area to work closely with AGRITEX subject-matter specialists on trials and demonstrations.

8. Synthesis of Assessment

The Agronomy Institute is involved in many specialized aspects of crop production, and in the DR&SS it has the leading responsibility to develop technical crop "packages" for all communal areas in different natural regions. It should, therefore, integrate and collate the expertise and results of other DR&SS institutes, as well as of AGRITEX. This explains to a large extent the institute's good level of performance in developing a problem-solving approach and

interdisciplinary research, in technology generation and adaptation, in integrating on-farm and experiment station research, and in promoting links with AGRITEX. The key organizational factors directly contributing to these achievements are the presence of all research officers at head office and their easy access to other scientists there, and the recent formation of the Committee for On-Farm Research and Extension.

With respect to characterization of farming systems and client groups, no wider role is desired, given lack of staff expertise, the presence of the Farming Systems Research Unit, and the potential contribution of AGRITEX in this area. The Committee for On-Farm Research and Extension should strengthen these linkages. Farmer participation is weak because of the combined effects of negative experiences of farmer participation in the past and the present emphasis on more applied research for technology generation. In this case, researcher-managed trials are more appropriate.

Recent organizational and managerial changes to consolidate the Agronomy Institute's on-farm research program should strengthen the institute's problem-solving approach, the integration of research on-farm and on-station, and its links with farmers and AGRITEX. The key changes have been: 1) assigning one research officer per commodity and per research area, 2) allocating 25% of researchers' time to on-farm research, and 3) the clustering of trials. Given the size and stage of the on-farm research program, the interest in economic analysis, and the desire to work with the Farming Systems Research Unit and AGRITEX, a full-time economist in the the Agronomy Institute would contribute substantially to the effectiveness and efficiency of this program.

THE COTTON RESEARCH INSTITUTE

1. Supporting a Problem-solving, Client-oriented Approach within Research

The Cotton Research Institute has on-farm research programs for breeding, agronomy, and entomology. Supporting a problem-solving approach with farmers as primary clients is not a priority area for the breeding unit but is important for agronomy and entomology. Overall, the performance of this function is assessed as good.

Researchers indicated that farmers' problems and opinions are solicited directly during their training visits and at a field day at the institute, and through informal surveys (used by the entomologist to confirm problems which have been identified) and continuous interaction with extension staff. The Cotton Research Institute staff looked at all aspects of the cotton production system and decided to focus particularly on pest management, fertility, plant population, moisture management, and variety testing. The breeding work is part of a national program evaluating improved cultivars in order to select one most suitable for all farming sectors in the middleveld (600-1,200 m) areas.

The research team has a fair knowledge of existing farming systems and a good feel for farmers' priority problems. Pest control and

expensive chemicals, low fertility, high fertilizer costs, low rainfall, and labor shortage are the major problems identified by farmers interviewed. The entomologist is testing a pegboard technique for scouting to determine economic damage thresholds and therefore minimize pesticide costs. This method is especially appropriate for farmers who cannot read or write. The on-farm research agronomist is testing four fertility regimes for optimum growth and yield and, on another trial, is studying the effects of moisture conservation techniques (potholes, ridges, and tied ridges) with and without fertilizer in order to optimize yield. Land reshaping, however, is labor-intensive and will exacerbate the problem of labor shortage unless it is scheduled before the rains begin or draft implements are used. Overall, better pest control, plant spacings, and fertilizer recommendations for different soils should increase yields and profits, which is why these trials are highly relevant to communal-area farmers.

Economic criteria for evaluating these technologies are often mentioned by on-farm research staff, but they are essentially using only statistical analysis on the yield data. An entomologist emphasized the use of farmer assessment in technology evaluation. Since he had even used a formal survey to confirm farmers' priorities, this work has strong client orientation.

On-farm research is considered essential for the Cotton Research Institute to develop cotton production for all farming systems and to show the government what it is doing for communal areas. The research officers directly involved do it for job satisfaction; research in communal areas had been neglected in the past, and on-farm research now offers the opportunity to discover practical problems of farmers and to develop solutions.

2. Contributing to the Application of an Interdisciplinary Systems Perspective

Within the Cotton Research Institute, all the professional staff participate in planning and review of experiment station and on-farm research. The institute does not have a social scientist and does not perform this type of analysis, but there has always been good interaction among biotechnical staff within and outside the institute. Contributing to the application of an interdisciplinary systems perspective is assessed as good.

The Cotton Research Institute on-farm research program is run by an interdisciplinary team of breeders, agronomists, an entomologist, and pathologists. They work on the same station, plan their trials together, and help each other with implementation and supervision of trials. However, research officers believe that there is not enough interaction at the trial implementation stage.

The two on-farm research officers interviewed think that the interdisciplinary approach is important and that the disciplines of breeding, agronomy, entomology, pathology, sociology, and economics are critical for production system interactions. Social and economic input and analysis is lacking, and one research officer believes that training in these areas is needed. The other research officer received training in the University of Zimbabwe-CIMMYT in

on-farm research diagnosis and experimentation. He did not, however, identify the social science field as critical, perhaps because he possesses some capability in this area. Although the on-farm research officers feel that interdisciplinary research has low priority and is not encouraged in DR&SS, the Cotton Research Institute believes in, and actively encourages, it.

3. Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

The Cotton Research Institute on-farm research program is not particularly strong on characterization, but its entomology program performed this function very well. Overall, the performance of this function is assessed as moderate.

The insect survey work was done to define research opportunities in pest management and was very successful. However, the institute in general expects AGRITEX to perform the characterization function on a larger scale and to provide feedback from farmers.

There is no doubt that through on-farm research trials and visits with farmers, research officers' knowledge of production systems and farmers' conditions has improved; for example, they are aware that farmers will reject recommendations which do not fit with their implement, cash, or labor situations. They are also aware that the pest control package being developed will have to reflect farmers' literacy levels and other abilities.

The Cotton Research Institute indicated that, at this stage, it does not need more characterization studies of cotton or other production systems. Key constraints to cotton production have already been identified, and research is being conducted to try to solve them. Moreover, the impact of any intervention will be very specific to cotton. Finally, the staff who started on-farm research in the institute possessed a high level of national and international experience in cotton production.

4. Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

The Cotton Research Institute has between 50 and 70 on-farm research trial sites each year for studying the effect of moisture conservation techniques (potholes, ridges, and tied ridges), testing different inorganic fertilizers and population levels, testing a pegboard technique for pest scouting, and conducting a variety of other trials. Its performance in adapting existing technologies and contributing to the development of alternatives is therefore assessed as good.

AGRITEX assists in identifying farmers. Since researchers believe that the problems being addressed apply to all communal-area farmers, no distinctions are made for selecting "representative" ones.

The program's present thrust was designed to solve the major constraints to improving cotton yields using technical recommendations from previous experiment station research and the

experience of research staff. Since research began on-farm, the main focus of the soil moisture conservation trials has changed to include different fertilizer levels. No modifications of the pegboard-scouting technique have been made yet, because it has only been tested for two seasons.

Although no formal recommendations have been released, research staff will probably recommend soon that plant-spacing should not be changed. Experiments on the pegboard system are not yet conclusive. Farmers have learned about soil moisture conservation techniques and the pegboard system and believe they are helpful, but they have not yet changed their present practices as a result. No farmers have pegboards at present. For ridging, farmers understood the experiments but found that ridging cannot be done without appropriate tools, since it is labor-intensive. The pothole technique is designed to overcome the equipment and draft problem; it is a simple operation which can be done with a hoe, combined with weeding. Ridges and crossties are aimed at farmers with draft power and equipment.

The Cotton Research Institute staff are quite aware of the need to produce a relevant version of the cotton handbook for communal areas. The handbook, published about every four years by the Cotton Research Institute and the Commercial Cotton Growers Association, was last issued in 1986. An abbreviated version by the Cotton Growers Association is used for training communal-area farmers, and the experience with on-farm research should assist in completing such an up-to-date publication.

5. Promoting Farmer Participation

Farmer participation in the entomology-related on-farm research is good, but has not been as strong in the agronomic research. However, in the Cotton Research Institute, farmer participation is important for the management of all trials, and the performance of this function is therefore assessed as good.

In the entomology program, farmers participate actively in defining problems and discussion of trial objectives, and their opinions are usually sought on the usefulness of the innovations. The entomologist talks to farmers informally when he visits trial sites. Farmers are enthusiastic about the pegboard technique. The agronomist discusses all trials with his collaborating farmers, but one farmer hosting an agronomy trial did not know its objectives and had not discussed it with the research officer. The researcher indicated that he does not usually talk to farmers informally because they are often away when visits are made. AGRITEX arranges farmers' meetings and field days for researchers to explain their work, usually before and during the growing season, and thinks that such meetings should be held more often.

The Cotton Research Institute on-farm research staff believe that farmers should not have any research responsibilities because they have obvious resource and time constraints. However, farmers' views and suggestions are fully considered when designing the research program, and staff request as much assistance from farmers as possible in trial implementation and informal ways of evaluation.

Researchers indicated that they achieve this by focusing on innovations that do not modify farmers' existing production systems too much and keep other management practices constant until they have made a real improvement. AGRITEX indicated that trial-clustering does improve interactive discussions with farmers.

6. Providing Feedback so that Experiment Station Research and On-farm Research Are a Coherent Program

The flow of information between on-farm research and experiment station research is assessed as good.

Feedback from on-farm research to experiment station research varies somewhat among the different trials. The data from the breeding program is used to increase researchers' confidence in developing the single-variety recommendation. In agronomy, on-farm research experience with soil moisture conservation techniques has led to testing on the experiment station, with a view to applying them in the large-scale commercial sector. In entomology, a farmer survey showed that communal-area farmers did not readily understand and could not follow the existing pest management recommendations; so a new method of scouting was designed at the experiment station. Otherwise, on-farm research has not influenced the directions and content of experiment station programs.

The input from experiment station research into on-farm research is much stronger because on-station researchers' experience with cotton production and problems as a well-developed and supported commodity in the commercial sector, makes it possible to solve a large number of problems in this rapidly expanding enterprise in the communal areas. According to research staff, adaptive research is all that is needed; therefore, on-farm agronomic research is emphasized in the communal areas. Within the Cotton Research Institute, it seems that no distinction exists between on-farm research and on-station researchers: all research officers are involved in on-farm research to some extent, particularly in the design and evaluation of experiments conducted on-farm. Researchers view on-farm research as essential and give it a reasonable level of priority.

7. Promoting Collaboration with AGRITEX

The Cotton Research Institute staff have good working relationships with AGRITEX at the senior and field levels. They see AGRITEX as the direct link with farmers and have used its staff effectively in the development of their on-farm research program. Therefore, the performance of this function is assessed as good.

At the senior staff level, a strong link with AGRITEX is achieved in research planning and farmer training activities, through which research officers become aware of farmers' problems and priorities. AGRITEX workers collaborate very well in site and farmer selection, moderately well on problem identification, trial implementation and monitoring, and minimally on trial design and evaluation. As a general rule, research officers visit trials in the company of AGRITEX field staff whenever possible. AGRITEX consider these contributions to be beneficial. They believe that extensionists should be involved in research because:

1) they are closer to farmers;

2) they need to have current knowledge of research advances;

3) they are the ones to extend technological recommendations deriving from research.

The Cotton Research Institute staff fully agree with this perspective and therefore gives high priority to AGRITEX participation.

The Cotton Research Institute on-farm research is closely associated with the Cotton Marketing Board and the Commercial Cotton Growers Association. These institutions have put considerable effort into extending their services and facilities to improve cotton production in communal areas. This inter-institutional cooperation is to a large degree responsible for the excellent progress of communal-area cotton enterprise in recent years.

8. Synthesis of Assessment

There are several reasons for the good performance of the Cotton Research Institute on-farm research program with respect to all functions except characterization, which was assessed as moderate. First, the institute has a commodity-based approach with research officers of all relevant disciplines participating and interacting in both experiment station research and on-farm research. Continuous informal consultations and the institute's annual planning meeting facilitate the exchange of technical information. It should be stressed here that cotton is a commercial crop and an important foreign exchange earner, with a traditionally strong political lobby through the Commercial Cotton Growers Association. Cotton is also a special crop because it is exclusively for sale, with strict market requirements, which means it must be grown under high-level management. The commodity approach, with attendant institutional and managerial operations, has favored the performance of all functions.

The second reason is the institutionalized relationship of the Cotton Research Institute with the farming community through the Commercial Cotton Growers Association. The Cotton Research Institute is accustomed to participating in farmers' training programs and conducting field days for farmers at the Institute-activities which are now arranged for communal-area farmers as well. This obviously facilitates the performance of applying a problem-solving client-oriented approach, promoting farmer participation, and adaptive research.

Third, the AGRITEX cotton specialist, who resides at the Cotton Research Institute, participates in research planning and programming activities and always consults with research staff there. The institute is also linked into the AGRITEX radio system, which facilitates coordination with field staff. The effective link between the Cotton Research Institute and AGRITEX also facilitates a problem orientation, a focus on clients' needs and priorities, and interdisciplinary research. It also helps explain why the institute has not given a high priority to characterization of farming systems and client groups.

Finally, the managerial aspects of the trial program, i.e., clustering of trial sites and farmer participation in trial operations, have facilitated the on-farm research process, especially in conducting effective adaptive research and building strong links with farmers and extensionists.

THE LOWVELD RESEARCH STATION

1. Supporting a Problem-solving, Client-oriented Approach within Research

Although the Lowveld Research Station focuses exclusively on crop research in an agroecological zone where in fact livestock production has an important role in the farming system, its program seems to place emphasis on key constraints for farmers in that area. Performance of the function of supporting a problem-solving approach with farmers as the primary clients is therefore assessed as good.

The staff have developed an on-farm research program testing water-harvesting techniques for maize and sorghum production, i.e. using ridges compared with flat land, the farmers' practice, as the experimental control. These are the main food crops, and maize is preferred by farmers, but AGRITEX discourages farmers from growing it because of high risks in that region. Because of the unsuitability of varieties and the problem of poor soils, researchers are testing varieties/hybrids of maize, sorghum, groundnuts, cotton, and sunflower on-farm, and are evaluating the yield effect of fertilizers on maize and sorghum.

Both farmers and extension agents consider that these trials will provide appropriate recommendations for solving some critical production problems. Farmers also highlighted other current problems, such as livestock diseases, shortage of grazing, and lack of implements. The latter was also confirmed by AGRITEX in its list of technologies needed for land preparation and landform construction. The on-farm research officers are also aware of these problems but, as agronomists, they are only exploring crop improvement opportunities. Therefore, the design of appropriate implements will be the next priority now that they know that specific landforms can stabilize yields considerably.

As agronomists, the Lowveld Research Station team basically uses technical criteria, plant growth, frequency of weeding, and yield. They also informally make use of farmers' interests and assessments; for example, some farmers are already adopting tied ridges, which is a clear indication of their acceptance. According to the Lowveld Research Station head, evaluation criteria were intentionally kept simple at an early stage. Now that they are sure the landform technology works, they will be looking at other aspects in detail; e.g., leaf moisture content, soil water content, and leaf area. Draft power implements will also be seriously considered from both a technical and economic perspective. Researchers argue that if they had considered all these aspects in the design phase, they probably would not have achieved anything.

Solving farmers' problems is a key objective of the Lowveld Research Station staff, according to its head because, unless the research officers learn to appreciate and solve farmers' problems, even their scientific articles would be weak. The on-farm research officers, who also carry out experiment station research, have a very positive appreciation of work with farmers: it helps to identify farmers' real problems and relevant research needs; it leads to easier adoption of research results; it frees more land for studies on the experiment station; and it provides job satisfaction. The only disadvantage mentioned is the lack of full control over trials conducted on-farm.

2. Contributing to the Application of an Interdisciplinary Systems Perspective

The Lowveld Research Station team is made up only of agronomists and horticulturists. Although there is good teamwork among on-farm research and experiment station research programs, there is limited interaction with other disciplinary researchers in DR&SS. The performance of the function of contributing to the application of an interdisciplinary systems perspective is assessed as moderate.

The on-farm research agronomists collaborate with cotton, maize, and sorghum breeders, but do not receive direct support from other disciplines or institutes. Furthermore, they do not analyze the economic and social implications and viability of technologies. However, research officers favor an interdisciplinary approach, since they perceive that economics and engineering could make valuable contributions at this stage of the research. Increasingly, the Lowveld Research Station will move towards interdisciplinary work as it becomes more confident of its technologies and training in the interdisciplinary systems approach will be desirable. Although they expressed interest in such training, one research officer said that he had never heard people talk positively of interdisciplinary work.

3. Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

At the Lowveld Research Station the function of characterizing major farming systems is based solely on soil types, since this is the key factor determining the specific technology being tested. Consequently, the performance of this function is assessed as weak. At present, the on-farm research leader thinks that they do not need any characterization studies to improve the efficiency of their crop-related program.

The team has not carried out any formal surveys, but they usually discuss problems informally with farmers and with AGRITEX staff. Farmers, however, were not involved in problem identification, which explains why the program was somewhat hypothetical. One on-farm research officer, however, comes from the lowveld area. The on-farm research leader argues that this researcher's indigenous knowledge has greatly facilitated both constraint diagnosis and design of the adaptive research program.

On-farm research staff of the Lowveld Research Station appear to understand farming conditions well and believe that their technologies would be difficult for the majority of farmers in the region to adopt; hence their approach of letting farmers decide for themselves. They believe that there is not much variation in farming practices because of restricting soil and climatic conditions, nor in farming objectives (all farmers have "crops for food and cash" and want "as many cattle as they can handle"). Since on-farm research officers also undertake experiment station research and there are frequent staff discussions at the Station regarding priorities and progress, researchers possess a good level of understanding of communal-area systems and practices, which was confirmed with the farmers interviewed.

The on-farm research staff have not used any socioeconomic criteria for problem definition. They contend that what is needed are "good" agronomists analyzing crop and climate data and liaising constantly with farmers to be aware of variations in practices and that this approach is much more effective for problem identification and technology testing than characterization studies. For example, farmers in this region do not follow AGRITEX recommendations on fertilizer and population levels because they are economically unattainable.

Collaborating farmers in the Lowveld Research Station program are selected with the assistance of AGRITEX, which usually means working with the better farmers or "master" farmers. For trials, farmers are selected from all over the area, but their farms must be accessible from the road.

4. Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

The Lowveld Research Station has a fairly ambitious trial program, but formal recommendations have not been made to date. The content of the program seems to be very relevant to farmers problems and therefore the performance of the function of adapting existing technologies and contributing to alternative technology development is assessed as good.

The research of the station includes all farmers in Natural Region V, in the southeast of Zimbabwe, who are growing crops under rainfall conditions. Research sites and farmers are selected accordingly, but since AGRITEX assists in this activity, the better farmers tend to be selected. The criterion of using accessible roadside farmers where possible does introduce another bias. Since all trials are well-controlled and researcher-managed, there is limited room for study of farmer/technology interaction.

There is evidence that the on-farm research program has evolved in response to the results of previous on-farm research. At first the team was thinking of introducing alternative crops which are being investigated on-station, but then they decided in favor of crops that farmers are currently growing (e.g., maize, sorghum, and groundnuts). Fertility trials were added in the 1985/86 season as the team gained more knowledge on soils from previous results. On sandy soils, the crop was being planted and fertilized in the

furrows of the ridges and flat-land treatments always did better. In the 1986/87 season, they added manure to the inorganic fertilizer to reduce the degree of fertilizer leaching and increase the soil water retention capacity. The results are already impressive.

From the literature reviews included in their reports, the Lowveld Research Station on-farm research team often refer to experiment station research results in Zimbabwe and elsewhere. For example, they seem to be well-informed on landforming techniques for dryland farming, citing references from other institutes, Australia, and the United States. From this review, it was clear that crop production in Natural Region V could not be raised or stabilized without first making a major change in approach to water conservation on every square meter of land and adjustment to crops and plant populations to meet the driest conditions expected. The Lowveld Research Station staff did not have much experience to draw upon. They had only worked with irrigated crop production before 1983, when experiment station and on-farm research on rainfed systems were initiated almost simultaneously.

No recommendations have yet been produced, but farmers expressed a great deal of interest in the on-farm research because it relates specifically to their own region and they are learning from the trial work. They have learned about planting early, the potential of groundnuts and sorghums, and the use of ridges to conserve soil moisture. As a result of the experimental program, half of the collaborating farmers are planting more sorghum and planting it earlier, and on-farm research officers claim that some farmers are already adopting ridges. Three out of the four farmers interviewed, however, thought that the research officers lacked practical farming experience.

5. Promoting Farmer Participation

Farmer involvement in on-farm research is not stressed. Farmers are primarily used as hosts for trials, although efforts are made to explain the trial program to them and to obtain feedback on problem confirmation and trial content. Thus, the performance of the function of promoting farmer participation is assessed as moderate. The researchers, however, are satisfied with the level of farmer participation at present.

According to on-farm research staff, farmers' principal contribution should be to problem identification. For this reason, the research officers have conducted an informal survey, arranged talks with farmer groups, and held AGRITEX-sponsored meetings and field days to define problem areas, explain trial objectives, and educate farmers and capture their interest. There are no researcher/farmer communication problems because researchers talk with farmers during regular farm visits, once or twice per month during the growing season. One research officer commented that through work with farmers he has learned that some farmers are competent, that they are very economic and cash oriented, and that they are aware of better crops and will allocate resources accordingly.

With respect to farmer participation, AGRITEX staff think that farmers are not technical and could do the "wrong things" in experiments. Farmers should only be a "labor pool", and only the better farmers should participate more actively. The on-farm research leader agrees that there is no point in working with the below-average farmers, since "they are there because they cannot get to Harare".

The farmers interviewed, on the other hand, said that researchers do explain trials to them and discuss objectives as well as seek their views and advice. Although these are master farmers, only half understand the trials in spite of having collaborated for more than three seasons. From the trial work, farmers have learned to grow better crops and knew more about soils which, in addition to the fringe benefits, motivates them to collaborate. Two farmers in 1984/85 even offered to host field days at their sites.

The on-farm research leader mentioned that they encouraged farmers to test on their own new crops available from experiment station research, such as cassava, pigeon peas, guar, leucaena, and improved castor beans. When trial land areas are prepared with tractors by research staff, farmers are asked if they want extra ridges. At first they did not, but now they do. The farmers interviewed in this study, however, indicated that they have not been encouraged to experiment.

Through on-farm research, there is increasing awareness that farmers are not adopting present AGRITEX recommendations of high plant population and fertilizer levels. Researchers have suggested that farmers are wise and that, given their climate conditions and risks, those recommendations are not optimal. On the other hand, one on-farm researcher thought farmers in research areas were "not applying fertilizer and manure due to ignorance".

6. Providing Feedback so that Experiment Station Research and On-farm Research Are a Coherent Program

All research officers and assistants are based at the Lowveld Research Station, and there is continuous interaction among those directly involved in both experiment station and on-farm research. Those who are involved only in experiment station research play a supportive role in on-farm research. The performance of the function of providing feedback to ensure a more coherent research program is assessed as good.

It is evident that on-station researchers view the on-farm research as credible and give it priority. Most researchers are involved directly or indirectly in research, both on-station and on-farm, in the sense that there is considerable interaction among officers through the regular annual planning and review meeting; joint research staff visits to on-farm research trials, field days for farmers and extension staff; and joint research staff visits to experiment station trials. Through these various mechanisms and informal discussions at tea breaks on-station, the on-farm research officers expressed a feeling of strong collaboration on problem identification, trial design, and reviewing results. The major responsibility for planning experiment station research and on-farm research rests with each research officer on the station.

Feedback from on-farm research to experiment station research has also been important, not so much in identifying new problems, but more in confirming and reinforcing existing priorities, such as the emphasis on maize, sorghum, and cotton, and the work on intercropping, low plant populations, and ox-driven equipment.

In the beginning, on-farm research was perceived as an extension of experiment station research. The technology for water-harvesting that is now being tested on farmers' fields was developed through research at the Lowveld Research Station, but primarily from elsewhere in Zimbabwe and Africa. Similarly, the germplasm material and fertilizer regimes that are being tried in the on-farm research program have been developed on-station. In addition, researchers who are not directly involved in on-farm research are supporting the on-farm research staff and are being continuously requested to make their contributions, as explained above. For this reason there is a high degree of complementarity in the type of trials and treatments in the on-farm research and experiment station research programs with respect to varietal, water-harvesting, and fertilizer trials on maize, sorghum, and groundnuts.

7. Promoting Collaboration with AGRITEX

AGRITEX is not fully aware of the on-farm research program and does not have much participation in the research process, other than discussing farmers' problems and selecting farmers as collaborators. Both on-farm research and AGRITEX staff, however, view extension as the primary mechanism for transmitting technical information to farmers and representing farmers' interests and problems. The performance of the function of promoting collaboration with AGRITEX is assessed as moderate.

AGRITEX staff have collaborated significantly only in farmer selection, trial implementation and monitoring, and informal evaluation of results. They are not very familiar with the content of the on-farm research program, other than to name the crops used. There is no direct contact with on-farm research staff, since research information comes through their senior officers. In the view of AGRITEX staff, on-farm research aims to demonstrate and recommend the best way to produce. They think, therefore, that linkages are important because extension workers know farmers' problems, they can help to implement recommendations, and extension will benefit from getting immediate advice from on-farm research. Probably because of this view, the on-farm research leader indicated that he would not want AGRITEX staff, especially field-level extension workers, to be too involved before there is something concrete to offer them. The impression given is that the techniques are so much at variance with what extension workers have been told to promote that they hesitate to comment at meetings with research staff.

On-farm research staff seek assistance from AGRITEX for various reasons. Extension inputs are useful because their knowledge of farmers' production and socioeconomic circumstances enables them to provide sound views on problem identification and on the economic viability and adoptability of technologies. Extension has taught them how to approach farmers, to talk to them at field days, and how

much collaboration to expect. The on-farm research staff are aware of present AGRITEX recommendations, particularly those relating to population and fertilizer levels, which they seriously challenge. They contend that extension workers have been "drilled" to promote only what is taught at training courses, even though farmers are not following such recommendations. They argue further that subject matter should recognize that the "centralized" technological packages do not work in Natural Region V.

There is an urgent need to develop courses for AGRITEX on an agroecological region basis to "de-program" extension staff, and the Lowveld Research Station could and should help with this. This is the justification for the Lowveld Research Station participating in field days and conducting joint visits with AGRITEX to on-farm research trials.

8. Synthesis of Assessment

The Lowveld Research Station on-farm research program has been quite successful in developing a problem-solving client-oriented research approach, conducting research to adapt technologies to local conditions, and in integrating on-farm and experiment station research. This good level of performance is due mainly to the following factors: 1) its focus on one agroecological region characterized by the overriding constraint of extremely low and erratic rainfall; 2) the indigenous knowledge of an on-farm researcher from the area, which has facilitated the process of setting research priorities and designing relevant trials; and 3) the incremental build-up of the on-farm research program. The program started small and kept trials simple until they started to produce useful results. The program has expanded as the research officers' experience and knowledge has developed.

There is an enthusiastic and good team spirit among staff, as indicated by the frequent informal discussions and meetings. This is facilitated by all research officers and research technicians being present on the station and also by the managerial attitude of the head of the station, who places high priority on the staff's professional and technical development, particularly in the problem-solving approach. There is good integration of on-farm and experiment station research.

All research officers participate in research planning and review meetings, and there are now field visits, both to experiment station and on-farm research sites every year, which strengthen linkages. Moreover, research officers working on-farm also have their own programs on the station. As the leader put it, if a research officer had only on-farm research, "he would be frustrated because of the frequent interference of external factors. Experiment station research keeps him sane and allows him to see the 'trees in the forest' and the trends." One staff member commented that the experiment station experience helps a research officer to "understand on-farm research results better, while concurrently identifying important problems."

The Lowveld Research Station does not employ the trial clustering technique nor does it post research staff to the field, practices potentially useful for the functions of promoting farmer participation and extension collaboration. The formal characterization of major farming systems has not been given priority, but this does not appear to have affected their adaptive research adversely. The lack of a strong interdisciplinary perspective may be explained by the geographical isolation of the Lowveld Research Station, and the lack of interest in Natural Region V by other DR&SS programs.

FARMING SYSTEMS RESEARCH UNIT

1. Supporting a Problem-solving, Client-oriented Approach Within Research

The program of the Farming Systems Research Unit includes crop and livestock trials aimed at solving critical problems of communal-area farmers. Thus, the performance of the function of supporting a problem-solving approach with farmers as the primary clients is assessed as very good.

The team of the Farming Systems Research Unit has a good understanding of farming systems, systems interactions, and constraints in the representative high- and low-potential areas in communal areas where the program is being implemented. In the high-potential area, for example, the main enterprises are maize and groundnuts, and key crop/livestock interactions are draft power, manure for crop production, and crop residues for livestock feed. In agreement with farmers interviewed, the team identified infertile soils, low land productivity, lack of draft power, shortage of financial resources, and shortages of labor and livestock feeds as the major constraints. In the low-potential area an additional key constraint is low and erratic rainfall, accounting for greater importance of small grains, in spite of farmers' preference for maize. Research has focused on alleviating the constraints imposed by low rainfall, low land productivity, and draft power shortages. The Farming Systems Research Unit used informal diagnostic surveys, involving experienced experiment station researchers, to identify constraints in the communal-area farming systems and to define key opportunities for research. To screen and evaluate appropriate technologies, the Farming Systems Research Unit uses statistical analysis (using technical performance indicators), economic analysis (mainly partial budgeting), and assessment by farmers (at household and community levels).

2. Contributing to the Application of an Interdisciplinary Systems Perspective

The Farming Systems Research Unit has a strong systems perspective, since its core team is composed of two crop agronomists, two livestock researchers, and an economist interacting in all phases of on-farm research planning, implementation, and evaluation. The Farming Systems Research team has also developed methodological procedures that promote informal but effective interactions with

senior scientists on experiment stations in DR&SS and from other institutions like the IARCs and the University of Zimbabwe. Thus the performance of the function of contributing to the application of an interdisciplinary systems perspective is assessed as very good.

With respect to interdisciplinary breadth, all members of the core team have been exposed to the research and analytical methods of other relevant or useful disciplines. For example, all technical scientists have been encouraged to participate in regional on-farm research courses and workshops to develop a capability on systems concepts, and diagnostic, experimental, and technology assessment methodologies. Further, the team leader is a senior livestock nutritionist with three years of experiment station research before joining the unit, and he has since participated in several on-farm research workshops. The senior agronomist has considerable experience of crop on-farm research dating back to 1981 and possesses a fairly good understanding and appreciation of socioeconomic analysis. The senior economist, the former team leader, has a good background in cropping and livestock production systems research. The younger members are being trained in on-farm research and farming systems research methodologies and in selected technical areas.

Within the Farming Systems Research Unit there is good interdisciplinary interaction in all phases of the research process. The team as a whole is responsible for planning the research program and analyzing its progress. Training for each research officer has been in line with his present technical capability, professional aspirations, and the interdisciplinary perspective required for effective teamwork.

The team of the Farming Systems Research Unit receives technical inputs from other institutes and disciplines in DR&SS and from other organizations. This is illustrated by the participation of experiment station scientists in the unit's research reviews, planning, and implementation. Outside DR&SS, the University of Zimbabwe collaborates with the Farming Systems Research Unit on economic studies and the IARCs on on-farm research methodologies and technological inputs.

The establishment of the Committee for On-Farm Research and Extension in 1986 has improved interdisciplinary research among on-farm researchers working on the same commodity. Such interactions should obviously lead to a better interdisciplinary perspective in DR&SS.

3. Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

The Farming Systems Research Unit systematically carries out informal and formal surveys and monitoring studies to identify and assess research opportunities in crop and livestock production systems. In doing so it has defined specific client groups that can be assisted by particular innovations. Given that the problems identified by farmers correspond closely to those being addressed by researchers, the performance of the function of characterizing major farming systems and client groups is assessed as very good.

Through diagnostic activities, each with specific objectives, the Farming Systems Research Unit has acquired a fairly good understanding of communal-area systems, with respect to the management of crop and livestock enterprises, interactions among components of the systems, and priority problems. For example, experience with these studies has led the team to define a number of client groups on the basis of key constraints and factors determining potential interventions. These include the use of reduced tillage for households with no or a limited number of draft animals, the use of cattle manure for crop production for cattle-owning households, improvement of crop residues for households with larger cattle herds, the introduction of early-maturing crops (e.g., sunflower) largely directed to the non-cattle-owning class, and the introduction of forage legumes on farms that have fallow land. It is noted that a particular innovation can affect different client groups in different ways, and such an analysis can be corroborated with formal studies, as in the case of the maize technology assessment survey.

It must be emphasized that all characterization studies are directly related to data requirements in the technology generation and assessment process. Their main objective is to improve ex ante and ex post evaluation of the technologies being tested. Another important objective is to discuss and share the diagnostic results with experiment station research scientists in the design of their own projects.

4. Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

During the last three seasons up to 1986/87, the Farming Systems Research Unit has had the largest number of on-farm research trials of any on-farm research program in DR&SS. Specializing in on-farm research, the unit is attempting to adapt specific technologies for grain crops, oilseed crops, forage, legumes, draft power, animal feeding, and goat production. Although no formal recommendations have been made, a number of promising innovations are at an advanced stage. Thus the performance of this function is assessed as good.

The clear definition of client groups ensures that each on-farm research trial is conducted with households having the required agroecological and socioeconomic characteristics; for example, type of soil (sandy and red), ownership of cattle or oxen (those farmers with two oxen and those with four), and farmers with or without fallow arable land. The identification of characteristics for defining target groups is derived from integrating analysis of diagnostic studies, experimental results, and farmers' assessment of technologies.

Over time, the choice and design of on-farm research trials are responding to the results of previous on-farm research. The program has expanded to include new crops (soyabeans, sunflower), new trials and treatments (use of cattle manures, inorganic fertilizers, draft implements for groundnut production, goat production, and cultivation of leucaena on red soils), and others have been dropped (soil moisture conservation, finger millet trials). Problems

detected through on-farm research trials have also led the research team to undertake more detailed monitoring studies (maize tillage depth, maize plant stand, groundnut production practices, crop utilization, and storage). Because of the strong crop/livestock feed interaction, the Farming Systems Research team is now evaluating the nutritive value (crude protein, digestibility, and mineral content) of the major crops and varieties under different input and management regimes tested in on-farm research crop trials.

Several promising recommendations for farmer client groups are emerging, but they have not yet been formalized. In the high-potential area, farmers are already adopting some crop production technologies proposed by the Farming Systems Research Unit. Farmers interviewed indicated that they are already adopting the recommended planting date and appropriate timing of fertilizer application, and reduced tillage plus herbicide use on maize This technology increases net cash income by 31% and returns to labor by 63% over the present conventional tillage plus hand weeding practice. Farmers claim that early fertilizer application at planting is definitely beneficial, that timely weeding keeps weeds from competing for fertilizers, and that well-managed smaller areas can yield higher production than poorly managed large areas. AGRITEX staff also believe that the technologies being investigated by the Farming Systems Research Unit are very relevant.

In the low-potential area, however, the story is different. Annual rainfall patterns are highly unreliable, and this has caused serious setbacks for the on-farm research program. Two out of three seasons are unfavorable for adequate crop growth. In the beginning, testing water-harvesting techniques, adapting drought-tolerant crops, and reducing fertilizer costs comprised the basic strategy. Water-harvesting techniques were dropped after the 1985/86 season due to poor results on sandy soils. Experiment station research on plant spacing and location, manure use to improve water-holding capacity and fertility, and design of appropriate implements for water-harvesting techniques are desperately needed, and this will be undertaken by the Lowveld Research Station and the Soil Productivity Research Laboratory. Other trials on the improved management of sorghum and pearl millet continue, but the reseachers have recorded poor and inconsistent responses to fertilizer due, to a large extent, to the poor seasons. It is evident that in lower-potential areas, the technical capability and the availability of appropriate technologies are extremely limited. The only good news in that area has been the successful introduction of leucaena around homesteads and vegetable gardens for livestock feed and the relatively rapid growth rates of goats under traditional management systems. The Farming Systems Research Unit should undoubtedly give more emphasis to livestock production as the key leverage component for improving farming systems performance in that area.

5. Promoting Farmer Participation

The Farming Systems Research Unit gives much importance to interacting with farmers in problem identification, screening of potential solutions, management of trials, and assessment of trial results. Thus the performance of the function of promoting farmer participation is assessed as very good.

Several methods are used by the Farming Systems Research Unit to involve farmers in research: 1) constraint analysis is done with farmers; 2) pre-planting demonstrations are done with AGRITEX for collaborating farmers; 3) farmers participate in the management of some trials; 4) special field days are held specifically for farmers; and 5) the collaborating farmers are awarded prizes for best trial management. These methods would not be possible without the competent field teams resident in the research areas and the help of AGRITEX staff.

Of the farmers interviewed, all indicated that they interact frequently with researchers and that they are very enthusiastic about collaborating with the Farming Systems Research Unit. However, few seemed to fully understand the trials, to have participated in organized meetings on their farm, or to have been asked by researchers for advice on the trials or to experiment on their own. AGRITEX staff supported the fact that farmers are often consulted, but suggested that farmers should be more involved in the management and operation of all farming systems research trials; i.e., all trials should be managed by farmers, and host farmers should be used more on field days. The problem for the Farming Systems Research Unit is that the state of farmers' technical knowledge on most aspects of the research program is not sufficiently advanced, and therefore research staff do not feel confident enough to develop fuller farmer participation in trial management.

The Farming Systems Research Unit has improved its understanding of why certain recommendations are not being widely adopted by communal-area farmers. Recommended fertilizer rates are probably too high for the risk and uncertainty factors they face; pen-fattening systems for beef production are not attractive due to the relative shortage of cattle and other more important roles of cattle in communal area systems; livestock grazing schemes are acceptable to communities if the fencing materials are provided, but farmers will not abide by stock control conditions; and intercropping is discouraged by AGRITEX, but farmers do consistently undersow cowpeas, squash, watermelons, and other minor crops to satisfy household diet requirements. These are examples of existing recommendations that Farming Systems Research Unit officers have discussed with AGRITEX staff to seek ways of defining new research and extension strategies.

6. Providing Feedback so that Experiment Station Research and On-Farm Research Are a Coherent Program

The close interaction between Farming Systems Research Unit staff and on-station researchers in other institutes, which was given priority by the DR&SS when the Unit was established, has resulted in a mutually beneficial collaboration. Thus performance of the function of providing feedback for a more coherent research program is assessed as good.

The Farming Systems Research Unit has collaborated with experiment station scientists in identifying critical areas or problems in the communal-area system which must be given top priority in research on

experiment stations. These are soil fertility management for cereal and legume crops under different tillage systems, intercropping systems which should be particularly suitable for low-potential areas, screening of annual and perennial forage legumes, upgrading of crop residues, and goat production.

The Unit was able to make a useful contribution to those new directions because the feedback linkage to experiment station research was designated as one of its two principal objectives. To achieve this objective, the strategy of the Unit was twofold: 1) to develop a competent team that could interact with and contribute to experiment station research programs; researchers with experiment station research experience were sought as a first choice, and if they were not available, researchers without such experience were trained quickly through readings, reviews, and courses; and 2) to involve experiment station scientists directly in key decisions in the farming systems research program from the initial phases. This strategy recognized that the Farming Systems Research Unit would make progress only if relevent technical information from experiment station research programs would be forthcoming; working alone they would progress slowly.

The second principal objective was to test and adapt technologies available from experiment stations. Since the Farming Systems Research Unit staff could not quickly review research literature, get access to the latest results which are not yet published, or acquire the expertise of the experiment station scientists, it adopted methodological procedures that promoted direct interaction with experienced on-station staff. These included: research review meetings, interactive field surveys with good farmers, formal planning meetings, joint projects, and joint authorship of papers. Five technical papers have so far been prepared with scientists working on-station.

These mechanisms have ensured consistent strong collaboration from experiment station research specialists on problem identification, screening of potential solutions, design and monitoring of trials, and analysis of trial results. The linkage has worked quite well, especially with livestock researchers, who realize that through collaboration they are making a real input to the development of communal areas; that they do not have to use their own scarce resources to implement the on-farm research; and that the Farming Systems Research Unit does all the "dirty" work. For them, participation in research activities of the Farming Systems Research Unit offers one of the few opportunities in DR&SS for experiment station scientists to exchange information and focus on real production problems across many disciplines.

One of the main reasons for the first major planning meeting of the Farming Systems Research Unit in 1984 was to identify areas in which complementary experiment station research was needed. Priority areas for experiment station research were defined for crop production (intercropping and cattle manure use) and for livestock production, (adaptability studies of fodder-tree and dual-purpose legumes, characterization of indigenous livestock, and small-stock studies). Some of these research projects were starting, and the groups' conclusions served to confirm these priorities.

Although collaboration with the Livestock and Pastures Division has been very successful, the Farming Systems Research Unit has had less success in providing feedback to those institutes or stations with their own on-farm research programs due to busy schedules, feelings of self-sufficiency, no synchronization of research areas, no incentives to coordinate, and/or differences in personal and professional interests.

7. Promoting Collaboration with AGRITEX

The Farming Systems Research Unit has emphasized the active participation of AGRITEX staff in the research program. Extension officers participate in diagnostic studies, problem identification, trial implementation, and evaluation of trial results. Thus, the performance of the function of promoting collaboration with extension workers is assessed as very good.

AGRITEX field staff, extension supervisors, and extension workers attend the yearly planning workshops in each research area and assist in pre-planting demonstrations and trial management. They also participate in soil-sampling of trial sites and the running of internal and external field days. Although the Farming Systems Research Unit staff favors AGRITEX involvement, there have been some problems resulting from the implicit bias in that AGRITEX staff prefer to work with local farmer leaders and more resourceful farmers. If the Farming Systems Research Unit selects other farmers, it becomes difficult to work with the local leaders.

The participation of staff from the Unit in AGRITEX activities has also been fairly good. Research staff are frequently invited to attend AGRITEX local and regional meetings, to address specific topics in them, and to participate in planning meetings at regional and provincial levels. AGRITEX regard the Farming Systems Research Unit as a source of relevant technologies for local conditions. In most on-farm research trials, AGRITEX recommendations are included as a treatment level. However, for low-potential areas the obvious lack of workable technologies from the Farming Systems Research Unit tends to weaken the strength of this linkage for AGRITEX.

Because of the very good interaction with AGRITEX and the appropriateness of the farming systems research approach for extension work, AGRITEX has redefined the roles of its agricultural extension officers and is planning to upgrade the technical capacities of subject-matter specialists, agricultural extension officers, and extension workers, in farming systems research methodologies.

8. Synthesis of Assessment

The Farming Systems Research Unit has achieved very good performance on all functions except adaptive research and feedback to experiment station research, in which a good level was achieved. The major reasons for this high level of performance are: first, the Farming Systems Research Unit was established explicitly to carry out most, if not all, the functions identified and has received the strong support of the directorate of DR&SS. Second, the technical strength

and central location of the Unit's core team allows good coordination and collaboration with experiment station scientists, thus ensuring a solid research input into its work. Even socioeconomic analysis done by the Unit has a strong contribution from technical scientists to ensure its relevance to the technological development objectives. Third, the permanent assignment of a well-trained and well-supported field team in each research area facilitates maximum interaction with AGRITEX field staff and farmers. Fourth, the methodological procedures, in particular pre-planting demonstrations, farmer participation in trial management, and award of prizes to collaborating farmers ensure a strong interest and input from farmers in the planning and evaluation phases. Fifth, the Farming Systems Research Unit has encouraged and assisted the on-farm research program of other institutes in DR&SS because their greater emphasis on applied research technically complements the Unit's work and enhances the range of potential production options for the Farming Systems Research Unit to test on-farm.

CHAPTER FIVE

COMPARATIVE FUNCTIONAL ANALYSIS

This chapter focuses on the key research policy, organizational and managerial factors affecting the on-farm research programs' performance of the seven research functions outlined in the previous chapter. The five case-study programs are compared and contrasted with respect to their performance of the functions and the key factors judged to determine that performance. The objective is to determine what organizational and managerial factors facilitate or impede the execution of the identified functions and the attainment of specific on-farm research objectives.

To supplement the study team's assessment, a survey was conducted among a stratified sample of 30 DR&SS staff. These included: five heads of the on-farm research case study programs, three directors, four heads of livestock research units, five heads of other institutes, eight research officers with direct on-farm research participation, and five research officers without on-farm research participation. They were requested to assess the actual importance of each function in DR&SS and its ideal importance; that is, the importance the function should have within the research system. A scale of 1 to 4 was used where: 1 is not important, 2 is moderately important, 3 is very important, and 4 is critical for on-farm research within DR&SS. The questionnaire is given in Annex 8, and the results are presented and briefly discussed under each function.

COMPARATIVE ANALYSIS OF PERFORMANCE OF FUNCTIONS IN THE FIVE PROGRAMS

Supporting a Problem-solving, Client-oriented Approach within Research

The experiences of the case-study programs demonstrate that each unit defines its on-farm research priorities and programs more in terms of its specialized technical area or the objectives perceived as essential to its research work, rather than in terms of the priorities and problems perceived by farmers.

The Crop Breeding Institute's performance is moderate because it only uses on-farm research to test germplasm under a wide range of agro-ecological conditions. This could be better done on well-protected experimental plots instead of farmers' fields. The Lowveld Research Station, also essentially a disciplinary institute (agronomy), achieved a good performance because working in only one natural region and having a good team spirit has facilitated consensus on priority problems and program formulation. However, the station is in a low-rainfall region where livestock is a major

component of the farming system; yet it has extremely limited facilities for dealing with farmers' livestock problems.

The Agronomy Institute's recent reorganization (provincial decentralization, clustering of trials, and strengthening collaborative linkages with AGRITEX) has improved its problem-solving approach remarkably. The development of a truly regional character for the institute's trial program will depend on the extent to which decentralization continues. At present the institute has one national program with minor modifications for each province.

Given present trial-program objectives and designs which require limited farmer participation in the case of the Crop Breeding Institute, the Lowveld Research Station, and the Agronomy Institute, there is no apparent reason for having most of their trials on farmers' plots, apart from not having access to experimental sites representative of their agro-ecological characteristics. However, this is not to say that their focus on solving the basic technical problems of farmers is not a high-priority objective, especially in low-potential areas.

The Cotton Research Institute performed this function well because it holds communal-area farmer and extension training at its headquarters, the AGRITEX specialist resides on the station and participates in research planning, and their on-farm research trials are researcher- and farmer-managed. Being a commodity-based program with considerable technical expertise, the Cotton Research Institute finds it fairly easy to define research programs, assess research progress, and organize training programs, all in line with the problems and priorities of cotton growers. The AGRITEX presence is definitely a contributory factor.

The problem-solving client-oriented approach is strong in the Farming Systems Research Unit because the team includes crop, livestock, and social scientists, follows methodological procedures to ensure a system- and farmer-focused analysis, and has intermediate-level staff outposted in the study areas, with responsibilities to liaise continuously with farmers. The broad scope of the research program (too many problems being addressed simultaneously), however, obviously indicates the need to prioritize and rationalize activities. The unit cannot adequately address all the important farmer priorities; consequently it must improve coordination with other DR&SS units and AGRITEX teams in order to expedite the technology development process.

Tables 44 and 45 present the results of the survey to assess the actual and ideal importance given to the function of supporting a problem-solving client-oriented approach, compared with the assessment of the study team. The study team rated the actual overall importance slightly higher than assessed by the heads of the five case study institutes. The heads indicated that the importance of the function should be somewhat higher than it is at the moment. The largest discrepancy between actual and ideal importance was in the head of the Crop Breeding Institute's assessment. He felt that much more importance should be given to this function.

Table 44: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Function of Supporting a Problem-solving Client-oriented Research Approach

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study team						
actual importance	2	3	3	3	4	3.0
On-farm research program heads						
actual importance	2	4	2	3	3	2.8
ideal importance	4	4	2	3	4	3.4

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 45: Assessment of the Importance of the Function of Supporting a Problem-solving Client-oriented Research Approach within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	3.0	3.7
Heads in Livestock Division	2.2	3.2
Heads in Crops and Services Division	2.4	3.2
Research officers with on-farm research activities	3.1	3.6
Research officers without on-farm research activities	3.0	3.6
Average	2.7	3.5

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

The directorate and research officers, with or without on-farm research involvement, have almost identical rankings for both actual and ideal importance. The other heads concurred with the five on-farm research program heads that ideally the function should be very important, but viewed its actual importance as lower than the on-farm research heads. The study team, like the directorate, assessed the actual importance of a problem-solving, client-oriented research approach within DR&SS as somewhat higher than did other staff surveyed.

Contributing to the Application of an Interdisciplinary Systems Perspective

The Crop Breeding Institute, the Agronomy Institute, and the Lowveld Research Station are all single-discipline research units. The Crop Breeding Institute's performance on the function of contributing to the application of an interdisciplinary systems perspective is weak because breeders see no real need for formal and continuous interaction with staff from other disciplines. Normally they are requested to make technical inputs into the research planning of other institutes, notably the Agronomy Institute and the Farming Systems Research Unit.

The Agronomy Institute recognizes the need for interdisciplinary coordination and therefore promotes, plans, and carries out informal consultations with staff in other institutes, joint technical seminars, and joint field days, to monitor trial performance and problems. It also spearheaded, together with the Farming Systems Research Unit, the formation of the Committee for On-Farm Research and Extension. The Agronomy Institute has the advantage of having its headquarters at head office in Harare, which facilitates interdisciplinary interactions with staff in other institutes and units located there.

The Lowveld Research Station, being rather isolated, does not have easy access to other units, even though staff claim that distance was not a serious constraint to communicating with staff in other sections. They do recognize, however, the need for a strong engineering and economic input at this stage of their program development and expressed interest in interdisciplinary training. There is a distinct impression among these three institutes that DR&SS does not encourage interdisciplinary research. Certainly the disciplinary structure of DR&SS does not help to broaden the reductionist and fragmentary approach in the work of these institutes.

The Cotton Research Institute has the advantage of being a commodity-based institute and possesses scientists in all major relevant disciplines. Its annual planning meetings and emphasis on cotton production recommendations are key factors determining good performance of this function. Socioeconomic analysis was defined by the Cotton Research Institute's on-farm research staff as an area needing attention and training.

The Farming Systems Research Unit's very good performance is due to the development of a strong team composed of staff from different disciplines who have worked together to develop an interdisciplinary research approach. Its members are about equally matched in

technical experience in their own specialized fields, and there is a clear definition of team responsibilities with respect to planning and analysis of research programs. Being located at head office and having a team as well trained and technically competent as other research units in DR&SS makes it easier for Farming Systems Research Unit staff to consult and collaborate with staff in other institutes. Training members in systems concepts and methodologies and the applications of research methodologies that promote interaction have been the main reasons for success. It should be emphasized, however, that interdisciplinary cooperation with staff outside of the unit depends strictly upon the good will and intentions of the other research staff, since there are no incentives or defined responsibilities for cooperation.

According to Tables 46 and 47, the overall assessment of actual importance given to the function of contributing to the application of an interdisciplinary systems perspective is similar for the study team and heads of the five on-farm research programs. The head of the Farming Systems Research Unit ranked it lower than the study team, and the Crop Breeding Institute head ranked it higher. The directorate ranks the actual importance higher than the other heads and research officers. All staff surveyed thought that the function should be very important, with the directorate giving the highest ranking. The livestock station heads gave the lowest scores for both actual and ideal importance of interdisciplinary systems research.

Table 46: Assessment by the Study Team and Heads of the Five On-Farm Research Programs of the Importance of the Function of Interdisciplinary Systems Research

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	1	3	3	2	4	2.6
On-farm research program heads						
actual importance	2	3	4	2	3	2.8
ideal importance	2	4	4	3	4	3.4

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 47: Assessment of the Importance of the Function of Interdisciplinary System Research within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	2.7	3.7
Heads in Livestock Division	2.0	2.7
Heads in Crops and Services Division	2.2	3.2
Research officers with on-farm research activities	2.2	3.5
Research officers without on-farm research activities	2.2	3.0
Average	2.3	3.2

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Characterizing Major Farming Systems and Client Groups and Identifying Key Constraints

The Crop Breeding Institute's performance of the function of characterizing major farming systems and client groups is weak because not much importance is attributed to it. They firmly believe that all farmers within a given natural region have essentially the same problems insofar as varietal development is concerned.

The Agronomy Institute's moderate performance is considered satisfactory at present, because it is still drawing on its previous farming systems research and some specific technical surveys. Since linkages with the Farming Systems Research Unit and AGRITEX are being strengthened through the Committee for On-farm Research and Extension, the Agronomy Institute sees no need to develop any particular capability in characterization, since it would have to be done at the expense of technology generation.

The Cotton Research Institute would rather depend on AGRITEX to fulfill this function. Its highly experienced on-station staff have been effective in identifying the major constraints which were confirmed by a very successful farmer survey on pest management problems.

The Lowveld Research Station does not attribute much importance to formal characterization efforts either, but their moderate performance was achieved through informal discussions with farmers, observations in the field, and indigenous knowledge of the area by its research staff.

The Farming Systems Research Unit, given its mandate, gives high priority to characterization studies, employing a combination of data collection methods for specific technology generation and evaluation questions as they arise in the research process. Of the five on-farm research programs, only the Farming Systems Research Unit has the technical expertise for system characterization as a means to identify research domains and production constraints and to assess technological impacts at the farm level. Characterization activities - in particular monitoring studies - can be expensive, however, in use of staff and logistic resources. This is another reason for improving coordination with AGRITEX.

Tables 48 and 49 show that the case-study team's assessment of the actual importance of characterization with DR&SS is lower than that of the on-farm research program heads. In particular, the heads of the Crop Breeding Institute and the Lowveld Research Station viewed the importance of this function in their institutes as higher than did the study team. The Farming Systems Research Unit head gives a lower level of actual importance than the team's assessment. Among others in DR&SS, actual importance is ranked much higher, especially by the directorate. The heads in the Livestock Division give the function the lowest ranking in actual importance.

There is considerable variation among groups of staff about the importance that characterization should ideally have with DR&SS. The directorate and the heads in the Crops and Services Divisions agree that this function is essential. The heads of livestock stations and research officers not working on-farm give the function the lowest ranking for ideal importance and agree that the appropriate level of importance has been achieved. This response is probably related to their view that research problems in their natural regions or farming systems are already fairly well defined and do not require further farm-level research.

Table 48: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Function of Characterizing Farming Systems and Client Groups

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	1	2	2	1	4	2.0
On-farm research program heads						
actual importance	2	2	2	3	3	2.4
ideal importance	3	4	2	3	4	3.2

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 49: Assessment of the Importance of the Function of Characterizing Farming Systems and Client Groups within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	3.3	3.7
Heads in Livestock Division	2.0	2.0
Heads in Crops and Services Division	2.3	4.0
Research officers with on-farm research activities	2.7	3.2
Research officers without on-farm research activities	2.8	2.4
Average	2.6	3.1

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Adapting Existing Technologies and Contributing to the Development of Alternative Technologies

The on-farm research trial program for the Crop Breeding Institute provides the opportunity for multi-location testing to complement their experiment station research work and to demonstrate to farmers "good" technologies under optimal management and input levels. For the Agronomy Institute, this function could have been more efficiently performed had it not been for the research staff's initial lack of experience, the requirement for more applied instead of adaptive research, and the rapid build-up on-farm research. The Cotton Research Institute has made good progress on the development of the pegboard and soil moisture conservation techniques. The Lowveld Research Station has considered the constraints to the adoption of moisture conservation techniques but decided to proceed with research on them and has made good progress. However, farmers cannot apply them unless the engineering problem of lack of appropriate implements is solved.

The Farming Systems Research Unit has made good progress with some technologies, mainly because it has drawn heavily from experiment station research and other on-farm research programs in DR&SS or other institutions, including the IARCs. However, the experiment station research units do not have ready-made technologies to test with farmers in low-potential areas. The Farming Systems Research Unit has recently started to emphasize the use of indigenous knowledge of farmers to advance its research programs.

It is important to note that in DR&SS most on-farm research programs started with a strong focus on adaptive research but have gradually shifted to emphasize more applied research; that is to generate appropriate technologies to solve the basic problems of farmers in the communal areas. This is not possible without on-farm research. There is no doubt that if there were more technologies "on the shelf", or if these on-farm research programs were to be successful in generating technological options, then the adaptive function would be quickly absorbed, particularly by the Farming Systems Research Unit and AGRITEX, because of strong political pressures to provide immediate technological answers to communal-area production problems.

In fact, no formal recommendations have been made by any of the on-farm research teams. There are several reasons for this slow progress. First, the research programs have a disciplinary and fragmented approach. For example, if the Lowveld Research Station had had the capability and had started to test appropriate equipment as soon as it obtained promising results from water-harvesting techniques, it is probable that by now (end of 1987), three years later, a viable recommendation for farmers would be available. The same criticism can be leveled at the Crop Breeding Institute. At the advanced testing stage, promising varieties or hybrids should be assessed under different dates of planting, population, fertility, and insect or pest control; also, crop outputs should be measured in terms of the key functions the crop plays in the communal-area systems. In other words, a cropping-system approach would be more appropriate, and the Crop Breeding Institute, the Agronomy Institute, and the Farming Systems Research Unit would have to work together.

Second, the on-farm research units do not give enough importance to clearly defined recommendations for farmers. If they did, on-farm research prioritizing and programming across institutes and integration of results would be facilitated.

Third, DR&SS's capability on rainfed crop systems in Natural Regions III, IV and V is not up to the standard necessary for contributing effectively to communal-area development, and its capability on rainfed livestock production has yet to be tested. Most senior research officers would not agree with this assessment, arguing that technologies are available but that communal-area farmers must change their attitudes and motivation, and that infrastructure or service constraints must be resolved.

Fourth, although on-farm research units incur high costs when working in rural areas, they are not capitalizing on the indigenous knowledge of AGRITEX and farmers for assessing the relevance and viability of proposed experimental treatments. Some degree of ex ante or technology screening analysis with both client groups would definitely improve the efficiency with which technology recommendations are developed.

Fifth, it has taken time to gain experience in managing on-farm research. Most units have now outposted research assistants to their research areas to improve trial management and supervision, except for the Lowveld Research Station, which intends to do so as soon as they obtain mobile huts.

Tables 50 and 51 show that the study team's overall assessment of actual importance of the function of adapting existing technologies and contributing to the development of alternative technologies is lower than the ranking by the on-farm research heads but higher than that of others in DR&SS. The directorate agrees with the study team's assessment that adaptive research has been important in the on-farm research programs. Again, the heads of livestock stations gave the actual importance of this function the lowest ranking. On ideal importance, there was general agreement that this function should be more important within DR&SS than it actually is. The study team and directorate thought this function should be critical. Scientists not involved in on-farm research, however, saw it only as very important in the future. These respondents were probably thinking of on-farm research benefitting all farmers, instead of specific "target groups".

Table 51: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Function of Adaptive Research

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	3	3	3	3	3	3.0
On-farm research program heads						
actual importance	2	4	4	3	3	3.2
ideal importance	3	4	3	4	4	3.6

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 51: Assessment of the Importance of the Function of Adaptive Research within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	3.0	4.0
Heads in Livestock Division	2.0	3.5
Heads in Crops and Services Division	2.6	3.4
Research officers with on-farm research activities	2.9	3.5
Research officers without on-farm research activities	2.8	3.0
Average	2.7	3.5

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Promoting Farmer Participation

The moderate level of the Crop Breeding Institute's performance on the function of promoting farmer participation was achieved mainly because field days are usually conducted to obtain some feedback from farmers on germplasm assessment. Research officers, however, readily admit that farmers' participation is not necessary. The Agronomy Institute's weak performance is more a case of not wanting farmers to participate directly in the trial program, but research staff are expected to liaise closely with farmers and AGRITEX staff in the research clusters to improve the identification of priority problems and evaluation of technologies.

The Cotton Research Institute's entomology program performance was good because farmers participate in trial management, assist in technology assessment, and even keep research records, whereas the breeding and agronomy programs do not achieve farmer participation in these phases. The Lowveld Research Station believe farmers can contribute well only in problem identification and technology assessment. Farmers' input is gained primarily through informal discussions with research staff.

The Farming Systems Research Unit's good performance in promoting farmer participation is due to its strong farmer-based approach: informal and formal surveys, monitoring studies, use of farmer-managed trials, farmer training and pre-planting demonstrations, decentralization of field teams, and the use of internal field days where host farmers are the main speakers. The awarding of prizes by the Farming Systems Research Unit and AGRITEX to farmer groups for good trial management promotes tremendous farmer interest in the trial program throughout the cultivation period.

Trial-clustering definitely increases farmer participation and education, mainly because research staff have more time to concentrate on farmer collaborators and on their neighboring households. This is clearly the case with the Cotton Research Institute and the Farming Systems Research Unit. Working with farmer groups, such as group development areas, can greatly enhance farmer participation. However, there is a risk of limiting research attention to a small group instead of a larger audience, and of sacrificing agroecological diversity.

On-farm research teams currently work mainly with better farmers; these are the ones AGRITEX can easily reach due to the very unfavorable farmer/extension worker ratio (800 to 1). Even so, on-farm research teams do not take advantage of the opportunity to exploit the indigenous knowledge and managerial inputs of these progressive farmers. Apart from providing land and protecting trial sites, the collaborating farmers of the Crop Breeding Institute, the Agronomy Institute, and the Lowveld Research Station do not contribute much to the trial program. Given the high cost of travel and supervision, there is no reason why much of this type of on-farm research could not be done more efficiently on "satellite" experiment stations. Farmer field days could then be arranged to obtain feedback.

Another problem is that farmer interaction becomes limited if research staff are too distant from the research areas, as in the case of the Crop Breeding Institute and the Lowveld Research Station. It would be logical to put a limit on the maximum distance research staff should travel to carry out regular on-farm research duties. Three- and four-hour trips for specific trial management activities are definitively expensive and physically demanding, and they allow very little time for productive interaction with farmers.

Tables 53 and 54 show that both the on-farm research heads and the case-study team viewed this function as being moderately important now within DR&SS. All the heads of on-farm research programs, except the leader of the Farming Systems Research Unit, indicated that farmer participation was now being given the appropriate level of importance.

The surveyed staff thought promotion of farmer participation should be very important except, surprisingly, the heads of livestock stations, who thought it should be rated critical. Their lack of on-farm research experience cannot account for this response, since other research officers not working in on-farm research gave it a much lower ranking. Overall, farmer participation is not given highest priority, either in terms of its actual importance in DR&SS or its desired importance.

Table 52: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Function of Promoting Farmer Participation

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	2	1	3	2	4	2.4
On-farm research program heads						
actual importance	2	2	3	3	2	2.4
ideal importance	2	2	3	3	4	2.8

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 53: Assessment of the Importance of the Function of Promoting Farmer Participation within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	3.0	3.3
Heads in Livestock Division	2.0	3.7
Heads in Crops and Services Division	2.6	2.6
Research officers with on-farm research activities	2.5	3.1
Research officers without on-farm research activities	2.2	2.8
Average	2.5	3.0

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Providing Feedback so that Experiment Station Research and On-Farm Research Are a Coherent Program

For the Crop Breeding Institute, on-farm research is basically an extension of experiment station research. Since breeders have indicated that they cannot do both efficiently, experiment station research clearly has priority. Information from on-farm research does not contribute substantially to setting priorities and agendas for experiment station research.

Within the Agronomy Institute, the integration of experiment station research and on-farm research is strong because each research officer is responsible for both and must present his/her proposals for both types of research at the same time. In other units, research officers use technical seminars and individual consultations to develop this linkage. In the Cotton Research Institute the linkage between experiment station and on-farm research is strong because there is substantial on-station research experience, and cotton is a rapidly expanding enterprise in communal areas. In this Institute, research officers are responsible for on-station research and on-farm research, and there are continuous opportunities for interaction.

At the Lowveld Research Station, the performance of this function is good because the same research officers do on-station and on-farm research, there are annual planning and review meetings, joint field visits are made to on-station and on-farm research sites, and there is continuous informal interaction, because all research staff reside on-station.

Even though the Farming Systems Research Unit does not have an on-station research component, it has managed to achieve a good performance through the direct involvement of station-based commodity and disciplinary specialists in on-farm research diagnosis, trial planning and analysis, joint preparation of new experiment research proposals, and co-authorship of technical papers. Respect for the technical and research competence of the Farming Systems Research Unit has been a necessary condition for development of this strong two-way flow of information. This linkage has been most successful with the livestock stations which do not have on-farm research programs.

The case-study team's assessment, together with the survey results on the actual and ideal importance of the feedback function, is presented in Tables 54 and 55. Both the case-study team and the heads of the on-farm research program assessed the feedback function of on-farm research as being very important.

However, the heads of on-farm research programs' assessment of the function's ideal importance was lower than that of the directorate and heads of other programs, including those of the livestock stations, who gave it the highest importance. Perhaps the on-farm research heads' response is shaped by the current availability of on-station technologies which are ready for transfer, as in the case of the Cotton Research Institute. As the experiences of the

Table 54: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Feedback Function

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	2	3	3	3	3	2.8
On-farm research program heads						
actual importance	3	3	2	3	3	2.8
ideal importance	3	3	2	3	4	3.0

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Table 55: Assessment of the Importance of the Feedback Function within DR&SS by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	2.3	4.0
Heads in Livestock Division	2.0	3.7
Heads in Crops and Services Division	2.8	3.8
Research officers with on-farm research activities	2.5	2.9
Research officers without on-farm research activities	3.0	3.2
Average	2.5	3.5

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Agronomy Institute and Farming Systems Research Unit clearly indicate, however, this assumption has to be tested, especially in relation to the feasibility of farmers adopting such techniques in the communal areas. It is interesting to note that senior research managers of stations and institutes without major on-farm research efforts gave the ideal importance of this function higher scores than did researchers, perhaps because they are the principal clients of such information.

Promoting Collaboration with AGRITEX and Development Agencies

No on-farm research program has formal collaboration with any development agencies. Research officers in DR&SS are consulted regularly by public and private development agencies and are expected to assist as part of their normal responsibilities, but this would not apply any more to research officers working on-farm than to other research officers in DR&SS.

Both the Crop Breeding Institute and the Lowveld Research Station see AGRITEX as the necessary link to farmers but believe that AGRITEX is not technically competent. They involve AGRITEX, where feasible, in the research program. The Agronomy Institute recognizes AGRITEX's weakness, and its recent organizational and management changes (organization of trials by province and cluster, workshops for AGRITEX on trial management, and participation in provincial AGRITEX meetings) are expected to improve collaboration with AGRITEX. One important advantage of the Agronomy Institute is that the Crop Production Units located at the various research stations can be an effective mechanism for collaboration - the Makoholi Crop Production Unit-Masvingo AGRITEX collaborations are a good example.

At the Cotton Research Institute the main factors determining good performance are that the AGRITEX cotton specialist is on the station and participates in the research program and training activities at the institute, that research staff help AGRITEX with communal-area farmer training, and that the institute is linked with AGRITEX through its national radio system.

The Farming Systems Research Unit's very good performance can be attributed to three major factors:

1) the decentralized, outposted small field teams can interact with AGRITEX field staff on a daily basis;

2) the annual workshops held with regional AGRITEX staff to review and plan research and to define a calender of joint responsibilities;

3) the participation of staff from the Farming Systems Research Unit in AGRITEX meetings and activities.

There are two major drawbacks of this close association, however:

1) researchers can be seen by farmers as competing with AGRITEX;

2) where no appropriate technologies are readily available, as in the case of the low-potential areas, AGRITEX tends to lose interest in, and reduce support for, the trial program.

Given the experience of the Agronomy Institute, the Cotton Research Institute, and the Farming Systems Research Unit, and the present less-than-desired capability of AGRITEX staff, it seems imperative that on-farm research teams must coordinate their work well with AGRITEX and use on-farm research trials as a mechanism for training them. Several mutual benefits are to be realized. AGRITEX will learn about trial objectives and designs, will be current with the latest research results, and will gain confidence and experience in the management of new technologies. In turn, if AGRITEX becomes more competent it would know the areas, farmers, and problems better; be able to implement and manage trials as well as research staff; and be able to monitor and assess the performance of proposed technologies, thereby providing an effective feedback to on-farm research programs. AGRITEX's contribution could, in the long run, substantially improve the technical and economic efficiency of the on-farm research programs, even with respect to the planning, management, and evaluation of the researcher-managed trials. A greater involvement of AGRITEX staff at all levels in characterization and adaptive research activities is strongly supported by the provincial officers and the directorate of AGRITEX.

Tables 56 and 57 show that there was a strong consensus between the case study team and the other staff surveyed on the level of importance actually given to promoting collaboration with extension. The heads of the five on-farm research programs, however, assessed its importance as somewhat lower. There was a general view that ideally this function should be more important than it is now, although it was not regarded as one of the most important functions for on-farm research in DR&SS. As would be expected, the heads of the on-farm programs of the Agronomy Institute and the Farming Systems Research Unit thought that collaboration with extension should be a critical role for on-farm research. With respect to ideal importance, on-farm research heads, as a group, attributed a slightly higher score than all others but similar to the ranking of the directorate. Overall it appears that the function of on-farm research promoting collaboration with AGRITEX is not given a high priority in DR&SS.

Table 56: Assessment by the Study Team and Heads of the Five On-farm Research Programs of the Importance of the Function of Promoting Collaboration with AGRITEX

Programs	CBI	AI	CRI	LRS	FSRU	Average
Assessment						
Study teams						
actual importance	2	3	3	2	4	2.8
On-farm research program heads						
actual importance	1	4	2	2	3	2.4
ideal importance	3	4	3	3	4	3.4

Notes: CBI = Crop Breeding Institute; AI = Agronomy Institute; CRI = Cotton Research Institute; LRS = Lowveld Research Station; FSRU = Farming Systems Research Unit.

1 = not important; 2 = moderately important; 3 = very important; 4 = critical

Table 57: Assessment of the Importance of the Function of Promoting Collaboration with AGRITEX by Different Categories of Staff

Assessment	Actual Importance	Ideal Importance
Staff Category		
Directorate	2.7	3.3
Heads in Livestock Division	2.3	2.7
Heads in Crops and Services Division	2.6	3.8
Research officers with on-farm research activities	2.9	3.2
Research officers without on-farm research activities	3.0	3.0
Average	2.7	3.2

Note: 1 = not important; 2 = moderately important; 3 = very important; 4 = critical.

Overview of the Importance Gap

The survey results and interviews indicate that staff view adaptive research, support of a problem-solving client-oriented research approach, and feedback to experiment station research as currently the most important roles for on-farm research in DR&SS. In contrast, characterization of farming systems and client groups and promotion of farmer participation are viewed to have been the roles given the least importance. This is not surprising, since technology generation and adaptation for the communal areas have been the on-farm research programs priority objectives.

Assessment of desired importance of the functions indicate that research managers and staff will continue to give these objectives priority. The three functions they ranked the highest in terms of ideal importance were: support of a problem-solving client-oriented approach within research, adapting existing technologies or contributing to the development of alternative technologies, and feedback to experiment station research.

The importance gap -- the gap between the actual level of importance and the desired level of importance to be given to the respective functions -- can be assessed by comparing the study team's assessment of the actual importance of the function with the level of importance desired for the functions by the directorate as well as by other research managers and staff (Table 58).

Table 58: Comparison of Actual Performance of the Functions as Assessed by the Study Team and Their Ideal Importance as Assessed by the Directorate and other Research Staff

Functions	Actual Performance Study Team	Ideal Importance		Difference between Actual and Ideal Performance	
		Directorate	Others	Directorate	Others
Problem-solving approach	3.0	3.7	3.5	0.7	0.5
Interdisciplinarity	2.6	3.7	3.2	1.1	0.6
Characterization	2.0	3.7	3.1	1.7	1.1
Technology generation/ adaptation	3.0	4.0	3.5	1.0	0.5
Farmer participation	2.4	3.3	3.0	0.9	0.6
Experiment station and on-farm research integration	2.8	4.0	3.5	1.2	0.7
Collaboration with AGRITEX	2.8	3.3	3.2	0.5	0.4

The greatest gap occurred with the directorate's assessment of the desired level of importance of three on-farm research functions: characterization of farming systems and client groups, feedback to experiment station research, and the application of an interdisciplinary systems perspective in research. The results were similar when comparing with the staff's assessment of the desired importance of the respective functions, except that the gap between actual and desired importance was not as great.

POLICY, ORGANIZATIONAL, AND MANAGERIAL FACTORS DETERMINING THE PERFORMANCE OF ON-FARM RESEARCH FUNCTIONS

The case-study team has compiled a list of the key policy, organizational, and managerial factors and qualitatively assessed the specific contribution that each has made to the actual performance of each on-farm research function on the basis of comparative analysis across the five case-study on-farm research programs.

Policy Factors

It is essential to recognize two predominant factors influencing the way on-farm research has been integrated into DR&SS. First, the expansion of on-farm research in DR&SS reflects the strong political commitment and support of senior managers in DR&SS. Second, although on-farm research initially received external donor assistance, particularly from the World Bank/IFAD project, the impetus has subsequently been maintained with minimal donor support, except in the case of the Farming Systems Research Unit, which has continued to receive substantial donor support from the International Development Research Centre. These two policy factors have helped the on-farm research programs to achieve their identified objectives.

However, as presented in Table 59, four other policy factors have facilitated the performance of various on-farm research functions. The availability of operational resources in DR&SS for on-farm research and the priority given to communal-area research have been the main facilitating factors. Another is the clear acceptance of responsibility for adaptive research by some units. In other units, flexibility has permitted their on-farm research programs to concentrate on more applied research where the state of technical knowledge was not adequate to address the critical production problems identified.

Organizational Factors

Table 59 shows that the major organizational factors in terms of the significance of their contribution and the number of functions they affect, are:

- research experience of the on-farm research officers;
- the Committee for On-farm Research and Extension;
- multidisciplinary teams;
- the location of on-farm research officers on station;
- the high quality of experiment station expertise;
- good research leadership.

Table 59: Qualitative Assessment of the Contribution of Key Policy and Organizational Factors to the Performance of Each On-farm Research Function

Function	Problem-solving orientation	Interdisciplinary systems research	Characterization	Technology generation/ adaptation	Farmer participation	On-farm/ on-station research integration	On-farm research/ AGRITEX linkage
Policy							
Research priority on communal-area sector	3	1	2	3	1	2	3
Rewards for staff interaction	1	3	2	2	0	3	1
Adequate operational resources	1	3	1	2	0	3	1
Responsibility for adaptive research clearly defined	1	3	2	1/3*	3	2	2
Organizational							
Disciplinary structure of DR&SS	0	N	N	3/1*	0	0	N
Committee for On-Farm Research and Extension (COFRE)	2	3	3	1	0	2	3
Regional mandate	2	2	1	2	1	0	2
Commodity mandate	2	2	1	2	1	0	2
Experience of research officers working on farm	3	3	3	3	0	3	2
Multidisciplinary team	3	3	3	2	1	0	2
Good research leadership	2	3	2	3	0	2	0
On-farm researchers based at experiment stations	3	3	2	3	–	3	0
Centralized and small size of institutes	2	3	1	2	0	3	1
High quality of research expertise on-station	2	2	1	3	1	2	2

Notes: 1) N = negative, 0 = neutral, 1 = weak, 2 = moderate, 3 = strong contribution.
* First is for technology generation, second is for adaptive research.

Only a few organizational factors, such as the commodity mandate and multidisciplinary teams, have had any effect on farmer participation. The disciplinary structure makes a large positive contribution to technology generation - an important objective of present on-farm research programs - but somewhat impedes interdisciplinary research and characterization.

Managerial Factors

The relevant managerial factors are many because of the wide diversity of methodological procedures employed by the on-farm research programs (Table 60). The case-study team considers that the following have been the major facilitating factors:

- emphasis given to the formulation of recommendations for communal-area farmers;
- scientists' exposure to interdisciplinary research;
- involvement of experiment station scientists in diagnostic field activities;
- internal field days and awards to farmers.

The least important contributory factors have been:

- joint authorship of articles;
- relations with AGRITEX provincial staff;
- the participation of economists.

This is primarily due to the limited experience on-farm research programs have had with these managerial practices. The rapid growth of on-farm research programs adversely affects the performance of all functions, except farmer participation, because a larger program necessitates more assistance from farmers. However, in the long run, a larger program will reduce researcher/farmer interaction and strengthen the extension linkage.

The utility of the preceding analysis does not lie in the overall importance of each factor with respect to all on-farm research functions as a whole, but rather in the size of the contribution of each factor with respect to specific functions. For example, if staff of an on-farm research program in DR&SS realize that a specific function (e.g., farmer participation) is being performed less well than desired, then a number of alternative options could be considered in order to improve its performance.

The analysis indicates that the interventions most likely to strengthen farmer participation are: clustering of trials, the use of farmer-managed trials, internal field days and awards for farmers, relations with AGRITEX district staff, and emphasis on farmer recommendations. The logistics and cost-effectiveness of these options, or preferably a combination of them, should be used as the decision criteria. What is certain is that previous experience of the five on-farm research programs in the case study has shown that all these options are technically feasible and effective for on-farm research functions in the political, institutional, and production environment within which DR&SS operates, and therefore their relevance to any institute or station in DR&SS with an established or new on-farm research activity is unquestionable.

Table 60: Qualitative Assessment of the Contribution of Key Managerial Factors to the Performance of Each On-farm Research Function

Function	Problem-solving orientation	Interdisciplinary systems research	Characterization	Technology generation adaptation	Farmer participation	On-farm/ on-station research integration	On-farm research/ AGRITEX linkage
Interdisciplinary exposure of staff	2*	3	2	3	1	2	1
Informal staff interaction	1	3	2	2	0	2	0
Sharing credit (i.e., joint authorship)	0	3	2	2	0	2	0
Multidisciplinary team planning	2	3	3	3	1	2	C
Participation of economist	3	2	3	1	1	0	2
AGRITEX participation in planning	3	0	2	2	1	0	3
Research officers sharing on-station and on-farm research duties	3	1	2	3	0	3	N
Outposting of field teams	2	0	2	3	2	0	3
Diagnosis: inputs and utility to on-station research	3	3	3	2	0	3	0
Desire of on-station research scientists to have "impact"	2	3	2	2	0	2	1
Trial proposals with justification	3	2	2	3	0	1	2
Clustering of trials	1	0	3	3	3	0	3
Farmer-managed trials	3	1	2	3	3	1	3
Review of trial results by commodity	1	3	1	3	0	2	1
Internal field days or awards for farmers	2	2	1	2	3	1	3
Joint DR&SS/AGRITEX visits of on-station and on-farm research sites	2	2	1	2	0	3	3
Research officers' duty to train farmers	2	0	2	2	2	1	3
Relation to AGRITEX provincial staff	2	0	1	1	1	0	2
Relation to AGRITEX district staff	2	0	2	0	3	0	3
Emphasis on recommendations for farmers	3	3	3	3	3	0	3
Rapid build-up of on-farm research	N	N	N	N	2	N	2

* N = negative, 0 = neutral, 1 = weak, 2 = moderate, 3 = strong contribution.

** 3 on adaptive research and N on Technology generation.

*** 2 in the short run and N in the long run.

ANNEX 1

ON-FARM RESEARCH PROGRAM OF THE CROP BREEDING INSTITUTE, 1982-1987

Research Areas in Which the Crop Breeding Institute was/is Active

	Travel time from headquarters (hours)	1982/83	1983/84	1984/85	1985/86	1986/87
Natural Region II						
Chirau	1.2		x	x	x	x
Guruve	1.0		x	x		
Madziva	1.2	x				
Mukwichi	2.0				x	x
Mhondoro	1.0		x	x	x	x
Murewa	1.0				x	x
Sosve	1.2					x
Zwimba	1.0	x	x	x	x	x
Natural Region III						
Bikita	4.0	x				
Chilimanzi North	2.2			x	x	x
Chivhu	2.0		x	x	x	x
Hurungwe	2.5		x	x	x	x
Makoni	1.5			x		
Manyene	2.0		x		x	x
Msasa	2.0			x	x	
Mt. Darwin (Chiwanda)	1.0			x	x	x
Mukwichi	2.0		x	x	x	x
Mutoko	2.0	x	x	x	x	x
Nharira	2.0		x	x	x	x
Nyanga	2.5				x	x
Range	2.0			x		
Wedza	2.0	x	x	x	x	x
Natural Region IV						
Chilimanzi South	2.5			x	x	x
Esigodini	5.0			x		x
Gutu	3.5	x		x		x
Maramba	1.5					x
Marange	3.0					x
Masvingo	3.0				x	x
Mudzi	2.5	x	x	x	x	x
Mukumbara	3.0	x	x	x		
Muzarabani	2.5				x	x
Ntabazinduna	4.5			x		
Nyati	4.5					x
Total	-	8	13	21	20	24

Identification of Trials per Season

Title	Entries	Number of sites	Research Officer Responsible
1982/83 season			
Groundnut: short season varieties	4	4	A. Chiteka
Sorghum		8	J. Mushonga
Pearlmillet	10	8	V. Gwarazimba
1983/84 season			
Maize	19	6	R. Olver
Groundnuts	10	6	A. Chiteka
Sorghum		8	J. Mushonga
Pearlmillet	10	8	V. Gwarazimba
1984/85 season			
Maize	15	30	R. Olver
Groundnuts	10	11	A. Chiteka
Sorghum		8	J. Mushonga
Pearlmillet	10	8	F. Muza
Sunflower	3	3	K. Mtindi
1985/86 season			
Maize	15	20	R. Olver
Groundnuts	10	6	Nyabadza(RT)
Sorghum		9	J. Mushonga
Pearlmillet	10	7	F. Muza
Fingermillet		2	F. Muza
Sunflower	3	5	K. Mtindi
1986/87 season			
Maize	15	20	R. Olver
Groundnuts	10	12	H. Gridley
Sorghum		7	J. Mushonga
Pearlmillet	10	7	F. Muza
Fingermillet		2	F. Muza
Sunflower	3	(Not available)	K. Mtindi

ANNEX 2

ON-FARM RESEARCH PROGRAM OF THE AGRONOMY INSTITUTE, 1980-1987

Research Areas in Which the Agronomy Institute was/is Active

	Travel time from headquarters (hours)	1980/ 81	1981/ 82	1982/ 83	1983/ 84	1984/ 85	1985/ 86	1986/ 87
Natural Region I								
Nyanga	2.5			x				
Natural Region II								
Chirau	1.2		x					
Chiota	1.2	x	x	x	x			
Chikwaka	0.7				x			
Guruve	1.0	x	x	x	x			
Goromonzi	0.5				x			
Hurungwe	2.5		x	x	x			
Mhondoro	1.0	x	x	x	x			
Mt Darwin	1.0		x					
Madziwa	1.2	x		x	x	x	x	
Makoni	1.5				x			
Mangwende	1.0		x	x				
Seke			x					
Wedza	2.0				x	x	x	
Zvimba	1.0	x	x		x	x	x	x
Natural Region III								
Bikita	4.0		x	x	x	x	x	
Buhera	3.0				x			
Chiwundura	3.0	x		x	x	x	x	
Gokwe	2.5				x	x		
Serima	3.5						x	
Marange	3.0			x	x	x	x	x
Mhondoro	1.5				x			
Nyika	1.5				x			
Zishiri (Zaka)	4.0					x		

Natural Region IV								
Esigodini	5.0		x	x		x	x	x
Essexvale	5.0	x						
Filabusi	4.5		x					
Gokwe	2.5	x	x	x	x	x	x	
Gutu	3.5	x	x		x	x	x	
Kandeya	3.0		x					
Katsande (Mtoko)	2.0					x	x	
Lupane	7.0		x	x				
Mudzi	2.5		x	x	x			
Mutambara	3.5			x				
Mutoko	2.0	x	x	x	x	x	x	x
Marange (South)	3.0				x	x	x	
Masvingo	3.0	x						
Mupfure	1.0					x		
Muzarabani	2.5						x	
Ndanga	4.0	x	x					
Nhema		x						
Nkayi	3.0		x					
Ntabazinduna	4.5					x	x	x
Nyajena	4.5		x	x				
Rushinga	2.5							x
Zaka	4.0				x	x	x	x
Natural Region V								
Chivi (FSR too)	3.5		x	x				
Gwanda	6.0	x	x					
Total	-	13	24	17	23	17	16	8

Identification of Trials per Season

Title	Treatment	Number of sites	Research Officer Responsible
1980/81 season			
Maize variety trial	13 varieties	3	A.N. Mashiringwani
Maize variety x population x fertility	3 varieties 2 in-row spacing 2 levels of fertilizers	5	"
Maize fertility trial	Different levels of fertilization	3	"
Soyabean variety x inoculation	4 varieties 3 Rhizobium strains	6	"

Title	Treatment	Number of sites	Research Officer Responsible
Groundnut variety trial	4 varieties	3	"
Groundnut fertility and fungicide trial	Different fertilizer (and manure) levels 2 levels of fungicide application	5	"
Pearlmillet variety trial	28 varieties	2	"
Sunflower variety trial	3 varieties	1	"
<u>1981/82 season</u>			
Maize variety trial	8 maize varieties	7	
Maize variety x spacing x fertility	2 maize varieties 2 in-row spacings 4 levels of AN	11	"
Maize fertility trial	Different fertilizer rates (and manure)	6	"
Maize variety x late planting trial	3 maize varieties	2	"
Maize: Communal Area farmer's yield assessment	Communal farmers' and trial yields	6	"
Groundnut variety x PD	4 varieties 2 planting dates	5	"
Soya variety x inoculation	6 varieties 2 levels of inoculation	9	"
Sunflower variety trial	6 varieties	4	"
Pearlmillet variety trial	12 varieties	3	"
Fingermillet variety trial	8 varieties	3	"

The following trials are conducted by Farming Systems Development Program (FASYD) under the Agronomy Institute:

Title	Treatment	Number of sites	Research Officer Responsible
Maize legume observation plots	1 cowpea cultivari 1 forage soya variety 1 local cowpea	2	E. Shumba
Maize tillage trial	2 tillage treatments 3 first weed treatments 2 second weeding treatments	10	"
Maize variety x time of planting x populations	3 planting dates 2 maize varieties 2 plant populations	10	"
Maize fertility trial	4 nitrogen levels 3 manure levels and 1 compound level	2	"
Fingermillet variety x planting date	3 fingermillet lines 3 planting dates	2	"
<u>1982/83 season</u>			
Comparison of cereals	4 cereals 3 planting dates 3 fertility levels	5	Chimbaranga
Comparison of grain legumes	4 grain legumes 3 planting dates 3 fertility levels	5	"
Frequency of manure application	Different levels of manure and fertilizer application	1	"
Effect of temperature on cowpea growth	4 cowpea varieties	1	"
Maize population x fertility	3 in-row spacings 5 fertility levels	4	"
Maize variety trial	8 varieties	11	"
Pearlmillet variety trial	8 varieties	2	"

Title	Treatment	Number of sites	Research Officer Responsible
Sorghum variety trial	8 varieties	1	"
Soya variety x inoculation	6 varieties 2 levels of inoculation	2	"
FASYD TRIALS			
Maize minimum tillage	Different tillage systems	14	E. Shumba
Fingermillet variety x planting date		3	"
Maize fertilizer management trial I	Time and type of fertilizer compound application	3	"
Maize fertilizer management trial II	3 planting dates 3 maize varieties 3 fertilizer levels	2	"
Sunflower variety x fertility trial	2 varieties 5 fertility levels	2	"
<u>1983/84 season</u>			
Maize population x fertility	3 in-row spacing 4 levels of fertilizer	17	Chinduza (3 months) and Whingwiri
Groundnut variety x population x fertility	4 varieties 2 populations 2 levels of fertilizer	9	"
Sorghum variety x seed rate	4 varieties 3 seed rates	2	"
Pearlmillet variety x seed rate	4 varieties 3 seed rates	1	"
Soyabean variety x inoculation	6 varieties 2 levels of inoculation	7	"
Cowpeas variety x population	4 varieties 2 row spacings	1	"

Title	Treatment	Number of sites	Research Officer Responsible
1984/85 season			
Maize spacing x fertility	3 in-row spacings 4 levels of fertilizer	17	Zharare
Cowpea variety x spacing x fertility	3 varieties 4 in-row spacings 3 fertilizer levels	3	"
Cowpea spacing x fertility	4 in-row spacings 3 fertilizer levels	13	"
Pearlmillet variety x seed rate x fertility	2 varieties 3 seed rates 3 fertility levels	6	"
Sorghum variety x seed rate x fertility	2 varieties 3 fertilizer levels 3 seed rates	15	"
Sunflower variety x spacing fertility	2 varieties 2 row spacings 3 fertilizer levels	18	"
Fingermillet variety x seed rate x fertility	2 varieties 3 seed rates 3 fertilizer levels	1	"
Soya variety x inoculation x fertility	2 varieties 2 inoculation levels 3 fertility levels	9	"
Groundnut variety x spacing x fertility	3 varieties 2 plant populations	17	"
1985/86 season		* different from Extension Worker data	
Effect of maize spacing on plant count/ha	3 in-row spacings	18	Zharare
Effect of fertility on groundnut grain yield	4 levels of fertilizers	17	"
Effect of spacing on sunflower grain yield and shelling percentage	4 in-row spacings	17	"

Title	Treatment	Number of sites	Research Officer Responsible
Effect of fertility on sunflower gross margin	4 levels of fertilizer	17	"
Effect of seed rate on pearlmillet	4 seed rates	9	"
Effect of fertility on pearlmillet	4 fertilizer levels	9	"
Soya inoculation x fertility	2 levels of inoculation 4 levels of fertilizer	9	"
Cowpea x spacing	4 in-row spacings	17	"
Sorghum x seed rate	4 rates	15	"
<u>1986/87 season</u>			
Maize	Nitrogen x phospate level	8	D. Mataruka
Maize	Nitrogen x time of application	8	"
Maize	Weed control * using ox-drawn implements * herbicides	1	S. Mabasa
Sorghum	Nitrogen levels x time of application	8	L. Gono
Sorghum	Population x row spacing	8	"
Pearlmillet	Nitrogen levels x time of application	7	"
Pearlmillet	Population x row spacing	1	"
Groundnut	Limiting factors * Micronutrients * inoculation * manure	6	G. Zharare M. Natarajan

Title	Treatment	Number of sites	Research Officer Responsible
Soyabeans	Limiting factors * nematicide * tied ridges	8	E. Whingwiri
Soyabeans	Variety x planting date	3	"
Soyabeans	Inoculant x fertilizer application	1	"
New Crops	Cassava and pigeon peas on contour ridges (observation trial)	8	P. Mafongoya
Maize/cowpea intercroppng	Planting date x row spacing x variety	4	J. Nleya
Sunflower	Nitrogen x phosphate trial	8	D. Hikwa

ANNEX 3

ON-FARM RESEARCH PROGRAM OF THE COTTON RESEARCH INSTITUTE, 1980-1987

Research Areas in which the Cotton Research Institute was/is Active

	Travel time from headquarters (hours)	1980/ 81	1981/ 82	1982/ 83	1983/ 84	1984/ 85	1985/ 86	1986/ 87
Natural Region II								
Guruve	2.5		x	x				
Mhondoro	1.0			x				
Murewa	2.5		x	x				
Musengezi	1.0			x				
Natural Region III								
Gokwe	1.0	x	x	x	x	x	x	x
Jomopani	1.0			x				
Sanyati	1.0				x	x	x	x
Zhombe	1.0			x				
Natural Region IV								
Mudzi	3.5		x	x				
Mutoko	3.5		x	x				
Sebungwe	2.5				x	x	x	x
Natural Region V								
Mat. North	5.5			x				
Nkayi	2.0			x				
Total		1	7	9	3	3	3	3

Identification of Trials per Season

Title	Treatment	Number of sites	Research Officer responsible
1980/81 season			
Variety trial:	9 entries	2	Jarvis/R. Chinodya
Herbicide demonstration	6 herbicides	3	G. Rabey
1981/82 season			
Variety trial:	10 entries	12	Jarvis/Chinodya
Herbicide trial	5 herbicides	14	G. Rabey
Fertilizer x ridge trial	3 fertility levels x ridge/flat	9	"
Variety x fertilizer trial	2 variety x 3 fertilizer levels	7	"
1982/83 season			
Variety trial:	10 entries	10	Jarvis/Chinodya
Spacing trial	4 spacings	6	G. Rabey
Fertilizer placement trial	3 methods of placement	5	"
1983/84 season			
Variety trial:	12 entries	25	G. Jones
Spacing trial	4 spacings	14	T. Mashavira
Fertilizer trial	4 rates	14	"
Moisture conservation trial	4 methods	12	"
1984/85 season			
Variety trial:	16 entries	19	G. Jones
Spacing trial	4 spacings	14	T. Mashavira
Fertilizer trial	4 rates	14	"
Moisture conservation x fertilizer trial:	2 methods x 2 fertilizer	13	"

Title	Treatment	Number of sites	Research Officer responsible
1985/86 season			
Variety trial:	6 or 16 entries	26	G. Jones
Spacing trial	4 spacings	14	T. Mashavira
Fertilizer trial	4 rates	14	"
Moisture conservation x fertilizer trial	4 methods x 2 fertilizer	11	"
Pest-scouting trial:	2 methods	20	P. Jowah
1986/87 season			
Variety trial:	8 or 16 entries	28	G. Jones
Fertilizer trial	4 rates	15	T. Mashavira
Moisture conservation x fertilizer trial:	4 methods x 2 fertilizer	14	"
Pest-scouting trial	2 methods	20	P. Jowah
Surveys			
1983/84 Preliminary survey on pest scouting.		80 farmers	P. Jowah
1984/85 Formal survey on pest scouting.		200 farmers	P. Jowah

ANNEX 4

ON-FARM RESEARCH PROGRAM OF THE LOWVELD RESEARCH STATION, 1982-1987

Research Areas in Natural Region V in Which The Lowveld Research Station was/is Active

	Travel time from headquarters (hours)	1982/83	1983/84	1984/85	1985/86	1986/87
Maranda	2.0		x	x	x	
Matibi I	1.5		x	x	x	x
Matibi II	1.5	x	x	x	x	x
Mutema	2.5				x	x
Musikavanhu	2.0			x	x	x
Nhowoyo	1.5		x	x	x	x
Sangwe	1.0	x	x	x	x	x
Sengwe	2.5		x	x	x	x
Total	-	2	6	7	8	7

Identification of Trials per Season

Title	Number of sites	Research Officer responsible
1982/83 season		
Observation plots comparing flat and basin sowing on sorghum yield	3	D. Lowe
1983/84 season		
Observation plots comparing flats, basins and furrows; three populations (low, medium and high) in the basins: cotton, maize, millet	9	P. Nyamudeza
Observation plots of sunflower, cowpea, guar, castor beans, groundnuts. soyabeans. cassava	6	"
Guar variety trial	6	"

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Title		Number of sites	Research Officer responsible
1984/85 season			
Repeated observation plots but sowing crops in furrows of 1.5 m ridges but sorghum was tested on flat, 1.5 and 2 m ridges as well as basins		9	Nyamudeza/C. Nyati
Pigeon pea added to new crops		6	"
Sorghum NPK and lime fertilizer trial sown on 1.5 m ridges on sandy soil		8	"
Guar variety trial		6	"
1985/86 season			
Sorghum landform x population x row spacing: flat land, furrow, low/medium/high population, and 1 and 1.5 m spacing		7	Nyamudeza/C. Nyati
Maize landform x population x row spacing (same as sorghum)		5	"
Sorghum variety trial:	6 entries	4	"
Maize variety trial:	6 entries	3	"
Sunflower variety trial:	5 entries	1	"
Groundnut variety trial:	5 entries	1	"
Cotton variety trial:	5 entries (run for Cotton Research Institute)	1	"
Sorghum fertilizer trial: 100 kg/ha N; none and Compound D.	none, 50 and 40kg/ha P	4	"
Maize fertilizer trial:	as for sorghum	4	"
1986/87 season			
Sorghum landform x population x row spacing trial		7	Nyamudeza/Nyati
Maize landform x population x row spacing trial		3	"
Cotton land form x population x row spacing trial		1	"
Sorghum variety trial		2	"
Maize variety trial		2	"
Cotton variety trial		1	"
Sorghum fertilizer trial		2	"
Maize fertilizer trial		1	"
Sorghum landform x fertility: flat, 1.5 m furrows; none, manure; none, N+P		2	"
Maize landform x fertility: as for sorghum		1	"

ANNEX 5

ON-FARM RESEARCH PROGRAM OF THE FARMING SYSTEMS RESEARCH UNIT, 1983-1987

1983/84 Season

Mangwende (Natural Region II, travel time from headquarters: 1 hour)

		Type of trial	Number of sites	Research Officer(s) responsible
1.	Maize reduced tillage: tine, conventional plowing; land-weeding, herbicide	RM[1)]	11	E. Shumba
2.	Maize fertilizer management: application at planting; after emergence; compound P, compound D	RM	7	"
3.	Groundnut variety/population/fertility: Plover, Swallow, Egret, Valencia; 266.666, 133.333 plants/ha; nil, 200kg/ha S, 200kg/ha SSP	RM	3	"
4.	Sunflower variety: Peridovik Sa 209, 77H158, 77H120	RM	3	"
5.	Soyabean variety/innoc./fertility: Kudu, Sable, Buffalo, Duiker; Nil, innoculation; 200kg/ha S, 200kg/ha SSP	RM	2	"

Chivi (Natural Regions IV and V, travel time from headquarters: 3.5 hours)

1.	Pearlmillet variety/seed rate: Tall-plain, Tall-awned, LC/MS/3, RMP1; 4, 8 and 12 kg/ha	RM	2	E. Shumba
2.	Sorghum variety/seed rate: M39335, Segaolane, Malkamosh, Red Swazi; 4, 8 and 12 kg/ha	RM	2	"
3.	Maize tillage/fertility: winter plowed land. summer-plowed land; nil, 100 kg/ha Comp. P plus 100 kg/ha AN	RM	2	"

1) RM = researcher-managed
FM = farmer-managed.

	Type of trial	Number of sites	Research Officer(s) responsible
1984/85 season			
Mangwende			
1. Maize reduced tillage: tine and summer plow. weed control with herbicide and hand hoe	FM	12	E. Shumba
2. Maize fertilizer management: 3 weeks after planting, at planting; 330kg/ha Comp P, 330kg/ha Comp D	FM	12	"
3. Maize variety observations plots R201, PNR473, PNR6427	FM	3	"
4. Maize planting date Oct. Nov. Dec; 37000, 44000 ppHa 330D + 220AN, 330D + 110AN, 330D + 330AN	RM	5	"
5. Maize manure x fertilizer Manure- 0,7,5 15 ton/ha; Nil 220D/ha and 330D/ha	RM	3	"
6. Maize liming x fertilizer: nil. 600kg/ha lime; 220, 330, 440kg/haD	RM	3	"
7. Sunflower variety x fertilizer: Peridovik, SA 209; 200kg/haS, 200kg/SSP, Nil	RM	7	"
8. Soyabean variety x inoculation x fertilizer. Kudu, Buffalo; Nil, inoculated; Nil, 200S/ha. 200kg/ha SSP	RM	12	"
9. Groundnut variety x liming x fertilizer Valencia, Egret; nil, 600kg/ha lime; Basal, 200kg/haS; 200kg/haSSP; nil, 200kg/ha Gypsum	RM	11	"
10. Sorhum Seedrate x variety x fertilizer Vars, RedSwazi, Dc.-99 Seedrates, 8, 12, 16kg/ha Fert rates, 1) 220D & 50AN, 2) 220D + 150 AN, 3) 220D + 250AN	RM	5	"

	Type of trial	Number of sites	Research Officer(s) responsible
11. Finger millet variety x fertilizer Demonstration: Varieties - 4 local lines, Fert: nil, 220D, 220AN, 220D + 100AN/ha	RM	1	"
12. Effect of perenial herbaceous legumes on fallow arable land on livestock feed and soil fertility: no legume, Finestem stylo, Siratro; no fert, 100kg/ha SSP + 50 kg/ha lime	RM	6	A. MacLaurin B. Mombeshora I. Reh
<u>Chivi</u>			
1. Maize variety x fertilizer R201, R200, PNR473, PNR6427 Fert: nil, 100kgD + 100AN /ha	PM	4	E. Shumba
2. Sorghum variety x fertilizer Red Swazi(A), M39335, local; nil, 100 P + 100 AN/ha	RM	4	"
3. Pearl millet variety x fertilizer GAS-(MS)5 - C2, RMPI, Local; nil. 100P + 100 AN/ha	RM	4	"
4. Maize plant on Moisture conservation techniques: flat, ridge, tied ridges, Plant of flat and earth-up rows at first weeding	RM	2	"
5. Sorghum moisture conservation techniques: same as maize and plan	RM	2	"
6. Maize reduced tillage: winter plough + summer plow and plant, winter plow + hoe plant, winter plow + tine plant; - Dry seed; Pre-soaked seed	RM	4	"
7. Maize manure: nil, 7,5, 15ton/ha manure; nil. 75kg 150kg/ha P	RM	3	E. Shumba
8. Cultivation of leucaena leucocephala: no lime, 5g lime/plant; no manure, 250g/plant manure	RM	6	P. Spear B. Mombeshora I. Reh

	Type of trial	Number of sites	Research Officer(s) responsible
1985/86 Season			
Mangwende			
1. Maize reduced tillage x fertilizer management: summer plow, hand or ox cultivate and 330D + 250AN/ha at 3 weeks after planting; winter plow, plant with tine, use 3.6 & Atrozine herb and apply same fert at planting	FM	20	E. Shumba
2. Maize manure x fertilizer trial 0, 7.5; 15 ton/ha Manure; 0. 220. 330kg/ha D	RM	2	"
3. Maize planting date x variety x population x fertilizer P/date: Oct, Nov, Dec Popn: 37000, 44000 Fert: 330D + 220AN, 330D + 110AN 330D + 330AN kg/ha	RM	5	
4. Groundnut variety x manure x fertlizer trial: Valencia R2, Plover; 0, 7.5 tons bns/ha manure; 0, 200kg/ha SSP + Uniform Gynsum dress	RM	5	Dendere
5. Groundnut labour sowing implements: Plow and hand plant, lift by hand; plow and use planter and lifter	R/FM	2	
6. Soyabean variety x fertilizer Variety: Braxton, Buffalo; 200kg/ha S, 200kg/ha SSP; Uniform inoculation	RM	5	Shumba
7. Sunflower variety x fertilizer Peredovik, Msasa; 0, 30, 60, 90kg/ha N; 0. 200 S 200kg/ha Comp L	RM	5	
8. Sorghum variety x fertilizer x seed rate. Red Swazi, DC 75; Rates: 9, 15kg/ha Seed; 330D + 220AN, 200D + 100AN, 250D + 125AN kg/ha	RM	5	Dendere
9. Effect of herbaceous legumes as in 1984/85	RM	4	A. MacLaurin B. Mombeshora I. Reh

	Type of trial	Number of sites	Research Officer(s) responsible
10. Protein supplementation for draft plowing: no special feeding, crop residues + 0,5bg/day protein supplement	R/FM	22	B. Mombeshora
11. Reinforcement of reverted grazing area with perenial legumes: unimproved reverted area, reinforced area; no land prep + no seed cover, land prep with cultivater + slight seed cover; no fert. 100kg/ha SSP + 200bg/ha lime; no zinc. 2kg/ha ZnO5	RM	1	B. Mombeshora
<u>Chivi</u>			
1. Maize variety x fertilizer trial: R201, R215, Breeders material; nil, 100kg/ha P, Uniform TD-100kg/ha AN 100kg/ha AN	RM	8	E. Shumba
2. Sorghum variety x fertilizer trial: Red Swazi, Mr39335; nil, 100kg/ha P	RM	8	S. Dendere
3. Pearl millet variety x fertilizer: Gas (MS) 5 - C2, RMPT, local; nil, 100kg/ha Comp P			
4. Maize manure x fertilizer trial R201; 0, 7,5, 15ton/ha manure; nil, 75, 150kg/ha D	RM	4	Shumba
5. Maize moisture conservation: flat, furrow, Tied ridge; 0. 100kg/ha P	R/FM	4	"
6. Sorghum moisture conservation: Flat, furrow, Tied ridge; nil, 100kg/ha Comp P.	R/FM	4	Dendere
7. Sunflower variety x population x fertilizer: Msasa, Peredovik 450 000, 300 000 plants/ha	RM	8	Shumba
8. Cultivation of leucaena (same as 84/85)	RM	4	I. Reh B. Mombeshora
9. Leucaena x spacing x manure x lime: 15cm, 30cm within row; no manure, 8.325 tons/ha; no lime, 166kg/ha	RM	1	B. Mombeshora

	Type of trial	Number of sites	Research Officer(s) responsible
1986/87 Season			
Mangwende			
1. Maize reduced tillage and fertilizer management. tillage methods, weed control, tine plus herbicide; Type of Comp D. and P; Time of application at planting and 1 1/2 weeks later	RM	2	Shumba
2. Maize planting dates x population x fertilizer x variety P/date: Oct. Nov. Dec Popn : 37000 and 44000 fert : 330D + 220AN, 330D + 110AN, 330D + 330AN kg/ha	RM	5	Shumba
3. Groundnut variety x manure x fertilizer Vars: Valancia, Plover; Manure: 0, 7.5 ton/ha Fertilizer: 0, 200 SSP, 200 L kg/ha	RM	1	Dendere
4. Evaluation of groundnut production Vars: Valancia, Plover; Basal: 0, 200 SSP, 200L bg/ha Lime : 0. 250kg/ha	RM	5	Dendere
5. Application of labour saving implement to improve the productivity of groundnuts Planting method: hand hoe, oxdrawn planter; Weed control: handweed, herbicide Harvesting: hand hoe, groundnut lifter	R/FM	4	Dendere
6. Evaluation of Soyabean production options Basal: 0, 200 S, 200 SSP kg/ha Inoculation: 145kg AN/ha, inoculate	RM	5	Shumba
7. Evaluation of Sunflower production options Varieties: Peridovik, Msasa Basal: 0, 200 L/ha Top dress: 0, 174kg/ha AN (50kg/ha N)	RM	5	Shumba
8. Evaluation of Sorghum production options Vars: DC 75, M39335 Comp: 0, 250P, 250D Top dress: 0, 220AN	RM	5	Shumba

	Type of trial	Number of sites	Research Officer(s) responsible
9. Herbacious legumes (same as before)	RM	4	B. Mombeshora
10. Protein supplementation for draft oxen	RM	22	B. Mombeshora
11. Reinforcement of reverted grazing area	RM	1	B. Mombeshora
<u>Chivi</u>			
1. Evaluation of maize production options Basal: 0, 200D, 200P kg/ha; Top : 100, 200 AN kg/ha; Popn : 24 691, 37037 plants/ha	RM	8	Shumba
2. Maize reduced tillage: Tillage method, weed control time and method, top dressing and basal dressing times and type of compound	RM	2	Shumba
3. Evaluation of Sorghum production options Varieties: M39335, Red Swazi; Basal fert: 0, 120D 150P kg/ha; AN : 0, 100kg/ha AN	RM	8	Dendere
4. Evaluation of Pearlmillet production option. Vars: Gas - 5 - (CS) -E, RMPI Comp: 0, 100kg/ha	RM	8	Dendere
5. Evaluation of Sunflower production options Vars : Peredovik, Msasa Basal: 0, 200kg/ha L Top dress: 0. 174kg/ha AN	RM	8	Shumba
6. Evaluation of groundnut production options Variety: Natal, Common Fert types: 0, 200kg/ha L 200kg/ha S. 200kg/ha SSP	RM	4	Dendere
7. Performance of indigenous x Boer crossbred goats under local management	FM	12	B. Mombeshora

ANNEX 5 TABLE 1

SURVEYS AND STUDIES CARRIED OUT BY THE FARMING SYSTEMS RESEARCH UNIT SINCE 1984

Type of study and subject	Objectives	Study period	Research area and approx. number of participants
1. Informal survey: general systems and constraint analysis	Basic information of areas, farmers' problems and research priorities	June/July 1984	Mangwende and Chivi: 15 researchers, six AGRITEX staff. Various households and Household groups in each area
2. Formal survey: resources availability and farming practices	Farmers' resources, some farming activities, practices and attitude toward proposed defined innovations	September 1984	Mangwende: 108 farmers Chivi: 131 farmers
3. Formal survey: farming systems research assessment	Farmer acceptance and adoptability of maize reduced tillage + fertilizer + herbicide technology under testing	July 1984	Mangwende: 76 farmers
4. Formal survey: livestock census (Division of Veterinary)	Livestock population figures per diptank area, ownership distribution, herd sizes	September/October 1984	Chivi: 50 dips (14.530 households)
5. Monitoring: livestock production	Production data for cattle, goats, donkeys, sheep, ownership and off-take information	1985-87	Mangwende: 61 households Chivi: 91
6. Seasonal sampling: livestock disease study	Determination of non-clinical diseases in young livestock	1986-87	Mangwende: 61 Chivi: 91

ANNEX 5 TABLE 1 (continued)

Type of study and subject	Objectives	Study period	Research area and approx. number of participants
7. Informal survey (workshop): household decision-making	Sex/age division for farming activities and responsibilities. Decision criteria for enterprise selection and management, right to and distribution of outputs	August/ September 1985	Mangwende and Chivi: 15 extension workers, 5 local key informants in each area
8. Informal survey: goat production	Purposes of goat keeping, management, marketing, constraints, identification of research activities and research needs	September 1985	Chivi: 38 households
9. Formal survey: economics of farming systems (Michigan State University/ University of Zimbabwe/ Farming Systems Research Unit)	Identification of key factors determining growth trends in maize production in recent years	1985-87	Mangwende: 103 households Chivi: 105 households
10. Monitoring: crop production	Characterization of groundnut production practices and maize practices and maize stand and tillage depth and their effect on performance	1986-87	Mangwende: 10 households Chivi: 10 households

Source: FSRU records.

ANNEX 5 TABLE 2

YEARLY DISTRIBUTION OF TRIAL SITES AND TRIALS
OF THE FARMING SYSTEMS RESEARCH UNIT
ACCORDING TO RESEARCH AREA AND COMMODITY, 1983-1987

	1983/84		1984/85		1985/86		1986/87	
Mangwende	Sites	Trials	Sites	Trials	Sites	Trials	Sites	Trials
Maize	18	2	38	6	27	3	7	2
Sorghum	-	-	5	1	5	1	5	1
Fingermillet	-	-	1	1	-	-	-	-
Groundnuts	3	1	11	1	7	2	10	3
Soyabeans	3	1	12	1			5	1
Sunflower	3	1	7	1	5	1	5	1
Forage legumes	-	-		1	4	1	4	1
Draft-feeding	-	-	22	1	22	1	22	1
Subtotal	27	5	102	13	65	9	58	10
Chivi								
Maize	2	1	13	4	16	3	10	2
Sorghum	2	1	6	2	4	1	8	1
Pearlmillet	2	1	4	1	4	1	8	1
Groundnuts	-	-	-	-	-	-	4	1
Sunflower	-	-	-	-	8	1	8	1
Forage legumes	-	-	6	1	7	2	7	2
Goat-breeding	-	-	-	-	12	1	12	1
Subtotal	6	3	23	7	51	9	57	9
Total	33	8	125	20	116	18	115	19

Source: FSRU records.

ANNEX 6

LIST OF PUBLICATIONS SELECTED FROM THE CASE STUDY OF FIVE RESEARCH INSTITUTES

Crop Breeding Institute

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Mushonga, J.N. "Sorghum improvement in Zimbabwe." Paper presented at the Third Regional Workshop on Sorghum and Millets for Southern Africa, 6-10 October, 1986, Lusaka, Zambia.

Muza, F.R. "Pearlmillet improvement in Zimbabwe." Paper presented at the Third Regional Workshop on Sorghum and Millets for Southern Africa, Lusaka, Zambia, 6-10 October, 1986.

Muza, F.R., J.N. Mushonga, and S. Appa Rao. "Pearlmillet improvement in Zimbabwe." Paper presented at the Second Regional Workshop on Sorghum and Millets for Southern Africa, 23-27 September, 1985, Gaborone, Botswana.

Agronomy Institute

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Whingwiri, E.E. and G. Harahwa. 1985. "Maize Varieties for the Low-yielding Environments of Zimbabwe." Zimbabwe Agricultural Journal, 82:29-30.

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Cotton Research Institute

Anon. Cotton Research Institute annual report 1980-81. Department of Research and Specialist Services, Harare.

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Lowveld Research Station

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Farming Systems Research Unit

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Clatworthy, J.N., A.R. MacLaurin, and M. Avila. 1986. "The possible role of forage legumes in communal area farming systems in Zimbabwe." In Potentials of forage legumes in farming systems of sub-Saharan Africa, ed. I. Haque, S.Jutzi and P.J.H. Neate, Addis Ababa: ILCA.

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Stewart, H.T.L., M. Avila, and J. Clatworthy. "A plan for the development of agroforestry research in Zimbabwe." Paper presented at the ICRAF Workshop on AFRENA, 10-12 September 1986, Harare, Zimbabwe.

ANNEX 7

LIST OF PERSONS INTERVIEWED FOR THE CASE STUDY

Crop Breeding Institute (CBI)

Name	Position	Institute	Date
R. Olver	Head	CBI	15/9/86 and 10/12/86
Mushonga J.N.	Research Officer	CBI	6/2/87
Muza F.	Research Officer	CBI	27/3/87
Masunda G.	Research Technician	CBI	13/3/87
Mlambo P.	Extension Supervisor	AGRITEX	9/12/87
Ngwende F.T.	Extension Worker	AGRITEX	9/12/87
Munhenga G.	Farmer		9/12/87
Matere	Farmer		9/12/87

Agronomy Institute (AI)

Whingwiri E.	Head	AI	11/12/86 and 12/3/87
Mataruka D.	Research Officer	AI	1/2/87 and 14/3/87
Pashapa	Research Technician	AI	17/3/87
Mpisa	Agronomy Assistant	AI	17/3/87
Chigwanda	Agricultural Extension Officer	AGRITEX	10/12/86
Masoja P.	Agricultural Extension Officer	AGRITEX	12/12/86
Masekesa M.	Extension Worker	AGRITEX	10/12/86
Bota R.	Extension Supervisor	AGRITEX	10/12/86
Mapfekedze	Farmer		12/12/86
Kutawushe S.G.	Farmer		12/12/86
Mujabuki	Farmer		12/12/86
Magande A.	Farmer		12/12/86
Chipuriro S.	Farmer		10/12/86
Nyahocha	Farmer		10/12/86

Cotton Research Institute (CRI)

Rabey G.	Head	CRI	17/9/86 and 8/12/86
Jowah P.	Research Officer	CRI	8/12/86 and 29/3/86
Mashavira T.	Research Officer	CRI	8/12/86
Sithole	Extesion Worker	AGRITEX	9/12/86
Chuchu M.	Research Technician	CRI	14/3/87
Maphosa B.	Farmer		9/12/86
Madoda	Farmer		9/12/86

Lowveld Research Station (LRS)

Jones E.	Head	LRS	4/12/86 and 13/3/87
Nyathi C.	Research Officer	LRS	4/12/86 and 9/3/87
Nyamudeza P.	Research Officer	LRS	4/12/86 and 9/3/87
Njekete E.	Agricultural Assistant	LRS	19/3/87
Chihora S.	Agricultural Extension Officer	AGRITEX (LRS)	11/12/86
Mangwana J.	Extension Worker	" "	11/12/86
Chitanga D.	Farmer	LRS	11/12/86
Mbulawa Z.	Farmer	(LRS)	11/12/86
Marufu S.	Farmer	(LRS)	11/12/86
Ngara J.	Farmer	(LRS)	11/12/86

Farming Systems Research Unit (FSRU)

Dendere S.	research officer	FSRU	15/12/86 and 14/3/87
Chiota G.	Research Technician	FSRU	13/3/87
Mavedzenge B.	Research Technician	FSRU	18/3/87
Murimbarimba F.	Agricultural Assistant	FSRU	18/3/87
Chiutsi J.	Extension Worker	AGRITEX	14/12/86
Kanyangarara E.	Extension Worker	AGRITEX	10/12/86
Makonyere	Agricultural Extension Officer	AGRITEX	14/12/86
Maponde E.	Agricultural Extension Officer	AGRITEX	10/12/86
Kaseke L.	Extension Supervisor	AGRITEX	10/12/86
Mlambo, M. MRS.	Farmer		10/12/86
Mazorodze O.	Farmer		14/12/86
Bere A.	Farmer		14/12/86
Mazhindu	Farmer		10/12/86

AGRITEX Provincial Agricultural Extension Officers (PAEO)

Mariti	PAEO	Mashonaland East	11/12/86
Tsododo G.	PAEO	Mashonaland Central	8/12/86
Masvaya	PAEO	Masvingo	12/12/86
	PAEO	Midlands	9/2/86

Others

Chigaru P.	Director	DR&SS	12/9/86
Ndimande B.	Director	AGRITEX	20/8/86
Vaughan-Evans R.	Deputy Director	AGRITEX	19/8/86
Mandiringana O.	Head	Soil Productive Research Laboratory	19/9/86
Mufandaedza O.	Head	Henderson Research Station	19/9/86

Sibanda S.	Acting Head	Grasslands Research Station	16/9/86
Clatworthy J.	Head	Pastures and Veld Unit	16/9/86
Madziva T.	Head	Chemistry and Soils Research Institute	19/9/86
Mlambo S.	Head	Plant Protection Research Institute	15/9/86
Gapare R.	President	National Farmers Association of Zimbabwe	10/12/86

Annex 8

Questionnaire for Survey on On-Farm Research Functions within the Department of Research and Specialist Services

Institute/Station/Unit _____ Position _____

Do you do on-farm research (OFR):_____ On-station research _____

Objective: This survey is the final stage of the study on the organization and management of on-farm research. Your careful consideration of the questions and prompt response would be greatly appreciated. The results will help us develop sound recommendations for improving on-farm research and its contribution within the Department.

Instructions: Please review the seven possible functions (roles) for on-farm research within DR&SS listed below. Rank each on a scale of 1-4 in terms of:

a) the importance that you think the functions for on-farm research should have within DR&SS (ideal);

b) the importance that you think the function for on-farm research actually has (actual)

1 = Not important
2 = Moderately important
3 = Very important
4 = Critically important (essential)

For each function please circle one number next to ideal and one number next to actual.

Function 1: on-farm research supports within DR&SS a problem-solving approach which is fundamentally oriented to farmers as the primary clients of research.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 2: on-farm research contributes to the application of an interdisciplinary systems perspective within research.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 3: on-farm research characterizes major farming systems and client groups, using agro-ecological and socio-economic criteria, in order to diagnose priority production problems and identify key opportunities for research with the objective of improving the productivity and/or stability of those systems.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 4: on-farm research adapts existing technologies* and/or contributes to the development of alternative technologies for targeted groups of farmers sharing common production problems by conducting experiments under farmers' conditions.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 5: on-farm research promotes farmer participation in research as collaborators, experimentors, testers, and evaluation of alternative technologies.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 6: on-farm research provides feedback of farm-level information for priority-setting, planning, and programming of on station research (experiment station research) so that experiment station research are intergrated into a coherent programme focussed on farmers' priority needs.

Ideal 1 2 3 4 Actual 1 2 3 4

Function 7: on-farm research promotes collaboration with extension and development agencies in order to improve efficiency of the technology generation and diffusion process.

Ideal 1 2 3 4 Actual 1 2 3 4

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* technology is used here in its sense to refer to varieties, agronomic and management practices, and agricultural equipment.

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