Centro Agronomico Tropical de Investigacion y Ensenañza
Caribbean Agricultural Research and Development Institute
Winrock International

Proceedings of a Workshop

Research on Crop-Animal Systems

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Research On Crop-Animal Systems

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Caribbean Agricultural Research
and Development Institute
University of West Indies Campus
St. Augustine, Trinidad

Winrock International
Morrilton, Arkansas, USA

Editors
(in alphabetical order):

H. A. Fitzhugh
R. D. Hart
R. A. Moreno
P. O. Osuji
M. E. Ruiz
L. Singh

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Participants

Caribbean Agricultural Research and Development Institute (CARDI)

Richard Carew, St. Augustine Campus, Trinidad, West Indies (Ag. Economist).
Rowland Fletcher, 64 Middle Street, Georgetown, Guyana (Agronomist).
Stephen Fontinelle, Castries, St. Lucia, West Indies (Animal Scientist).
John Hammerton, P.O. Box 971, Castries, St. Lucia, West Indies (Agronomist).
Gerald Proverbs, Barbados, West Indies (Animal Nutritionist).
Pascal Osuji, University Campus, St. Augustine, Trinidad, West Indies (Animal Nutritionist).
Laxman Singh, c/o Ministry of Agriculture, St. Kitts-Nevis, West Indies (Systems Agronomist).

Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE)

Marcelino Avila, Turrialba, Costa Rica (Ag. Economist).
Rolain Borel, Turrialba, Costa Rica (Pasture Specialist).
Carlos Burgos, Turrialba, Costa Rica (Soils Scientist).
Oliver Deaton, Turrialba, Costa Rica (Animal Scientist).
German Escobar, Turrialba, Costa Rica (Ag. Economist).
Marco Esnaola, Turrialba, Costa Rica (Animal Nutritionist).
Raul Moreno, Turrialba, Costa Rica (Plant Pathologist).
Eduard Muller, Turrialba, Costa Rica (Animal Scientist).
Luis Navarro, Turrialba, Costa Rica (Economist).
Manuel Ruiz, Turrialba, Costa Rica (Animal Nutritionist).

Winrock International

James Bemis, Conway, Arkansas, USA (Communications Consultant).
Hank Fitzhugh, Morrilton, Arkansas, USA (Animal Scientist).
Nestor Gutierrez, Morrilton, Arkansas, USA (Ag. Economist).
Robert Hart, Morrilton, Arkansas, USA (Agronomist).

International Development Research Centre (IDRC)

Hubert Zandstra, Vancouver, B.C., Canada.

U.S. Agency for International Development (AID/ROCAP)

Henry Tschinkel, c/o American Embassy, San Jose, Costa Rica.

Preface

Scientists from the three institutions participating in this Workshop--CATIE, CARDI, and Winrock International--have been involved for several years in crop and/or animal production systems research. Their experiences have increasingly pointed to the need for research on the interface of crop and animal components of the farming system. This common interest in crop-animal systems, especially on small farms in the tropics, was the basis for organizing a joint multidisciplinary workshop with the following objectives:

- To identify major opportunities for research to improve the crop-animal component of mixed farming systems in the tropics.
- To identify constraints and problems in accomplishing these research goals.
- To develop strategies and methodologies for resolving constraints and improving effectiveness of research on the crop-animal component of tropical farming systems, emphasizing application to CATIE, CARDI, and Winrock programs.

Preparation of case studies and other presentations for the Workshop would also serve to consolidate and organize each institution's experiences with crop-animal systems. By so doing, each institution could more readily identify opportunities and set appropriate priorities for future research on the crop-animal component of farming systems. The opportunity for scientists to share experiences and learn from each other was also viewed as a significant benefit to be gained from the Workshop.

The Steering Committee for the Workshop included two scientists from each institution:

CARDI - Pascal Osuji and Laxman Singh

CATIE - Raul Moreno and Manuel Ruiz

Winrock International - Hank Fitzhugh and Robert Hart

This Committee met in October 1981 to plan activities, including case studies on crop-animal systems, a bibliography of scientific literature on crop-animal systems, an agenda and participants for the Workshop, and publication of the Proceedings.

The Workshop was held April 4-7, 1982, at CATIE headquarters in Turrialba, Costa Rica. The participants were selected by their respective institutions on the basis of experience, interest, and responsibility for crop-animal systems research. The number of participants was deliberately kept small to facilitate group discussion and exchange of ideas. The participants, aided by the Proceedings, will serve as the communications link to their colleagues who did not attend the Workshop.

The keynote speaker, Hubert Zandstra, Associate Director (Animal Science) of IDRC, is well known for his accomplishments and experience in farming systems research. Zandstra also has firsthand knowledge of the respective research programs of the participating institutions.

Publications, in addition to these Proceedings and a Spanish-language version, include a separate volume of 11 case studies on crop-animal systems listed on the following page and a bibliography containing 760 titles of publications on crop-animal systems.

Acknowledgements

These publications and the Workshop experience itself are productive accomplishments that have significant potential value to future research by the participating institutions and, perhaps, other institutions as well. The success of the Workshop was due to the joint efforts of the participants, of the authors of the case studies, and of their colleagues in both participating and collaborating national institutions who are conducting research on crop-animal systems.

Translation and secretarial services for the Proceedings were provided by Florencia Jimenez, Chantal Montoya, and Giselle Simm of TRADINSA; Priscilla Hine, San Jose, Costa Rica; and Esperanza de Gutierrez and Shirley Zimmerman, Morrilton, Arkansas.

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Case Studies Developed For Workshop*

CARDI

Mixed Farming Systems on Small Farms in Upper Berbice River District, Guyana.
W. C. Massiah, R. E. Fletcher.

A Small Farm in St. Lucia. A Microstudy #225.
R. Carew, S. Fontinelle, C. George.

A Case Study of a Small Farm System in Belize. R. Carew.

Sheep Production - A System Based on Tethered Animals on Marginal Lands.
G. A. Proverbs.

A Case Study of a Small Farm System in Grenada. R. Carew, K. Buckmire.

Farming Systems of Small Farms in Leeward Islands of the Eastern Caribbean - Selected Case Studies. L. Singh, K. A. E. Archibald, J. Hammerton.

Aspects of the Farming System of Southeast St. Elizabeth, Jamaica.
L. Daisley, E. Johnson, R. Francis.

CATIE

Crop-Animal Mixed Systems: (a) Corn, Beans, Rice with Dual-purpose Cattle, Pigs. (b) Corn, Beans with Dual-purpose Cattle. R. Piskulich, M. Ruiz, M. Avila, D. Pezo, A. Ruiz.

Cash-Crop with Animal Production System: Coffee, Sugarcane with Dual-purpose Cattle. E. Muller.

The Animal Component in Maize-Sorghum Farming System in Central America.
J. Larios, J. Arze, R. Arias.

Winrock International

Mixed Farming Systems in Western Kenya with Interaction Among Maize, Sorghum, Beans, Cassava with Goats, Hair Sheep, and Cattle.
R. Hart, H. Fitzhugh, M. Sands.

*Bound copies of these case studies will be available in limited numbers for distribution from participating institutions.

Summary

Mixed farms including both crop and animal components are a dominant farming system in most developing countries and interactions between these components often have major impact on the productivity and efficiency of the mixed farming system. Some interactions are indirect, resulting from competition between crop and animal enterprises for land, labor, and capital. Direct interactions--both competitive and complementary--also occur; for example, when crop residues are fed to animals, animal power is used for cropping activities, animal manure is used as fertilizer, and forage crops are combined with food or cash crops. Relatively little research has been done with interacting crop-animal components of mixed farming systems. However, as pointed out by the keynote speaker, Hubert Zandstra, considerable research has been done on the separate crop production systems and animal production systems on mixed farms. This research has been called "Farming System Research" because results are measured at the farm level, i.e., the alternative technology developed to improve either crop or animal production is evaluated on the basis of its effect on the performance of the farm as a whole. Farming System Research can be oriented toward improving crop production systems, animal production systems, or crop-animal production systems.

In outlining the research activities that make up farming-systems research strategy, the keynote address included:

- Selection of target areas.
- Site description.
- Selection of land types or farming systems.
- Design of alternative systems.
- Testing of alternative systems.
- Technology transfer and pilot production programs.

The overviews of farming systems research strategies and experience with crop-animal systems research, presented by CATIE, CARDI, and Winrock, indicated that all three institutions take a similar approach. There was general agreement that the farming systems approach is also the key to research with crop-animal systems, and that a critical appraisal of research strategies would be beneficial in identifying research methods to improve crop-animal systems and in improving current farming-systems-research efforts with crop and animal production systems.

Following the keynote address and discussion of the three institutions' overview presentations, four subject areas were selected for special attention:

- Characterization of farming systems.
- Design of technological alternatives.
- Testing of technological alternatives.
- Organizational problems affecting crop-animal systems research.

Four small work groups were organized to analyze these four topics and to outline current methodologies and institutional and research management aspects that affect crop-animal research. Recommendations were developed to improve methodologies and institutional organizations to facilitate crop-animal systems research.

Work Group 1, which analyzed the characterization process, noted that results produced by the characterization phase are often not available at the beginning of the design phase. The Group analyzed this problem by first identifying the information needed to begin the design phase and then suggesting techniques that could be used to produce the needed information. A crucial methodological concern was the identification of crop-animal interactions early in the characterization process so that later activities could quantify the intensity of the interaction. The Group recommended that a creative approach should be taken and that techniques other than surveys and farm monitoring should be considered, including rapid appraisal, group interviews, and key informant interviews. These techniques were suggested for use in obtaining a general overview of the farm systems and their operational characteristics (including the existence of crop-animal interaction) and to identify the key constraints before beginning the design phase.

Work Group 2 noted that design is a difficult stage in any farming systems research and that it is particularly difficult when there are crop-animal interactions. Most of the characterization and testing methodologies developed for crop and animal production systems research can be used directly for research with crop-animal systems. However, the design methodology used by most farming systems teams is basically a subjective process; thus the methodology depends upon the scientists' ability to use their combined experiences to identify technologies that will overcome production constraints and meet the farmers' objectives. Since few scientists have experience with crop-animal interactions, this subjective approach to design has serious limitations.

In analyzing research activities within the design process, the Group classified the activities as: identification of technology to resolve constraints, development and implementation of technology, screening of technology, and identification of criteria for evaluating the technology in the testing stage. The evaluation criteria were analyzed with regard to crop-animal interaction, and the group recommended that criteria be developed to evaluate farm-level performances and flows among interacting crop and animal subsystems on mixed farms.

Work Group 3 analyzed the testing stage by identifying and comparing testing procedures. Testing activities were classified as "on-farm" and "on-station." On-farm testing of crop or animal technology was recognized as a difficult process that can be divided into several types, including:

- Trials with many farms in a homogeneous area.
- Trials on few farms with different alternatives tested at the same time or in sequences.
- Trials with the primary objective of validating a model.
- Comparison of farms using a specific technological practice (have's) with farms that do not use the practice (have-not's).

This Group recommended that strong emphasis be placed on on-farm testing but acknowledged that on-station testing can play a very important complementary role to on-farm testing. Social and economic evaluation usually should be done on-farm, but some biological testing could best be done on the field station.

Work Group 4 analyzed organizational problems by discussing questions relating to:

- Team structure and organization.
- Institutional relationships.
- Administration of interdisciplinary teams.
- Stability and consistency of the team.
- Communication among team members.

They agreed that teams conducting research with crop-animal systems should consist of specialists in crop, animal, and social sciences. Ideally, all team members would be interested in, and conversant with, the terminology of other disciplines, but individual scientists would be expected to provide leadership in their specific disciplines. The individual scientist should be motivated to emphasize the interdisciplinary team objectives (rather than discipline-focused objectives) by the potential synergism that can produce team results that are equal to more than the sum of individual efforts. Administrative relationships within institutions were discussed and the importance of administrative autonomy for the team was recognized as being extremely important. Administrative relationships among institutions also were discussed, and the Group stressed that all institutions must agree on the goals of the program, especially when several donor agencies, international or regional research institutions, and national programs are involved.

Future Considerations

Research with crop-animal systems remains at a preliminary stage. However, many of the methodologies developed for farming systems research with crop and animal production systems are also appropriate for crop-animal research. In spite of the obvious difficulties that stem from the complexity of these systems and lack of experience with this type of research, there is ample evidence indicating that research with crop-animal systems is necessary and feasible.

Improvements in the present state-of-the-art in farming systems research have crucial implications for the people of developing countries; thus the subject of crop-animal research merits increased consideration. The participants felt that the Workshop had provided valuable insight into the problems and potentials for successful crop-animal research methodologies.

Experiences With Research On Crop-Animal Systems

Hubert G. Zandstra

INTRODUCTION

Historically, agricultural research has made considerable contributions to increasing the production of food and industrial crops in temperate regions. The increases in agricultural efficiency have been primarily from an increase in the yield potentials of crops and animals, a reduced labor input through mechanization, and increases in production obtained from the substantial use of fertilizers and pesticides.

The contributions to agricultural production in developing countries have also been impressive (Scobie 1979) in farming regions with well-defined cropping systems and stable (irrigated or predictable rainfall) production environments. Where rainfall is limited and the farm enterprise is composed of a number of crop sequences or combinations, plus one or more animal production activities, research results have been less convincing. This is, in part, because research priorities focused first on the safe, stable, high-potential environments. It is also because researchers were intuitively aware that as individual breeders, nutritionists, or agronomists, they had little to contribute towards improving the highly partitioned, small bits of maize, upland rice, cattle, poultry, plantains and swine enterprises that they encountered in mixed farming regions.

The development of cropping systems research methods and the comparative analyses of a great number of farming systems (Ruthenberg 1980) has led to an understanding of mixed small farms and the availability of some tools that allow the courageous researchers to tackle production systems that are considerably more complex than the monocrop systems heretofore addressed by researchers.

Research on crop-animal systems considers modifications in the crop and animal enterprise to improve the benefits farmers derive from their farms. In this presentation, I will review some of the crop-animal (or farming) systems research approaches that have been developed with particular attention to the objectives of this research and the institutional framework in which it has been conducted. I will also discuss the priorities for further strengthening our capability to develop improved technology that is acceptable to operators of crop-animal production enterprises.

TYPES OF FARMING SYSTEMS RESEARCH

Considerable agreement exists among researchers about the general approach (framework) required for farming systems research (Byerlee et al. 1980; Navarro and Moreno 1976; Borel et al. 1982; Norman 1978; Nygaard 1980; and Zandstra 1977). All consider a careful description of the existing production system to be an important first step, to be followed by the evaluation of improved production practices in the farm setting.

For completeness sake, I will include what is essentially the farming systems research framework used by the International Rice Research Institute (IRRI) and the Tropical Agricultural Research and Training Center (CATIE). It consists of seven research phases, which form a conceptual sequence. In practice, however, several research phases may take place at the same time.

Selection of the Target Areas

One or more geographical areas representative of a large homogenous production zone are selected. The area should be a priority area for development by the national government. In this way, when the potential for increased production has been demonstrated, support for production programs will be given.

Site Description

The first activity of the research is to describe the existing farming systems, the physical environment, the socioeconomic environment, and constraints to production. The characteristics of the farm environment will decide research priorities at the on-farm research site and at supporting research stations. At this time, the area is also divided into different land types, each of which may require a different production recommendation.

Selection of Land Types or Farming Systems

The stratification of the target area into land types is based on important environmental traits that are generally reflected in the type of food or forage crops grown and the type of animal feeding system or animal species that predominate. Land types are usually differentiated on the basis of pedological, irrigation, market, climatological, or social factors. They should be general enough in occurrence to warrant research expenditures. Because of staff and funding limitations and to reduce complexity, the research is generally confined to one or two land types and the predominant farm types associated with them. For the selected land types, the predominant farm types are studied in depth over time. This occurs while other research is ongoing and continues throughout the testing phase. This analysis concentrates on the biological and economic performance of the existing systems and its components.

In mixed farming systems, particular attention has to be paid to the competition for farm resources--cash, labor, and land at certain times of the year--and to input transfers between subsystems--crops as feed, manure as fertilizer, animal power, etc. The particular roles that livestock play in the farm enterprise have to be clearly defined.

Design of Alternative Systems

This includes the design of alternative cropping patterns, feeding systems, animal housing, and management methods that are well adapted to the area. The design of alternative production methods takes into consideration the physical and socioeconomic site characteristics, the performance of the existing production methods, and the available component technology for the crops and animals in the farming system. There are numerous practices that must be specified at the design stage. Many can be specified on the basis of existing knowledge and local methods. Others warrant separate experiments to establish optimal input levels or time and method of application. This component technology research may be conducted in national, regional, and local experiment stations or, where possible, on the farming systems research sites.

Testing of Alternative Systems

This involves the testing of the designed systems or selected management components in their respective environments on the farm. Farmers participate in the testing by managing the crops and animals according to the designed methods, with frequent advice from and constant monitoring by the research staff. Based on the biological and economic performance of designed systems, problems that limit the intensification of production can be identified and fed back to discipline- or commodity-oriented researchers. This scheme helps orientate such research to solve relevant problems of the target farmers.

The evaluation of alternative systems involves careful analyses of the performance of each component management change in terms of its contribution to farm productivity. Where possible, a whole-farm analysis has to be used to evaluate the performance of a number of changes in management components that constitute the alternative system under evaluation. Farmers' observations and their tendency to adopt changes in the study area are important means for the evaluation of alternatives.

Extrapolation Areas

When acceptable production alternatives have been identified, greater benefits from these research results can be achieved by their extrapolation to a wider area. Identification of similar land types and confirmation of the suitability of the new production methods to those environmental homologues is a necessary step prior to extension activities.

Pilot Production Program

The on-farm testing and the identification of extrapolation areas for the recommendation have, at this stage, provided substantial information about the performance of the new production methods. A pilot production program is often advisable before embarking on large-scale extension activity. Such a program generally starts off in the original testing area and has the objective to identify the institutional support and intervention required to assure the successful introduction of the recommendation. If successful, this experience will provide the information needed in the design of a full-fledged production program.

OBJECTIVES OF FARMING SYSTEMS RESEARCH (FSR)

An overview of FSR practiced throughout the world indicates that the formulation presented above is not generally practiced. It appears that the all-embracing nature of the term "farming systems research" has led to a wide variety of activities. These differ considerably in objectives and in the way the research is conducted.

Description Research

In this type of FSR the objective is to document and compare existing production systems in biological, economic, or social terms. The research is often confined to farm surveys, generally conducted by persons not from the target area. Results of this research are often used in sector analyses on the cost and benefits of the production systems. When the research considers dynamic aspects of the production system, the objective is often to arrive at a mechanistic model of the system, which can then be used to identify production constraints or set research priorities. These studies have led to a considerable broadening of our knowledge of farming systems and their adaptation to widely different environments.

Methodological FSR

It is not appropriate for international agencies to assume the responsibility for FSR in each environmental complex of the world. Fine tuning of technology for individual environments is appropriately the responsibility of national research organizations (Flinn and Denning 1982). This concern has led most international agricultural research centers to concentrate on methodology development, training, research on key technological components (bottlenecks), and the analytical support of FSR research in national programs.

Experiences of these centers show that to play this supportive role their staff must be actively involved in the application of FSR in a few target areas. This assures a continuous testing of methodological innovations and a thorough familiarity with the operational constraints to on-farm research. International center scientists must also recognize that they are developing research methods that will be used by field teams in which few persons have advanced degrees. The research methods must therefore be operationally simple and should not conflict with all the all-important cordial relationship between the research teams and farmers. I strongly recommend that research methods be developed in collaboration with national program leaders and that a continuous dialogue be encouraged about the place of FSR in the national research system.

Interventionist FSR

Whether conducted by international centers or, as will be more commonly the case, by national research institutes, the prime objective of crop-animal systems research must remain the identification of improved production methods that are acceptable to farmers in the selected land types. This research activity should not degenerate into one that is primarily descriptive. It should consist of experimentation with improved production methods that has been carefully structured to address the major constraints to improvement of the existing system.

The selection of variables to be studied, e.g., pasture varieties, frequency of milking, improved parasite control, or feed storage techniques, and the design of alternatives must be based on a continuing analysis of the existing system. This should include ex ante evaluation of how suitable these alternatives would be if they were to function as expected.

EXPERIENCES IN ON-FARM CROP-ANIMAL SYSTEMS RESEARCH

There are few examples of on-farm research that combine the study of changes in the crop and the animal enterprise (including crops only for forage or fodder in the latter). Most FSR has concentrated on farms in which the crop enterprise dominates (often underestimating the contribution of animals) or dealt with farms that specialize in animal production.

Considerable component technology research has been conducted on improved forage crops, the use of by-products, and feed-storage methods. Recently, more attention has been given to the identification of techniques that modify the crop production system to increase the production of animal feeds. Outstanding examples are the judicious pruning of the sweet potato or cassava canopy to provide high quality forage (CATIE 1978) and the detasseling of maize (Cormick and Kirkby 1980). However, these techniques have not been evaluated in the farm setting as part of an improved crop-animal system.

Excellent diagnostic research has been conducted. This has greatly improved the focus of a number of research programs (Avila et al. 1980; IDIAP 1980). These studies have also led to the establishment of small farm simulations on experiment stations (CATIE, IVITA). Such simulations (modules) were found to be excellent research tools to arrive at an understanding of the production system and to allow pretesting of alternative systems before their final evaluation with cooperating farmers.

The animal production programs at CATIE and IDIAP have also evaluated alternative production technologies in on-farm tests. CATIE has successfully applied the results of its milk production module in the Parruas Integrated Development Project (Avila et al. 1980). IDIAP has developed cooperation on six evaluation farms in three regions of Panama in which the improved dual-purpose production system will be compared to six check farms. These exciting programs, however, are confined to specialized animal production enterprises.

Description or Diagnostic Studies

During the last five years, continuous change took place in the methods for the description of the existing production systems in selected target areas. Initially, elaborate farm surveys were the norm. These were generally static (once over) in nature and depended considerably on farmers' recall of events in the production cycle. Many researchers found this approach cumbersome and felt that limited insight was obtained about biological or socioeconomic production constraints. Increasingly, initial surveys have changed towards more interactive studies that focused on or perceived constraints. These surveys began to employ

interdisciplinary research teams with less input from interviewers. They continuously incorporated their findings into a generally agreed-upon format and adjusted their questioning of farmers, community leaders, and key informants towards aspects that required further elaboration. This approach has allowed a much quicker start of experimental work on key components.

The reduced duration and cost of the diagnostic study were also encouraged by an increasing awareness among applied research teams that the descriptive component of FSR continues during the experimental research phase. Farm record keeping, generally on a small number of case farms or selected subenterprises (e.g., crop, swine enterprises), continuously refines the teams' understanding of the performance of the existing system. A major advantage of this approach is that the performance of the existing system becomes understood in comparison with a number of alternatives. For example, knowing that digestible dry-matter yields of native pastures range from 0.5 to 0.9 t/ha/month during the rainy season has considerably more meaning if it is also known that these can be increased to 1.5 to 2 t/ha/month with a change in species and additional inputs.

The diagnostic phase of FSR also improved in efficiency because FSR researchers gained experience in identifying which variables were critical and which variables could be measured at a later stage. In this respect, further work is needed towards simple graphic representations of the mixed farm and the contributions of the subenterprises to each other, to the farm family, and to the market and vice versa. Presentations such as those used by McDowell and Hildebrand (1980) and those developed by Hart (Hart et al. 1982) provide an excellent insight into the interactions and limits that operate on the farm.

Other aspects of the descriptive phase that merit further debate and definition are:

- The stratification of crop-animal production systems. Are these best stratified by the predominant type of crop and animal enterprise, such as maize/beans and pasture + milk cow and bullocks, or should there be a more general approach that employs characteristics of the farming systems structure as differentiating criteria, such as the relative subsistence vs commercial aspects of each enterprise? Other examples of structural variables are: the extent to which each enterprise uses off-farm links for inputs or depends entirely on on-farm generated inputs, and relative land use (e.g., shifting, rotational, sedentary fixed, sedentary with on-farm rotation).
- Further indexing of crop-animal systems. This is required by regional or international research groups and will allow more comparisons between systems and a greater understanding of the relationship between a system's performance and its endowments.
- The attention given to the multiple objectives of the animal enterprise in descriptive studies and schematic presentations of farming systems. This shortcoming is less severe for the crop enterprise, although shade, litter formation, dry-season feeding of by-products or clippings and wet-season use of thinnings and weeds for feed are still often ignored. For the animal enterprise, the relative importance of its

multiple products for consumption or sale (milk, traction, meat, hides, fiber, heat, fuel, cooking fat), or for the function of the farm (e.g., security through savings, on-farm and off-farm scavenging [bees], recycling of nutrients, control of pests, capturing marginal labor) should be defined.

Design of Crop-Animal Systems

The design phase involves the formulation and ex ante evaluation of one or a number of alternatives for selected management components or subsystems. It also involves the design of research techniques that allows the evaluation of the performance of these alternatives in a background set of management methods that is as close as possible to that used by target farmers.

Some experiences in the design of technology that merit discussion are:

- Researchers only consider the biological and possibly managerial aspects of technology. Not enough thought is given to the relationship between on-farm technology and off-farm constraints. This is the concern expressed by Avila et al. (1980).
- The design process is a critical step in the functioning of cross-disciplinary research. Care must be taken to avoid disciplinary bias, and the team's energy should be channeled towards the synthesis of feasible and promising alternative production methods.
- Many FSR research programs have been hesitant to encourage field teams to include substantial changes in farming practices. This hesitation comes from numerous experiences of farmers' rejections to new technology. In part, this careful approach to the formulation is also a result of our avowed objective to generate technology that is acceptable to farmers. This has led to notions of incremental change and low-input systems becoming predominant in FSR circles.

One of the most common constraints of small-farm production systems is precisely farm size and the farmers' limited access to inputs that would increase production. These farmers often have excess labor or available labor can be created by increasing the labor efficiency of selected operations. Such labor can be invested in farm improvements such as field leveling or drainage, building of storage structures, or in secondary production processes often involving animal products. It can certainly be used to support additional labor demands that arise from a greater production of food or fodder crops obtained from changes in crop varieties and input levels.

It may be instructive for research teams to approach technology design with a knowledge of biological potential and an understanding of the yield gaps that operate to reduce production to the level observed on farms. Biological potential of forage production, for example, can be estimated from rainfall, evaporation, and temperature, and by making certain assumptions about the transpiration coefficient of the crop. Alternatively, the biological potential can be measured on experimental plots, assuming that researchers are aware of biological constraints. (Micro-element deficiencies, periods of soil saturation, and diseases can easily be overlooked.) By estimating the value of yield and production

losses, researchers can then identify which constraints, when removed, will be most efficient in improving production per unit cost. They can also estimate how much the additional inputs that are required for the removal of the production constraint are allowed to cost. (Less than one-half the value of the yield gap is a good starting point.)

Some of the reasons for the rejection of new technology by farmers are discussed below:

- Claims made about the benefits of technology are not realistic because yields are lower, costs are higher, or product prices and acceptability are lower than those assumed by the researchers.
- Infrastructural support is lacking because of lack of political will, poor management by the institutions involved, or weak design of institutional support programs (credit, input availability, marketing).

Extensive on-farm testing, careful economic analyses, and serious consideration of farmers' opinions help FSR teams avoid the problem of unrealistic claims. Researcher teams should be continuously reminded to be critical of the technology they test and to take farmers' comments seriously. The failure of the delivery system, or of production programs, has become a major concern of FSR teams. The major reasons for this failure have been that researchers were not realistic in their assessment of the type of infrastructural support that will be available and that extension staff had not participated in the selection of the target population and in the final evaluation of the new techniques to be recommended. It is important for researchers to discuss with extension groups the type of technology they are considering and to consult with them about the credit and input support this technology may require.

FSR research teams should also participate in the design of production programs to ensure that the institutional prerequisites of the new recommendations are met.

- Methodological issues involved in the pretesting evaluation of technological innovations have not been adequately explored (Flinn and Denning 1982). Procedures for ex ante analyses of the relative merit of alternative choices should be strengthened. Anderson and Hardaker (1979) conclude that skilled intuition, complemented with the careful application of simple budgeting-based models, remain the most useful techniques. Skilled intuition is, however, hard to teach.

  The ex ante evaluation of designed technology that influences both the crop and animal production enterprise becomes very complex. Particular attention will need to be given to avoiding conflicts of labor requirements (Price and Barker 1978). This has been the most common resource conflict in cropping systems research programs.

  The animal production subsystem can interact in many ways with the crop subsystem, and testing of substantial changes in animal production is difficult on small farms. For this reason, animal-production-systems

researchers recently have emphasized the need for whole-farm models. These models would be used to estimate the performance of designed component technology before on-farm testing. They would also be used to compare the performance of alternative subsystems that incorporate several technological innovations.

- More importance should be given to the objectives the farmer has for his production activities. The fact that he has a few pigs scavenging around the house does not mean that he necessarily should become a commercial swine producer who would depend on the availability of commercial concentrates and a veterinarian. Such a change may destroy the original objective of his keeping a few pigs as a low-risk, low-input activity on which he can fall back in times of need.

- Because FSR is not limited to a certain commodity, the number of possible research activities is often too great for the limited expertise that can be employed in a field team or national program. Research to improve any of the several subenterprises of a farm type requires access to genetic material and a range of management techniques. The research team must be familiar with these and must be confident in their ability to manage experiments that employ this new component technology. Often the availability of seed or the familiarity with new management methods is lacking. For these reasons, a careful choice of research emphasis must be made and generally only one or two subsystems can be considered as a research focus for an FSR team in a certain target area. In this choice, access to expertise and existing component technology and the expected impact on the farming system are, of course, important considerations.

The Testing Phase in Crop-Animal Systems Research

On-farm testing of new technology has many advantages. The farmer can participate in this evaluation while he is insured against serious losses. On-farm evaluation also reduces the chance that researchers will overestimate the benefits of new techniques because land type, climatic constraints, quality of land preparation, and times of establishment are dictated by the cooperating farmers.

The major problems associated with on-farm testing:

- It has been difficult to convince researchers that farmers can become partners in research. It will indeed be necessary to carefully explain to farmers that researchers are not sure of the outcome of their trials. The farmers are often unaware of the researchers' inabilities to judge the performance of a new technology without extensive measurement and repeated observations. On the other hand, farmers have also been found curious, eager to learn, and inveterate experimenters. In the case of animal production systems, problems of on-farm testing are even more serious because farmers are reputedly more reluctant to expose their animals to new feed sources or management conditions, and because the number of animals is often small, only one treatment can be tested per farm.

There is also an advantage in animal research. Animal performance, given a certain amount and quality of feed and certain health and housing conditions, is more predictable and less site-dependent than crop performance. For this reason, initial on-farm testing can be confined to a measurement of the effects of technology on those intermediate performance variables. In this respect, year-round feed availability and feed quality are the key concerns.

- Measurement and economic evaluation of the performance of technological components is an area of continuous concern to systems researchers. Considerable on-farm testing of cropping systems has shown the importance of limiting the measurement scheme to the most important input and output parameters associated with the components being tested. These intermediate measures of production should be augmented by aggregate measures of the performance of the subsystem or subsystems directly affected by the research intervention. An example may be the use of cassava pruning in the feeding regime of two milk cows. In this case, labor inputs, yield of cassava tops and roots, and the performance of the cows should be measured. In addition, an overall analysis of the combined crop-animal enterprise is required so that it can be compared to that of farms on which cassava was not pruned. In the case of modifications to the animal production system, multiple products, the use of by-product feeds whose costs are difficult to measure, and very fractionated labor use make record keeping difficult. The use of partial budget analysis may become increasingly difficult if simultaneous changes are made in the crop and animal production enterprises of the farm. Also care must be taken not to overlook the effects on labor inputs or productivity of activities elsewhere on the farm.

  The simulation or linear programming models that were suggested to evaluate ex ante the performance of designed "technology" can be used for testing. Observed yields and labor and material inputs for the components being tested can be employed together with the observed aggregate performance of the subsystems involved.

Institutional Aspects

The experiences gained in cropping systems research in Asia were strongly based on an institutional model (Table 1). This model considers a national research program in which area-specific systems research is conducted by interdisciplinary teams of three to four professionals with locally hired technicians and village assistants. These teams are supported by a technical committee of experienced farming systems researchers that can provide support in the design of technology and in the design and execution of research on the site. Through decentralization of research decision-making, the site teams must become increasingly instrumental in the formulation of their research. They must always be responsible for the initial analysis (be it graphic) of their results and for the presentation of these results to their peers and superiors.

Table 1. Division of Responsibilities Among Components of a National Cropping Systems Program

Program Component	Responsibility
Network of test sites	Site description, design of improved patterns, testing. Formulation of recommendations with support from Technical Support Team(s) (TST).
Regional research stations (Commodity and disciplinary programs)	Component technology research; varietal screening, long-term cropping pattern trials; performance of agricultural chemicals; operational support to nearby sites.
Technical Support Teams (TST)	Full-time team. Visit test sites to provide support in research design, experimental design, analyses and interpretation; ensure feedback on technical and operational problems to the Cropping Systems Program Committee (CIP). Identify trainees, serve as trainer, organize workshops, combine site results.
Coordinated interagency Cropping Systems Program Committee (CIP)	Sets policy, selects sites, structures staff complements at sites and in technical support teams, monitors methodology used, ensures feedback to commodity and disciplinary programs or departments, identifies training needs.
Commodity and disciplinary programs or departments	Conduct research on aspects of component technology, environmental classification, research methods, and problems identified in on-farm test sites.

Source: Zandstra 1980.

Scientists involved in the development of research methods for crop-animal systems research must give serious consideration to the technical level of personnel who will be asked to do on-farm research in national programs. Research methods for on-site research teams must be simple enough for good B.Sc. level professionals, and analytical techniques should be such that they can be managed with hand-held calculators.

Farming systems research teams are expected to deal with a wide range of concepts and must therefore be trained in the observational and experimental methods required for field-oriented systems research. Initially, such training can only be obtained from experienced researchers at international and regional centers. Increasingly, national technical committees will take on the responsibility of training-site research teams.

The site research teams are completely dependent on provincial and national research centers for their awareness of new component technology. They should have access to a range of varieties of the crops with which they work and to the agricultural chemicals or supplements they may need to employ. They should be kept aware of ongoing research in the commodities they deal with through visits and publications. There is a great deal of truth in the observation that the success of FSR depends as much on the range of component technology available at the research site as on the methodological capabilities of the research team. Too often, a lack of viable, improved seed of forage crops and grain legumes limits the effectiveness of on-farm research.

The structure and leadership provided to interdisciplinary teams at the on-farm research sites or at the national or international research level are key elements in farming systems research (Flinn and Denning 1982). The most successful research teams have a sharp focus, are small (not more than seven persons), and are encouraged by the team leader to arrive at a consensus through mutual discussion among team members. It is therefore important to limit the scope of the teams' research activities to those farm enterprises on which they can have substantial impact and for which they have access to component technology.

CONCLUSIONS

The development of improved technology for small farms with animal and crop production activities requires a consideration of the whole farm structure and the environment in which the farm operates. Considerable advances have been made in the development of cross-disciplinary methods for research directed to this farm type.

The experiences in crop-animal systems are primarily from groups that focus on either the crop or animal enterprise on the farm, while giving due consideration to the effects of their research on the total farm enterprise structure. These experiences indicate that there generally exists considerable potential to increase the biological productivity of the farm. These increases depend, however, on the availability of new crop varieties or pasture species and the judicious application of agricultural inputs such as fertilizers, pesticides, and feed supplements. It is therefore important that on-farm research teams be assured access to seed of new varieties and are made aware of new production techniques.

Although research teams must continue to be critical about excessively increasing purchased inputs, this means of increasing small farm productivity should not be ignored. More work is needed to ensure that assumptions about the availability of credit and inputs be made in consultation with extension services and the institutions responsible for input and credit delivery to the farm community.

On-farm testing of crop and, particularly, animal production technology requires careful structuring and normally is associated with difficulties. With patience and sensitivity to farmers' limitations, and after considerable dialogue with farmers, many of the technological innovations can be tested as individual components under each farmer's management. There is, unfortunately, no sure way to predict the performance of alternative production techniques without having farmers evaluate them. Continuous efforts should be made to agree upon test arrangements with the farm community that protects individual farmers, allows monitoring of inputs and results, and allows researchers to differentiate with confidence between existing and introduced production methods.

Much of the crop-animal systems research has been conducted by international centers and highly qualified advisors to national programs. Such activities are necessary to develop the needed research techniques and to train future members of research teams. More emphasis should be given to the training of national

program research teams and the development of an on-site research methodology that can be managed by B.Sc. or M.Sc. level professionals who have received specific training in farming systems research.

Because of the wide scope of crop-animal systems research, research activities should be directed to a selected group of farms (land or farm-type) in defined areas. At the time of research design, care should be taken to focus research on a limited number of enterprises and only on their key management components. The research team must also be assured of access to improved varieties, chemical inputs, and new management techniques.

Farming systems research teams should be encouraged to participate in the design and monitoring of pilot programs for the extension of research results. Particularly where, during the testing phase, the evaluation of improved techniques could not be made with farmer-managed trials, pilot production programs provide the first realistic test of the recommended technology.

Many research workers have combined their experiences in the formulation of on-farm research methods designed to improve the crop and animal enterprise of small farms. Considerable farmer participation has helped guide much of this work. It appears that there is now a research method that can take into account the complexity of small farms and develop improved production practices that recognize the existence of the constraints under which the farmers operate. Experience has shown that there is considerable scope for increasing the profits from their crops or marketed produce--without unrealistic institutional demands.

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Crop-Animal Systems Research: The Experiences Of CARDI

P. O. Osuji and S. Parasram

INTRODUCTION

The Windward and Leeward Caribbean Islands have a total population (English-speaking) of over 500,000 on a land mass of approximately 2,500 hectares. The economies of these islands are dominated by an agriculture characterized by smallholder populations of low productivity. The traditional smallholder farming system is complex, comprising several enterprises or commodity lines that are grown in various sequences, frequently intermixed or overlapping on the same piece of land. These systems have evolved from experience to fit the availability of traditional resources and local conditions to satisfy the farm families' multiple, and sometimes conflicting, objectives. Although the general nature of these systems is known, little accurate information is available to describe the chronology of events during the year or the frequency or relative importance of the different systems and combinations. There is also an ignorance of the relative importance of the farm families' objectives, e.g., income, cash flow, labor utilization, nutrition, risk reduction, and of the capacity of the numerous systems to fulfill these objectives.

Traditional agricultural research, conducted almost entirely on the experiment station and on single commodities, has proven inadequate in providing answers for small farmers' complex systems. The problem is how to take the bits and pieces of successful biological research and fit them together with economic reality and cultural preferences to meet the needs of systems whose multiple ends are measured in terms different from those used in traditional research.

Over the past four years, CARDI has been doing on-farm research aimed at developing improved cropping systems through adaptive, farm-based research. The goal of this research effort is to increase the value of agricultural production in the Leeward and Windward Islands of the Eastern Caribbean through the improvement of small-farm profitability and small-farmer nutrition, and by generating employment. More specifically, the overall objectives of the CARDI project are:

- to establish cooperative host country-CARDI small farmer systems research programs in eight countries.
- to increase the understanding of smallholder farming systems, resources, and objectives through the creation of an agrosocioeconomic information base, obtained from surveys and on-farm research by multidisciplinary teams.
- to design improved smallholder farming systems based on the integration of proven crop and livestock technology with economic analyses that take into account profitability, cash flow, nutritional contribution, and labor utilization characteristics.

- to transmit information on smallholder characteristics and improved farming systems to extension and credit officers, planners, and other agricultural officials through publications, presentations, and field day activities.

The first part of this overview deals with the objectives of the cropping-systems project, policy and institutional issues, including the types of crop-animal systems being studied and descriptions of some of the small-farm animal production systems. The second part deals with methodology, some results, and an evaluation of previous experiences.

POLICY AND INSTITUTIONAL ISSUES

The CARDI Cropping Systems Research Project, in addition to generating an appreciable amount of baseline data, has forcefully demonstrated the importance of an integrated crop-animal systems approach when the objectives are to improve the profitability of small farms, enhance the nutritional well-being of the farm family, improve the stability of the farm system and generate employment. The importance of the animal component in the realization of these objectives has been clearly demonstrated by:

- the amount of time the farmer spends on his animals, even when the animal component is a supplementary enterprise, and
- the cash value and financial reserve role of the animals in the micro-economy of the small farm.

CARDI has therefore decided to redirect its research efforts to the study of integrated crop-animal systems.

Our approach is primarily geared to the development of the small farm. Thus, the Institute is examining the various milk and beef production models and swine and small ruminant systems appropriate to this target group. This emphasis is important because the meat and milk needs of the Region (Tables 1 and 2) will be met for a long time by the efforts of the so-called small farmers who have traditionally produced these commodities.

Table 1. Milk and Meat Imports into the Eastern Caribbean and Caribbean Community (CARICOM) (metric tons)

	Beef	Milk & Milk Products	Mutton & Lamb	Poultry	Pork
Eastern Caribbean*	1,055	6,342	225	5,006	2,072
CARICOM	14,573	54,790	3,484	33,193	9,438

* Cropping Systems Project Territories.
Source: Archibald, K. A. E. and P. O. Osuji (1977). Prospects for the Improvement of Livestock Output in the ECCM Countries.

Table 2. Milk and Meat Production in the Eastern Caribbean and CARICOM (metric tons)

	Beef	Milk	Mutton & Lamb	Pork	Eggs
Eastern Caribbean	1,277	8	127	468	n.a.
CARICOM	19,000	109	n.a.	n.a.	25,000

n.a. = not available.
Source: Archibald and Osuji (1977).

CARDI's current research activities relating specifically to crop-animal systems have been designed with these new research priorities in mind. Such current research activities include:

- forage legume/grass associations for grazing and cut-and-carry (zero grazing).
- utilization of crop by-products to supplement animal feeds in well-defined production systems.

CARDI has selected forage legumes for their nitrogen economy, yield, and adaptability to various pH and soil moisture regimes, as well as competitiveness with various grasses under different systems of grazing and cut-and-carry. The Institute has been able to bulk and distribute clean seed of recommended selections. An EDF-funded (European Development Fund), three-year Forage Seed Production Project will endeavor to provide the seed to improve a minimum of 700 acres of pastureland annually.

Traditionally, farmers have used a wide range of by-products as animal feed: peels from the kitchen and leftover food, canetops, coconut meal, oilcakes, rice and wheat middlings, bananas, etc. Brewers waste, bagasse, sorrel meal, citrus pulp and citrus meal, and cocoa pod meal also have been used. In an effort to maximize their use, CARDI is developing and testing rations based on these products.

While it is relevant to research these individual and integrated systems, a concerted effort is required to bring adequate evidence of the need for crop-animal integrated systems to planners, farming groups, and their service agencies. Particularly in the Caribbean, it must be recognized that:

- the development of a majority of small farms lies in having both animals and crops.
- these two components should be integrated fully.
- the milk and meat requirements of these small nations can be adequately met (both in quality and quantity) through such small farm systems.
- such systems will have greater <u>stability</u> through reduced risks. They will provide the opportunity for meaningful employment, nutritional improvement, and reduction of the national food-import bill.

The Institute is endeavoring to meet with national agricultural planning bodies to discuss this policy. This is the first step in establishing and implementing strategies for research and development. CARDI works side-by-side with the national governments to achieve these goals.

The Institute is confident that this is the correct approach and has the mandate of the regional ministers to pursue research and development activities on these lines and to provide <u>ad hoc</u> and technical assistance to member governments. However, the implications and usefulness of integrated crop-animal systems research are still not fully appreciated.

The Institute will never have the funds to keep the full complement of staff that such a task will necessitate, and we expect to complement our resources with those of other institutions that have the desired expertise. Such expertise must be available at short notice.

TYPES OF CROP-ANIMAL SYSTEMS BEING RESEARCHED

In this section, we first attempt to describe the types of animal production systems that have been found on the cropping systems research farms in the Eastern Caribbean. St. Lucia will be used as the example. Secondly, we will review some constraints to increasing the contribution of the animal component to the whole farm income, and finally we will give a resume of the forage-based systems that are currently being researched in Guyana and the Leeward Islands.

CARDI Cropping Systems

This research is farm based, thus the crop-animal systems studied are those that happen to be found on the cooperating farms. A list of the major crop-animal systems found on the target farms is presented in Table 3. The crop-animal systems found in the Windward Islands (i.e., the more humid countries of the Organization of Eastern Caribbean States [OECS]) differ from those found in the drier countries of the Leeward Islands. Also, within countries, the crop-animal combinations vary as one moves from the windward (wetter) to the leeward (drier) parts of the Islands.

Table 3. Major Crop-Animal Systems Found in the Windward and Leeward Islands of the Caribbean

Windward Islands	Leeward Islands
1. Bananas - Pigs	1. Root Crops, Vegetables - Cattle, Sheep, Donkeys
2. Bananas, Coconuts - Cattle	2. Vegetables, Root Crops - Cattle, Sheep, Goats, Poultry
3. Coconuts - Cattle	3. Peanuts, Root Crops, Cotton, Pigeon Peas - Cattle, Pigs
4. Root Crops, Vegetables - Sheep	4. Cotton, Peanuts, Vegetables - Cattle, Pigs
5. Scrubland - Goats	5. Sugarcane, Vegetables - Cattle, Sheep, Pigs
	6. Vegetables - Sheep, Goats

Animal Production Systems

Cattle. Among the larger farms, extensive cattle grazing is the main production system, utilizing indigenous pasture species and, occasionally, improved species such as Pangola grass. The main production system used by the small farmers is roadside grazing, cut-and-carry, communal grazing, and combinations of these with tethering. Animals usually are not housed; water is either taken to the animals wherever they are tethered, or animals are taken to watering points on roadsides or in the villages. Castration and dehorning are not practiced as a regular routine (the farmers utilize the horns in restraining the animals and also for tethering). Deworming, though practiced sporadically, is not a regular practice of management, nor is the provision of salt ticks. Often the cattle are kept for both meat and milk. The milk is mainly for home consumption, although some milk is sold by farmers with more than one cow.

Sheep and Goats. Extensive grazing, tethering, cut-and-carry, communal grazing, and the use of crop residues are the main features of sheep production. Goats, when kept, are often on the scrublands, as most small farmers recognize the incompatibility of goats with the major food crops grown by small farmers. Usually, and probably because of praedial larceny, sheep and goats are housed at night in small backyard sheds where additional feed can be provided.

Castration is not a common management feature, nor is dehorning. Small farmers know the value of deworming their sheep and goats, but due to cost and lack of expertise, farmers do not deworm their animals routinely. Attempts are made to rear lambs or kids on milk substitute or cow's milk.

Poultry. A large number of local creole dual-purpose birds are reared in the backyard where they scavenge for food. Some small farmers who grow vegetables in their backyard either have small fenced areas for these birds or small barbed-wire chicken coops. When a coop is provided, kitchen refuse or cracked corn and, occasionally, commercial feeds are fed to the birds.

Commercial poultry production is on the increase and the deep litter system is widely used. Small farmers seldom market dressed chickens, but occasionally sell live chickens.

Pigs. There are two distinct systems of pig production. The local pigs are allowed to scavenge or are tethered in the farmer's backyard. When improved breeds are kept, some form of housing usually is provided, often with a concrete floor. The Lehmann system of feeding is often used on small farms. Farm and kitchen residues, mainly succulents, are fed to the pigs. By-products such as coconut meal and/or wheat middlings and/or some fishmeal are used as protein supplements. One small farmer prepared his own supplement at home by mixing one bucket (about 4 kg) of copra meal with one kg of wheat middlings and about 0.25 kg of fish meal. Only a small amount of fish meal was used because of its high cost and the need to prevent fish flavor in the pork. Some farmers feed whole fish whenever they can purchase it cheaply.

While most small farmers who keep one pig, usually a boar, slaughter it for home use at Christmas, some farmers also keep sows to produce for sale weaner or finished pigs. However, the scarcity and high cost of feed seem to discourage farmers from the finisher operation, except on the few farms where pig production is a major activity.

Rabbits. Rabbit production is a backyard operation. Rabbits are reared in hutches made of cheap, locally available materials. Most of the rabbits produced are used for home consumption, or are sold to other farmers to start a rabbit operation.

Feed Resources. The main feed resources of the small farmer in St. Lucia are (1) crop residues from his farm (at present, relatively fully utilized); (2) copra meal; (3) wheat middlings which, until Hurricane Allen, were available from the local flour mill, now are imported from St. Vincent. Appendix I summa-

rizes the available or potentially available feeds in St. Lucia. The main problem with feeding animals in St. Lucia is the short supply of cheap feed, especially during the dry season when pastures are dry and there is limited vegetable production.

CONSTRAINTS TO ANIMAL PRODUCTION IN THE EASTERN CARIBBEAN

The main constraints to animal production in the Leeward and Windward Islands are:

- poor nutrition due to the seasonality and unavailability of local feed, poor quality pastures, and high feed costs.
- parasitism in animals with both ecto- and endoparasites. Lack of information among farmers plus inadequate supply and high cost of anthelmintics and tickicides have limited the productivity of most animal species.
- the market structure, lack of adequate transportation, wide differences between farm-gate prices and the retail prices, and the absence of market information to farmers. Animals are sold by sight, and pricing policy is consumer oriented.
- distance to processing facilities. The availability of processing facilities may increase the farmer's earnings through the value added to his processed products.
- pasture expansion limited by unavailability of suitable land. Most farmers are willing to expand only if they can obtain access to additional, suitable land.
- lack of suitable breeding stock for animal improvement, especially in ruminants.
- praedial larceny and predation by dogs, especially with small ruminants.
- poor management of animals, especially in housing, nutrition, and health.

METHODOLOGY

Cropping Systems

The methodology used in the Cropping Systems Project can be summarized as follows:

> A baseline survey of representative groups of farms was conducted, and from these groups, a subset of farms was selected for monitoring of inputs, outputs, and inventory changes. Based on the evaluation of the survey results and some of the monitoring outputs, a set of on-farm "interventions" was identified for implementation. The basic aim was to enhance farm productivity and allow for better resource use and improvement in farm income (Henderson & Gomes 1979; Rankine, Gomes, Ferguson & Archibald 1980).

Forage (Grass/Legume) Systems Project

The current CARDI projects in which specific crop-animal systems are being researched is the Forage Production and Utilization Project. Two projects are now

being implemented, one in Antigua (EDF funding) and one in Guyana (IDRC funding). They have similar and/or complementary objectives and approaches.

A production systems approach is used consisting of description, design, and testing activities. The description combines several sources of information into the design of the research or work program. These include:

- description of the existing production systems at Moblissa, Antigua, and on satellite farms, and identification of constraints to increased production and institutional limitations.
- review of existing pasture and milk/beef production research findings to identify component research to evolve technology that can be applied towards improving the existing system.
- use of early research results in subsequent designs to improve production systems.

The research design seeks to develop one or more improved production systems models, which are specified in terms of inputs, operations, and timing of operations required for seed production, pasture production, feed processing, and feed utilization (including grazing methods, concentrate feeding, zero grazing, herd management, and milking methods). As the improved production systems are designed, the needs for additional information on management components will be defined, leading to the component technology research that will be conducted during the next growing season.

The production systems designed will be compared to the existing system, and biological and economic criteria will be used to judge the performance of the system components and the system as a whole. The testing activity also will consist of trials and surveys conducted to test alternative components not yet included in the model systems. These alternatives may include rotational grazing, fertilizer application methods, concentrate supplementation, feed storage techniques, and other aspects considered to have potential for improving the initial specification of the model system.

RESULTS

The cropping systems project has produced much information on the characterization of small farms in terms of human, physical, and input/output activities. Importantly, we have gained a strong appreciation of the need for, and the role of, integrated crop-animal systems on the small farms of the Eastern Caribbean.

Case studies have been done by our cropping systems group. We now have a fuller understanding of small farms and small-farmer practices and needs, and we are better able to design and implement effective improvements on these farms. A set of animal production alternatives that we have identified are presented in Appendices II and III.

The forage systems project not only provided the capability to produce legume and grass seeds, which otherwise would have to be imported at very high foreign exchange costs, but also clearly demonstrated (Tables 4 and 5) the efficacy of using forage legumes as protein banks on small-farm plots. The legumes more frequently recommended are the browse types like Leucaena leucocephala. In the drier territories (Antigua, St. Kitts/Nevis, and Carriacou in Grenada), the use of protein-energy banks has been found to be very useful in helping small farmers deal with the perennial problem of feed scarcity and stock deaths during the dry season. The grass of choice has been Elephant grass (Pennisetum purpureum), but Guinea grass (Panicum maximum) also has been used.

Table 4. Quantity and Species of Legume and Grass Seeds Supplied to Farmers or Institutions

Species	Variety/Accession	Quantity Weight of Cleaned Seed (kg)
A. LEGUMES		
Leucaena leucocephala	"CARDI Cunningham"	60.2
N. wightii	CFI 52614	20.5
M. atropurpureum	"Siratro" & Y61	9.5
Desmodium spp.	CIAT 335	3.9
Centrosema spp.	CIAT 438	0.9
T. labialis	CPI 52793	2.0
Legume mixture	-	3.0
Miscellaneous* (experimental quantities)	-	3.6
B. GRASSES		
P. maximum	"Antigua"	28.5
B. decumbens	CIAT 606	0.3
A. gayanus	CIAT 621	0.3
C. OTHERS		
Azadarachta indica	"Neem"	0.5
TOTAL		133.2

* S. hamata CIAT 118; Codariocalyx gyroides CIAT 3007; S. guianensis "Endeavour"; Macroptilium spp. CIAT 535; Desmodium heterophyllum CIAT 349; Pithecellobium unguis Cati L. leucocephala "Giant Selected".

Table 5. Quantities of Legume and Grass Seeds Supplied to Various Countries

Country	Legume Seed Supplied (kg)	Grass Seed Supplied (kg)	Total (kg)
Barbados	31.0	-	31.0
Dominica	1.0	-	1.0
Jamaica	16.05	0.5	16.55
Montserrat	7.0	-	-
Nevis	11.0	5.0	16.0
Panama	6.25	-	6.25
St. Kitts	6.05	5.1	11.15
St. Lucia	3.82	-	3.82
Tobago	5.0	-	5.0
Tortola	5.0	1.0	6.0
Trinidad	1.35	13.0	14.35
Turks & Caicos Islands	10.05	4.5	15.05
TOTAL	102.6	29.1	133.2

Another important output of our forage-systems project is the successful production of a leucaena leaf-molasses-urea-mineral supplement. We have demonstrated that this supplement (in addition to helping to feed animals during the dry season when they usually lose weight) can yield gains (0.5 kg/day) in Senepol bulls as great as those from a commercial protein block (0.57 kg/day).

APPRAISAL OF CURRENT RESEARCH ACTIVITIES

This project has increased our understanding of the small farmer, his farm systems, and his problems, while highlighting a number of very important issues such as institutional policy and effectiveness. The multicountry location of CARDI staff and projects no doubt creates problems of both logistics and administration. This is further aggravated by the lack of effective, reliable, and rapid communications. The cost and time implications of these are obvious.

In retrospect, we feel that the cropping-systems project would have been improved considerably if there had been fewer farmers and countries involved, thus enabling a more in-depth study of the representative farms. The farm monitoring exercise could have been more effective, even with fewer visits, if a more functional and readily analyzable monitoring schedule were used by a multidisciplinary team. The sheer size and number of farms involved tied up staff time and overloaded our analytical facilities.

More workshops at the planning, project design, and evaluation stages of the project are clearly needed. These workshops, in addition to bringing together the project staff, should also involve specialist resource staff members. Our experience has been put to use in our Forage Systems Project in Guyana, where we have just concluded a very useful project design workshop.

The problems of delays in recruiting suitable staff and the costs involved suggest the need for precise phasing of operations, both within and between countries. In our project, while there was some phasing, we attempted to tackle many countries simultaneously, thus over-extending both our resource and field staff.

There is also a need for adequate biometrics support in the design, implementation, and evaluation of all the survey and test data. Our biometrics services were over-extended by the volume of material to be handled, and future projects must provide for their own biometrics support.

Finally, and probably the most unfortunate part of the cropping-systems project was that it was called "cropping systems" and not "farming systems." The use of the term "cropping" or "multiple cropping" led to very serious misconceptions in the minds of our field staff who thought that animals were not included. This may have caused bias at the ministry level (when lists of farmers were compiled during the baseline survey) and in the emphasis given to the animal component in the monitoring exercises. However, it is reassuring that as a result of our experiences in this project, CARDI has made the policy decision to redirect its

efforts towards the promotion and study of the integrated crop-animal systems among the small farmers of the Eastern Caribbean. This will be the thrust of our future efforts.

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APPENDIX I

Animal Feed Resources of St. Lucia

Feed	Quantity available (tons)	Comments and season when available	Cost/lb (EC cents)
Copra	5,239	Year round	13
Bananas	22,500	Year round	17
Mangoes	8,482	Seasonal (30% wastage)	-
Cocoa	-	Seasonal. Pods could be used for animal feeding	-
Breadfruit	-	Mainly human food	-
Root crops (sweet potatoes, cassava, yam, aroids)	-	Vines and damaged roots available for animal feed	-
Brewers grain	80 metric	One brewery now used at Govt. farm in Veauxfort	
Citrus			
Slaughter house offals	-	Poultry offals available for pig feeding	
Wheat middlings	-	Now imported	21
Fish meal	-	Now imported	60
Leucaena	-	Growing wild	-

APPENDIX II

General Recommendations of Interventions for all Territories

Current Situation	Proposed Intervention	Suggested Procedures
On-Farm		
I. Animal Nutrition Undernutrition and malnutrition promote disease susceptibility and inhibit productivity. Energy sources are generally in good supply (except during drought) but protein, minerals and other essential nutrients are often inadequate.	A. Provide balanced rations, esp. protein and mineral supplements to energy resources.	1. Protein sources--legumes, fish by-products, molasses-urea, cottonseed, sweet potato vines, insects. 2. Mineral sources--steamed bone meal, egg shells.
	B. Augment feed resource base with emphasis on ensuring adequate nutrient supplies in all seasons.	1. Feed preservation when available in excess for use in season of scarcity: solar drying, hay making under shelter, steel drum/plastic bag ensilage. 2. Forage harvest from food crops--sweet potato vines, maize thinnings, leaves harvested from growing plants. 3. Catch crops (usually grass/legume) grown between food crop seasons. 4. a. Highly productive grasses on marginal lands, field borders (Napier, Guatemala); frequent harvest schedule essential to good nutrient quality of these grasses. b. Legumes grown on marginal lands, field borders (leucaena). 5. Improve utilization of crop residues and agri by-products (reject bananas, copra, cottonseed).
II. Animal Health Poor nutrition and parasitism are the primary health problems affecting animals on small farms. Future introductions of breeding stocks, increased tourism, and other such contacts with other countries provide opportunity for introduction of disease.	A. Improve nutritional status.	1. Suggested procedures in previous section apply here. Additional attention should be given to nutrition of young stock to improve postnatal survival (e.g. iron supplements to newborn pigs).
	B. Treat for parasitism.	1. Regular drenching for endoparasites (primarily worms) should be instituted. Periodic treatment should coincide with parasite life cycle (often 3-4 weeks.) 2. Regular dipping or spraying for ecto-parasites (primarily ticks). 3. Routine health monitoring of local stocks; quarantine and inspection of all introduced stocks. Maintain stand-by readiness for vaccination and other action in case of major disease outbreak.

Appendix II continued.

Current Situation	Proposed Intervention	Suggested Procedures
III. Genetic Improvement		
Little attention has been given to improving genetic potential for productivity (meat, milk, eggs) under conditions of small farms.	A. Improve genetic potential for production and reproduction traits and eliminate effects of inbreeding. B. Small farmers should have access to these superior breeding stocks on an affordable basis. C. Management interventions should be introduced to ensure that the genetic improvement program is effective. These interventions include nutrition and health interventions to allow attainment of genetic potential, controlled matings to avoid inferior males (also, castration of such males).	1. Improved genotypes should be introduced through AI or importation of males. Initially, improved stocks should be kept in government multiplication centers to ensure proper management. Subsequently, their progeny should be distributed (preferably sold at reasonable prices) to small farmers. 2. Emphasis should be on multiple purpose genotypes (meat-milk, eggs-meat) rather than specialized types; adaptation to local conditions is a necessary condition to selection for high productivity. 3. Attention should be given to choice of species to be improved as well as the traits to be improved. For example, the feed resource base in some territories is nonruminants. Moreover, the dual-purpose goat may be better suited to the needs of small farmers than the dual-purpose cow. 4. Numbers of females (cows, ewes, does, sows, hens) per small farm will often be insufficient to justify keeping a male for breeding. Communal studs or private studs can maintain superior males to service females on nearby farms.
IV. Animal Management		
Animal and feed resources available to small farmers are limited in both quantity and quality. Management strategies to make optimal use of these limited resources have been given little consideration. Modern advances in knowledge and low cost, practical technology can have significant value to small farm productivity, if applied under good management.	A. Implement improved management strategies and techniques. 1. Feed resources 2. Animal resources 3. Animal products	1. Animals should have access to feed at least 10 hours per day. This will generally require longer grazing periods and cut-and-carry feedings during night confinement for ruminants. 2. Feed resources should be preserved in periods of seasonal excess and stored until needed in periods of scarcity. Care in storage is necessary to preserve nutritional qualities. 3. Housing for rabbits and poultry should be provided to protect against predators, especially rats. Solar-powered electric fencing can provide protection from dogs as well as controlling stock movements. 4. Inferior males should be castrated (or preferably short scrotum) to prevent unplanned matings. 5. Good quality drinking water should be readily available. Hydraulic rams can provide water from otherwise inaccessible sources. 6. Local community or on-farm preservation of animal products: hot water bath pasteurization; smoked, pickled and solar dried meat; home tanning.

Appendix II continued.

Current Situation	Proposed Intervention	Suggested Procedures
V. Policy and Institutional Interventions		
Factors beyond the small farmers' control are often significant constraints to the improved productivity of the animal component of small farm. These factors are discussed in some detail in the text of the report and are only listed here.	A. Provide mechanisms to ensure that small farmers receive fair market value for animal products.	1. Remove price controls on locally produced animal products. 2. Provide grading standards that allow price differential for different quality. 3. Facilitate communication of fair market prices so that seller is not at a disadvantage to middlemen or other buyers.
	B. Develop marketing infrastructure to support animal agriculture.	1. Develop marketing cooperatives, processing facilities, and other means to facilitate marketing of animal products. 2. Improve access to unborn markets, both local and export.
VI. Farm Management	A. Simple farm records	1. Provide simple farm accounting records. 2. Provide simple animal performance records.
	B. Extension, education and information.	1. Provide fact sheets, audio/visual materials, etc., on optimum marketing times, market intelligence, and new technologies. 2. Provide periodic evaluation of farm performance.

APPENDIX III

Suggested Priority Interventions

	Nevis	Antigua	Montserrat	Dominica	St. Lucia	St. Vincent	Grenada and Carriacou
I. Animal Nutrition Interventions A & B (cottonseed in the Windward Islands and bananas in the Leeward Islands)	XXX	XXX	XXX	XXX	XXX	XXX	XXX
II. Animal Health	XX	XXX	XX	X	X	XX	XX
III. Genetic Improvement Cattle Sheep & Goats (Leeward Islands & Carriacou) Pigs (Windward Islands) Poultry	XX	X	X	X	X	XX	X
IV. Animal Management	XXX	XX	XX	XXX	XX	XXX	XXX
V. Policy and Institutional Interventions	X	XX	X	XX	X	XX	X
VI. Farm Management	XXX	XXX	XXX	XXX	XXX	XXX	XXX

Note: The interventions for specific territories have been ranked for purposes of implementation. Highest Priority - XXX; Moderate Priority - XX; Low Priority - X.

Crop-Animal Production Systems Research At CATIE

M. E. Ruiz

BACKGROUND

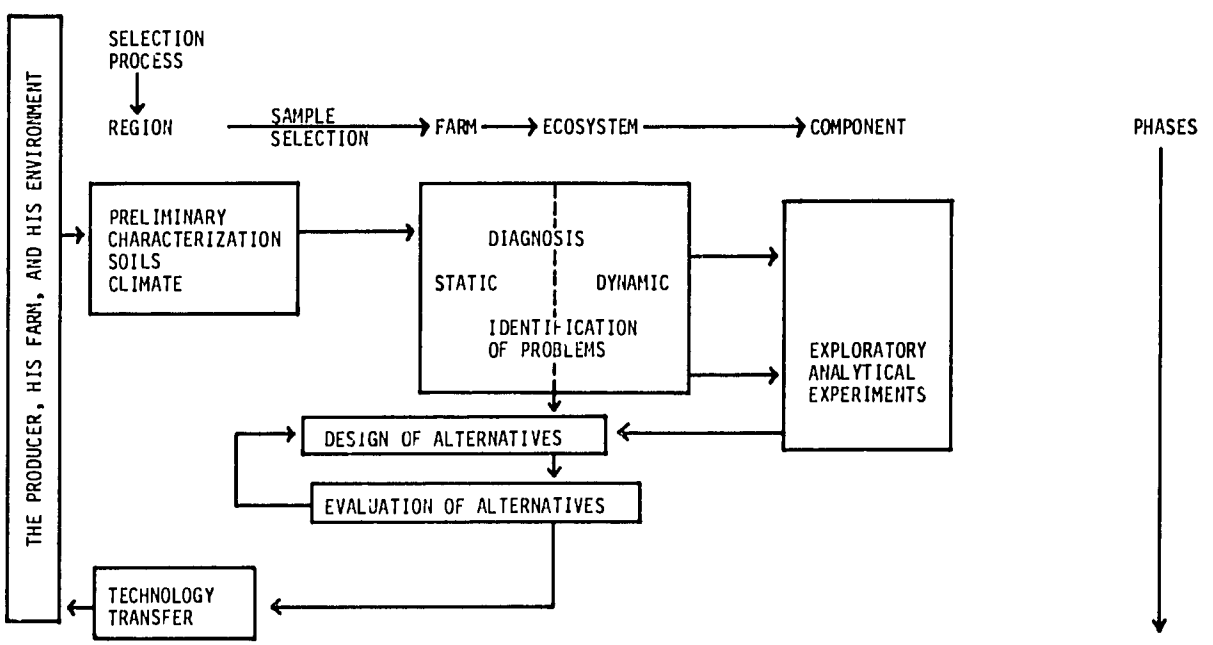
Since its beginning in 1973, CATIE has directed its resources toward the betterment of the welfare of small producers in tropical America through the improvement of crop, livestock, and forestry production systems.

Research has been concentrated in the countries of the Central American Isthmus where strategies have been guided by the knowledge that approximately 70% of the food available in the region is produced on small farms of less than 35 ha. The major products on these small farms are maize and beans. Approximately 80% of these farms have livestock for the production of meat and milk, and most such farms have swine, chickens, and some forestry resources in their production schemes.

In studying these systems of production, CATIE has adopted an interdisciplinary, regional focus that includes the active participation of the collaborating national institutions. The ultimate objective of all research at CATIE is to generate recommendations for production systems of the small farmer. Thus, a detailed knowledge of the environment of the producers and their systems is essential, and obtaining such information has required the study of areas with high concentrations of small producers. These farmers are included in the diagnostic phase of the study, in the identification and the selection of problems, in the design of alternatives, in the conduct of the principal investigation, in the validation of the production model, and in the evaluation of alternatives. The methodology employed in this process of research has been described by Borel et al. (1982) and is summarized in Figure 1.

To date, CATIE has not fully applied this methodology in the research of crop-animal systems. However, a project funded by the International Research Development Centre (IDRC, Canada) since 1976 has studied the use of tropical crops and the residues of these crops in the feeding of dual-purpose cattle. Since 1978, CATIE also has conducted a project funded by AID/ROCAP that specifically contains provisions for working with mixed systems; however, such research was not begun until 1981. Consequently, for purposes of this report, most of the information about crop-animal systems at CATIE has been provided by the CATIE/IDRC research project.

Figure 1. Phases in a Methodology for Production System Research



EVIDENCE OF MIXED SYSTEMS ON SMALL FARMS

Various diagnostic studies of small producer farms have been made in all the countries of the Isthmus of Central America (except Belize), and most of these studies have found that such production can be described as mixed agriculture, combining livestock with crops. For example, in Costa Rica surveys in four different areas produced the results shown in Table 1.

Table 1. Type of Livestock Production Associated With the Production Systems of Small Farms of Costa Rica and Percentage of Farms in Each System

Small Farm System	Meat Production	Dairy	Dual-purpose
Only livestock	2	36	62
Livestock and annual crops	0	3	97
Livestock and perennial crops	2	14	84
Livestock and both annual and perennial crops	0	2	98

Source: Pezo et al. (1979).

Only two types of interactions were found at the farm level: (1) the competition for resources that begins at the moment the producer decides upon the proportion of land, labor, and capital that should be devoted to the subsystem, and (2) the interaction of the agricultural residue and by-products used in the feeding of animals (Table 2).

Table 2. Supplemental Feedstuffs and Percentage Used in the Feeding of Livestock on Dairy and Dual-purpose Farms in Costa Rica

	Dairy %	Dual-purpose %
Farms that use supplementary feedstuffs	41	37
Type of supplement:		
Commercial concentrates	75	12
Cane molasses	50	25
By-products of bananas	62	65
Sugar cane	12	28
Others	19	17

Source: Ruiz (1981).

The data in Table 2 reflect only the proportion of farms using the indicated practices; the percentages do not indicate the importance of the agricultural products derived in the total program of feeding.

METHODOLOGY FOR THE DEVELOPMENT OF SUBSYSTEMS FOR FEEDING ANIMALS WITH CROPS AND CROP RESIDUES

The conceptualization of the CATIE/IDRC project referred to above has included the development of a methodological scheme (Figure 2) that can be applied to the objectives of this Workshop on mixed systems research.

Figure 2. General Scheme for the Research Program of the Project "Milk and Meat Production Systems for Small Producers, Using Crop Residues" (CATIE/IDRC Project)

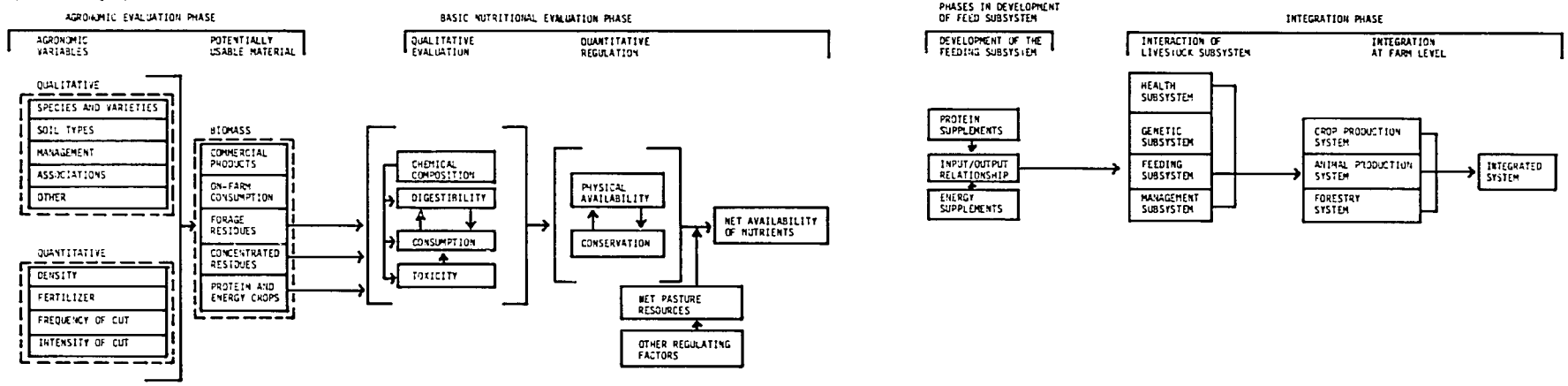


Figure 2 indicates that CATIE has attempted two types of experimentation, each identified by two types of crop-animal interactions: (1) evaluations of crop residues as a feed for ruminants, and (2) modification of the agronomic management of tropical crops with a view to their use as a feed source for animals and for humans (dual-purpose crop). More recently, the CATIE/ROCAP project has adopted this methodology in its work with small ruminants.

An excellent example of the first type of interaction is a series of experiments (Lozano et al. 1980a, 1980b; Ruiz et al. 1980) on the use of bean stubble as a feed for cattle. This series was initiated because the bean crop is one that is cultivated by small producers. The amount of bean stubble produced under various cultivation conditions was quantified (Figure 3), and the findings indicated a reduction of almost 50% in available stubble when the bean crop was associated with another crop.

After establishing the quantitative importance of bean stubble, the researchers evaluated the chemical characteristics and potential digestibility of the stubble to determine the appropriate nutritional additives that might be required. The principal limiting factor of bean stubble is its low protein content, plus a substantial lack of energy content. These limiting factors were taken into account in trials of voluntary feed intake, the results of which served as a base for production trials. These trials were designed to establish input/output relationships (and input/input relationships) that could serve in the development of feeding alternatives at the level of production desired. Figure 4 shows the results of a production trial with the use of bean stubble and various types of supplements.

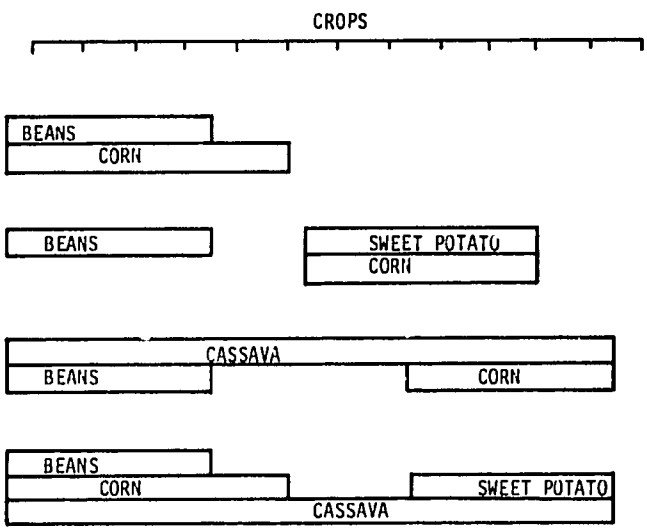
The use of the sweet potato crop for animal feeding (Backer et al. 1980; Ruiz et al. 1980) also illustrates the type of research that CATIE has undertaken for the development of mixed crop-animal systems. Table 3 summarizes the characteristics of the use of this crop for both crop and animal production. The animal production data is based on the use of sweet potato as a forage and a proportion of roots that are not used for human consumption; but the implication is that all of the crop could be used for animal feed if the economic situation warranted this use.

Table 3. Crop Production and Meat Production Systems Based on the Cultivation of Sweet Potato on One Hectare

Crop Production		Meat Production	
Area considered	1 ha	Green matter of aerial portion	13.00 MT
Variety of sweet potato	C-15	Green matter of discarded roots	1.80 MT
Cultivation cycle in days	150	Urea	1.1%
Sale of 88% of tubers produced	13.20 MT	Minerals and vitamins according to NRC tables	--
Sale price per kg of tuber	US $ 0.13	Consumption kg DM/animal/day	4.91
Total cost	US $660.00	Number of animals	5.50
Profit	$152.00	Number of days of feeding	100.00
		Kg of weight gain/animal/day	0.71
		Total cost/animal/day (US$)	0.28
		Price/kg of live weight (US$)	0.58
		Profit, %	48.00

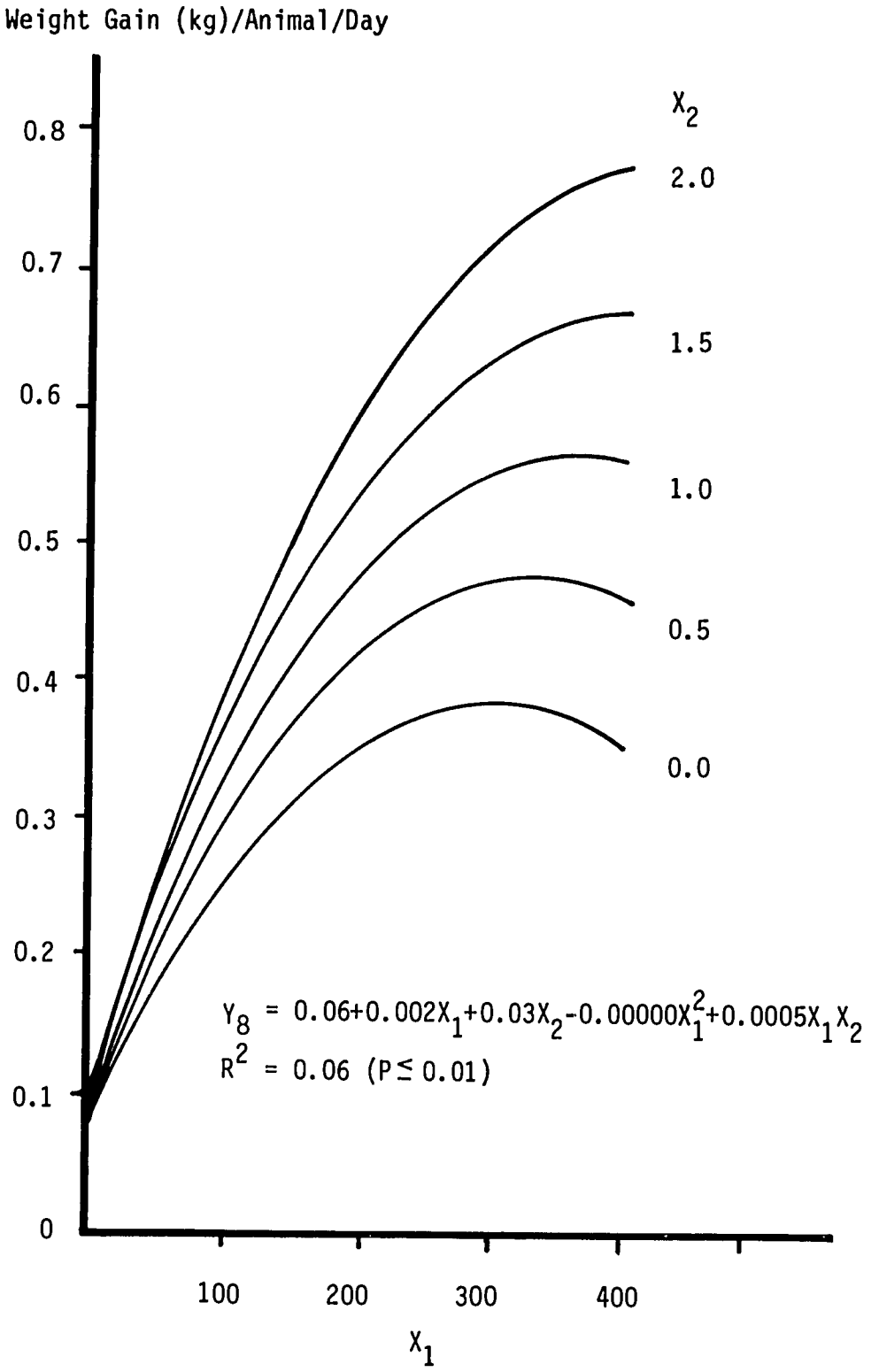
Source: Ruiz (1981)

Figure 3. Production of Bean Stubble on Central American Farms



FERTILIZER Kg/Ha		STUBBLE Kg/DM/Ha/Crop
$(NH_4)_2 NO_3$	KC_1	
125	23	631
81	4.5	1028
125	33	888
125	4.5	610

Figure 4. Weight Gain in Bull Calves Fed Bean Stubble, Supplemented With Protein and Energy (X_1 = g Crude Protein/100 kg LW/day, (X_2 = kg Molasses/100 kg LW/day)

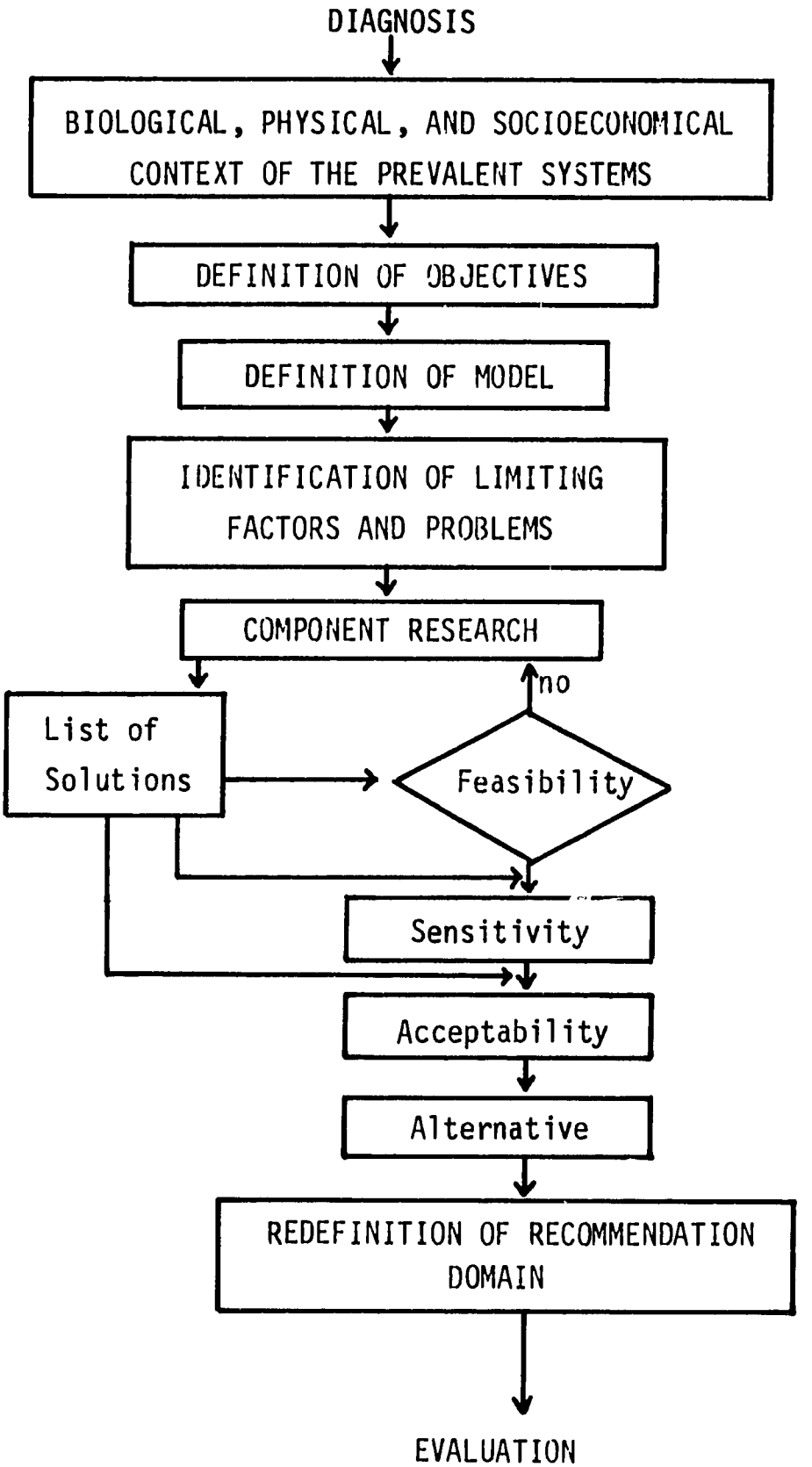


DESIGN OF ALTERNATIVES

The results described above are the result of diagnostic farm research and biological research that is part of the design process for developing alternatives (prototypes of systems). Such research is developed in the socioeconomic context and physical and political environment of small producers. In a recent workshop, Borel et al. (1982) developed an organization scheme for the design of such alternatives; a modified version is shown in Figure 5.

CATIE has limited experience in the evaluation of alternatives. Evaluations have been proposed at the farm level as conditions permit, including use of evaluations on experiment stations and use of computer facilities and simulation techniques. This evaluation of alternatives will be given greater emphasis in future CATIE activities.

Figure 5. Diagram for the Design of Production Alternatives



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Crop-Animal Production System Research At Winrock International

R. Hart, H. Fitzhugh, and N. Gutierrez

BACKGROUND

Research and development activities at Winrock International are primarily designed to improve livestock production systems. Because the institution takes a systems approach, livestock production is analyzed within the context of larger systems; for example, the farm as a whole, the geographic or political region in which farms are located, and the international trade sector.

Some livestock producers (such as those in pastoral societies in Africa and the large ranchers in Latin America) produce few crops; however, by far the greatest number of the livestock in developing countries are produced on mixed (crop and animal) farms. Different degrees of crop-animal interaction occur on these mixed farms. All mixed farms have an indirect type of interaction resulting from competition among crop and livestock enterprises for land, capital, and labor. Some mixed farms also have direct crop-animal interactions; for example, those occurring when crop residue is fed to animals, draft power or animal manure is used to produce crops, or when forage and food crops are planted in rotation, relay cropped, or intercropped.

Winrock International has a number of projects designed to improve livestock production on mixed farms, and both indirect and direct crop-livestock interaction are being studied. This paper outlines the approach used to investigate crop-animal interactions.

TYPES OF FARM-LEVEL CROP-ANIMAL INTERACTION

Crop-animal interaction on mixed farms has been classified according to five general types. Type 1 interactions are indirect, and types 2-5 are direct.

1. Enterprise Competition
   On any farm with more than one production system (enterprise), the farmer must make a choice as to how much land, labor, and capital should be allocated to each enterprise. If there is no biological interaction between enterprises (as in types 2 to 5 described below), this decision can be made on the basis of efficiency of resource use.

2. Animals Fed Crop Residue
   Crop biomass that cannot be consumed by humans (or sold) is often used as a feed resource for animals. Usually, animals also are fed other types of feed (such as cut-and-carry forage crops, or grazing on or off the farm).

Feed preservation (drying or silage) is often an important component of production systems with this type of interaction.

3. Animal Manure Applied to Crops

Manure is often applied to crops by allowing animals to feed in an area where crops will be planted later, or manure is systematically collected from an area where animals are confined and is applied to the soil at an appropriate time to produce a beneficial affect on crop production.

4. Animal Traction Used to Produce Crops

This type of crop-animal interaction is often found in combination with types 2 and 3. Generally, castrates are maintained primarily to be used for traction purposes, but milk cows are sometimes used and multiple objectives must be taken into consideration, including milk and meat production.

5. Forage Crops Included As Part of a Cropping System

On many mixed farms, forage and food crops are part of the same cropping system. Forage and food crops are commonly planted in rotation, often with the forage legume planted to restore soil fertility before planting a food crop. Forage crops are sometimes relay cropped or intercropped with food crops.

WINROCK PROJECTS THAT INCLUDE CROP-ANIMAL RESEARCH

Table 1 lists type of crop-animal interaction research, livestock component, and the country where Winrock is conducting research on mixed farms. Several of the projects described in Table 1 are in the initial stages and research with crop-animal interaction has not begun. The projects in Kenya and Brazil include on-going research with crop-animal interactions. Both projects are part of Winrock's activities in the Small Ruminant Collaborative Research Support Program funded by USAID/Title XII. The Kenya project involves dual-purpose (milk and meat) goat production with crop residue as an important feed resource. In Brazil, project emphasis is on meat goats and hair sheep, and the research emphasizes the analysis of enterprise competition. The research strategies used to study crop-animal interaction in Kenya and Brazil are described below as examples of Winrock's approach.

Table 1. Examples of Winrock International Research Projects Involving Mixed Farming Systems

Crop-Animal Interaction Research	Animal Component	Country
1. Crop residue fed to animals; manure applied to crops; forage crops part of cropping systems	Dual-purpose goats, cattle, hair sheep	Kenya
2. Crop residue fed to animals	Hair sheep	Trinidad-Tobago
3. Enterprise competition	Meat goats and hair sheep	Brazil, Indonesia
4. Crop residues fed to animals	Dual-purpose goats	Haiti
5. Crop residues fed to animals; manure applied to crops; forage crops part of cropping systems; enterprise competition	Dual-purpose cattle and buffalo; goats and sheep	Egypt

Kenya -- Crop Residue with Dual-purpose Goats

A dual-purpose goat production project is being implemented in Kenya in collaboration with the Ministry of Livestock Development and several U.S. universities. A successful goat production system in western Kenya must fit into existing small (approximately 1.0 ha), intensively cropped farm systems. Cattle and hair sheep are kept when sufficient feed is available from on-farm or communal grazing lands. These ruminants compete with dual-purpose goats for the feed resources. The milk and meat goat production system that is the expected project output has been conceptualized as having four subsystems: (1) feed production, (2) feed preservation, (3) goat management, and (4) animal product preservation and utilization. Interaction between this production system and crop production occurs because the feed production subsystem is strongly linked to crop production systems.

After an initial survey and farm monitoring study, research has begun with all four subsystems. Results will be evaluated periodically by testing recommendations on the experiment station and on the farms of participating producers.

Feed production research includes the evaluation of cut-and-carry crops that can be planted along fence rows and in the small areas within the farms that are not presently cropped. However, because of the strong interaction between forage production and food production, the primary emphasis of the feed production research has been upon cropping-system modification. A series of experiments are being conducted to identify types of forage-producing interventions that can be applied to cropping systems without decreasing food production. Types of interventions being tested include:

- Stripping leaves from maize and sorghum at different stages of physiological maturity and using the leaves for forage.

- Planting a higher-than-necessary crop population and later thinning back to optimum plant population and using the thinnings for forage.

- Ratooning sorghum either at a very early stage or after grain has been harvested and using the ratooned sorghum for forage.

- Pruning cassava leaves and using the leaves for forage.

- Relay cropping a forage legume and forage sorghum into existing cropping systems.

Although the project has emphasized crop-animal interaction resulting from crop residue being fed to animals, and interaction among forage and food crops that are part of the same cropping system, the researchers also are interested in the effects of goat manure applied to crops and in the economic analysis of enterprise competition.

Brazil -- Enterprise Competition Between Crops and Sheep and Goats

A meat-goat and hair sheep production project is being implemented in Brazil in collaboration with Empresa Brasileira de Pesquisa Agropecuaria-Centro Nacional de Pesquisa de Caprinos (EMBRAPA-CNPC). The project consists of a core program in production economics that provides substantial input into the analysis and evaluation of problems in technology generation and transfer. Producers in the Sobral area have cattle, sheep, goats, and crops. While there is little biological interaction between animals and crops, economic analysis of these farms requires consideration of enterprise competition. The objectives of this project are to:

- Carry out descriptive (diagnostic) studies to define existing small ruminant production systems and to identify constraints operating against higher animal numbers and higher animal productivity; construct agroeconomic profiles; define farmer goals and objectives related to small ruminant production; and quantify interactions between small ruminants and other animal species as well as between animal and crop production.

- Develop a set of bioeconomic models incorporating the major components and the interactions among components of the farming systems within which small ruminants are produced. These can be used to evaluate research results generated by experiment station trials on an ex ante basis, as well as in the evaluation of field trials.

- Conduct research on marketing and pricing efficiency to ascertain if current input or output marketing systems impose serious constraints on the adoption of improved technology.

- Conduct research on the credit requirements for technological adoption, on the risk factors related to traditional versus improved technologies, on the consequences of new technology for income distribution, employment and human nutrition, and on the pricing strategies to facilitate adoption of research results.

- Sponsor long-term training for collaborating researchers, as well as a variety of short-term training activities related to all stages in the research program described above.

As primary objectives, diagnostic studies and the development of bioeconomic models have required consideration of crop-animal interaction. During the diagnostic stage of the project, preliminary surveys were made of both crop and animal production activities. Bioeconomic models are being developed that will play an important role in the design stage of the project. These models must (1) be based upon detailed knowledge of actual farming situations, (2) be able to effectively discriminate among the various farming systems being studied, and (3) be capable of capturing the farming system interactions resulting from changes in specific production practices. Various models will be developed, but first priority will be deterministic simulation models that will provide a convenient means of analyzing long-term results when weather and prices are highly variable and when long-term investment strategies must be considered.

SUMMARY

Winrock International is involved in a number of projects to improve animal production systems that are part of mixed farming systems in developing countries. Crop-animal interactions must be considered as part of the research with these livestock production systems. Crop-animal interactions being studied include (1) competition for land, labor, and capital; (2) crop residues fed to animals; (3) animal manure applied to crops; (4) animal traction used in crop production; and (5) forage and food crop interactions within the same cropping system. Initial emphasis has been on types 1 and 2, but all types of crop-animal interaction will be considered as research projects are developed to improve animal production systems on mixed farms.

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Work Group 1 Report

Characterization Of Farming Systems

PARTICIPANTS:

Marcelino Avila, CATIE (Chairman)
Marco Esnaola, CATIE
Stephen Fontinelle, CARDI
Robert Hart, Winrock (Reporter)

THE PROBLEM

The characterization phase of all farming systems projects, for purposes of this Workshop, is defined as beginning after target area and target farmers have been identified. As a descriptive activity, its primary objective is to understand how the farmers' present systems work. Results of the characterization phase should provide sufficient understanding for development of hypotheses about production constraints. Such characterization of mixed farms and their crop-animal interactions presents a series of methodological problems.

GROUP OBJECTIVE

To identify: (1) methodological problems occurring in the characterization phase of the on-going farming systems research projects of the three participating institutions, (2) methodological problems that are specific to the characterization of crop-animal systems, and (3) potential solutions or guidelines to resolving the problems that are identified.

METHODOLOGY

The work group followed these steps in analyzing the characterization phase:

- Identification of (a) the products required to begin the design phase, (b) the information necessary to obtain these products, and (c) the techniques used to produce the required information.
- Critical appraisal of the methodologies currently being used by CATIE, CARDI, and Winrock.
- Identification of methodological aspects that should be considered in the characterization of mixed farms.
- Recommendation of improved characterization methodologies.

GENERAL STATEMENTS AND ASSUMPTIONS

Although the selection of target area and target farmer has been excluded from the characterization phase for purposes of this workshop, the selection process can greatly affect research with crop-animal systems. National programs should target their responses to development needs. International and regional technical assistance institutions need a rapid appraisal methodology to determine their technical capability to assist national institutions in farming systems projects with the target farmers in a selected area.

The primary objective of characterization is to describe existing farming systems at a level of detail necessary to begin the design phase of farming systems research. This description is not an end in itself; the use of time and money on this phase must be kept to a minimum necessary to obtain the required information.

Biological scientists, as well as social scientists, should be involved in a continuous characterization process that occurs in parallel with design and testing activities. The results from the testing process are an important input into characterization.

Characterization usually involves the use of many different techniques, including rapid appraisal, surveys, group interviews, key informants, guided interviews, analysis of secondary information, direct observation, farm records, and historical documents.

PRODUCTS NEEDED FOR DESIGN

To begin design activities, the following type of information is required:

- Farmers objectives -
  - Production constraints should be identified relative to a performance goal--which is not always greater production.
- Production constraints -
  - At the enterprise level:
    - Crop or animal production system, if there is low crop-animal interaction.
    - Crop-animal production system, if there is high crop-animal interaction.
  - At the farm level.
- Environmental description -
  - Ecological (physical and biological).
  - Socioeconomic and infrastructure:
    - Market, credit.
    - Input availability.
    - Institutional support.
- Evolutionary tendencies of agriculture in the area.

INFORMATION NEEDED TO PRODUCE CHARACTERIZATION PRODUCTS

The information needed to obtain the products outlined above include:

- Identification of farmer objectives and goal trade-offs, with detailed information on -
  - Present characteristics of the farm system. If a farm has subsistence crops and animals, the farmer's objectives probably include minimal economic risk.
  - Recent changes in the farm systems. Knowing that a farm recently began planting cash crops is an obvious indicator of a farmer's objectives.
  - A farmer's expressed desire, or lack of desire, for certain changes.
  - Farmers' choices or actions when presented different hypothetical scenarios.
- Identification of production constraints -
  - Available resources: land, labor, capital, and management capabilities.
  - Inputs and outputs for specific enterprises:
    - Crop production systems.
    - Animal production systems.
    - Crop-animal production systems (inputs and outputs from both crop and animal production systems, as well as farm activities that link crops and animals). Examples of these linking components are feed preservation, manure management, and animal traction management.
  - Description of existing technology:
    - Biological (varieties, breeds, etc.).
    - Agrochemical inputs.
    - Physical infrastructure.
    - Management.
  - Description of the dynamic aspects of crop, animal, and crop-animal enterprises.
  - Farm level information:
    - Total resource allocation to different farm enterprises.
    - Total farm income and the percent generated by each enterprise and off-farm activity.
- Descriptions of the ecological and socioeconomic environment, including -
  - Physical: soils, climate, topography, etc.
  - Biological: weeds, insects, diseases, etc.
  - Economic: market, credit, infrastructure, cooperative.
  - Social: farmer organizations, religious beliefs, customs and rituals.
- Analysis of evolutionary tendencies of agriculture in the region, through -
  - Historical sources.
  - Information from older citizens with long experience in the area.
  - Aerial photos, satelite imagery, etc.

IDENTIFICATION OF TECHNIQUES TO PRODUCE THE REQUIRED INFORMATION

Information needed to obtain the products necessary for the design phase can be generated by many different techniques. One technique may be used for more than one type of information, or many techniques may be needed to produce one type of information.

Table 1.1 lists characterization techniques and the advantages and disadvantages of each; however, characterization always involves the use of multiple techniques.

CRITICAL APPRAISAL OF CATIE, CARDI, AND WINROCK'S CHARACTERIZATION METHODOLOGY

Evaluation criteria include time and money expended plus value of characterization output for design.

- CATIE

  Present Approach: In general, a static diagnosis (survey) is conducted first, then follow-up or dynamic or monitoring studies. In recent years, static surveys have tended to become smaller in scale. The survey is designed by several scientists with different disciplines who have visited the area. Recently, rapid appraisal methods have been evaluated. The methodologies used during the monitoring phase have varied from a case study appraisal with few farmers to that of monitoring a large number of farmers every two weeks. Either crop or animal enterprises may be emphasized, but basic data is usually collected on both.

  Evaluation:

  Often there has been a long delay between the survey and the analysis of information needed to begin the design phase.

  In some cases, there has been little multidisciplinary input into the analysis.

  Participation of field staff in the analysis phase has been made difficult because analyses are usually done at a centralized point due to the lack of minicomputers or calculators (and programs) in the field.

  Motivation of national staff is difficult if nationals do not participate in the design of questionnaires, thus it is difficult to use the same questionnaire in several countries.

- CARDI

  Present Approach: An initial survey is conducted, then farms are monitored on a weekly basis for a year. This approach is relatively similar in all countries; at first, only crop enterprises are monitored, with animal production included later.

TABLE 1.1 A GENERAL APPRAISAL OF DIFFERENT TECHNIQUES THAT CAN BE COMBINED TO FORM A GENERAL CHARACTERIZATION METHODOLOGY

APPROPRIATENESS FOR TYPE OF INFORMATION NEEDED									APPROPRIATENESS TO MEET OBJECTIVE (+)									TECHNIQUE
DESCRIPTION OF ECOLOGICAL AND SOCIO-ECONOMIC ENVIRONMENT	EVOLUTION OF AGRICULTURE	INCOME DATA	DYNAMIC ASPECTS OF SYSTEM	TECHNOLOGY DESCRIPTION	INPUT-OUTPUT COEFFICIENTS	INVENTORY OF RESOURCES	FARMER OBJECTIVES AND GOAL TRADE-OFFS	SUBJECTIVE IMPRESSIONS	CONTACT WITH FARMERS	NEED OF COMPUTER FACILITIES	INTEGRATIVE PICTURE	QUALITY OF INFORMATION	DEPTH OF ANALYSIS	POPULATION VARIABILITY	STATISTICAL INFERENCE	LOW COST	SPEED	INVOLVEMENT OF TEAM	
+	+									+					+	+	+	+	USE OF SECONDARY INFORMATION
				+		+			+	+	+					+	+	+	RAPID APPRAISAL
		+		+	+	+			+					+	+				ONE VISIT SURVEY
		+	+	+	+	+	+		+		+	+	+						FARM MONITORING
	+		+	+			+	+		+	+		+			+	+	+	KEY INFORMANT INTERVIEW
				+			+	+	+	+						+	+	+	GROUP INTERVIEWS
			+	+		+	+	+	+	+	+	+	+					+	DIRECT OBSERVATION BY STAFF

Evaluation:

Characterization has taken longer and used more resources than expected.

Long delays have been experienced between data collection at the central office and sending analyzed results back to the field.

At times, objectives other than producing information for design have been included in the characterization. (Examples include information to compare research sites and agricultural sector analysis).

- Winrock

Present Approach: Approach has been variable; some projects are more traditional field station projects; others are farming systems projects. Usually, a detailed initial survey is conducted, followed by monitoring for two years.

Evaluation:

Research and design emphasis often has been decided before characterization is begun, and the information collected is more often used for building bioeconomic models to evaluate potential technology than for actual design.

The combining of thesis research objectives with project objectives has resulted in a long delay between data collection and analyzed results.

Surveys sometimes have been designed before sufficient qualitative understanding of the system was available.

METHODOLOGICAL ASPECTS SPECIFIC TO CROP-ANIMAL INTERACTION

- The sheer volume of information that must be collected if both crop and animal production systems are characterized has important methodological implications. In general, more selectivity in collecting information would reduce this volume.
- Farmer objectives are probably more difficult to identify when crop-animal interaction occurs, since dominant subsistence or economic enterprises may interact.
- An interdisciplinary approach must be taken from the beginning, since the design of techniques (questionnaire, etc.) require input from both crop and animal scientists.
- The characterization methodology should include an early identification of any crop-animal interaction, so that farm activities and components that link crops and animals can be examined.
- Characterization must include a quantitative measurement of the intensity of any crop-animal interaction. (For example: to design alternative technology, it is necessary to know if the percentage of animal feed from crop residues relative to other feeds is 5% or 95%.)
- The existence of crop-animal interaction should be taken into account in collecting the information necessary to an adequate analysis of

enterprise competition. In general, crop-animal interaction is often associated with labor-intensive activities, suggesting that analysis of labor use and availability may be very important.

- The existence of crop-animal interaction requires, in addition to the identification of the constraints to crop and animal production, the identification of constraints to the performance of farm components that link crops and animals. For example, crop residue preservation is a farm subsystem with its own constraints (e.g., lack of adequate storage containers or ensiling management capabilities).
- Format should be determined for presenting the product of the characterization of mixed farms and crop-animal interaction.

GENERAL RECOMMENDATIONS

General recommendations for improving the present methodologies used by CATIE, CARDI, and Winrock are difficult to separate from the specific recommendations related to crop-animal interactions. The same improvements needed for characterization of crop-animal production systems would also be worth considering for a crop production program or an animal production program.

Recommendations for changes in the present characterization methodologies used by the three institutions are summarized in Figure 1.1. In general, the primary problem seems to be that a two-phase process involving an initial survey and farm monitoring does not produce sufficient information quickly enough to serve as the basis of design activities. Techniques that are inexpensive and fast, such as (1) review of secondary information, (2) rapid appraisal, (3) key informant interviews, and (4) group interviews should be used to identify the key questions that have to be answered before design can begin. These questions should then be answered by conducting a statistically sound survey. The survey should be short, easily analyzable, and should include only key questions.

Characterization continues after design has begun and even after testing has started. Consideration should be given to conducting the farm monitoring activities concurrently with the design of potential technology. Direct observations of field staff should become an important source of characterization information during later phases of the farming system project.

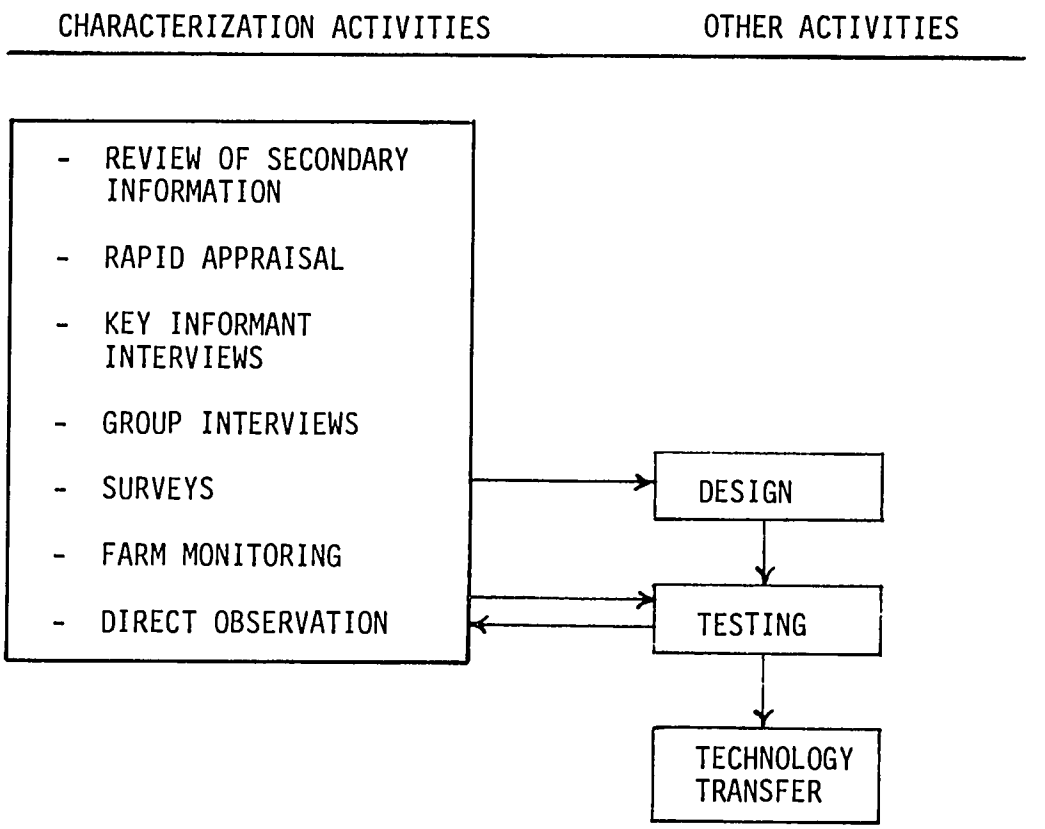


Figure 1.1 Recommended steps in a characterization methodology and the relationship between characterization activities and design, testing, and technology transfer activities.

Work Group 2 Report

Design Of Technological Alternatives

PARTICIPANTS:

Rolain Borel, CATIE (Chairman)
German Escobar, CATIE
Raul Moreno, CATIE
Gerald Proverbs, CARDI (Reporter)
Laxman Singh, CARDI

THE PROBLEM

In the methodology to develop technology for small mixed-production farms, the design phase is the conceptual activity occurring after the characterization of the existing systems and before the field-testing phase. In terms of the traditional scientific method, the design phase can be compared to the formation of hypotheses. In operational terms, the design phase involves the following steps:

- Defining goals.
- Identifying constraints.
- Obtaining appropriate technologies.
- Screening of technologies.

The first two steps overlap the characterization phase and are listed here to stress the importance of obtaining appropriate information before entering into the design process; the latter step overlaps the testing phase and indicates the importance of designs that are testable.

GROUP OBJECTIVE

To identify: (1) methodological problems within the design phase of the on-going farming systems projects, (2) methodological problems that are specific to the design of crop-animal systems, and (3) potential solutions or guidelines for resolving these problems.

METHODOLOGY

The Work Group first looked at methodological problems encountered at each step of the design process, then proposed possible solutions. The following report is organized similarly; first, problems of each phase are described, then solutions are proposed.

DESIGN PROCESS

Stage 1 - Defining Goals

Problem: Definition of social and political goals usually has been either completely lacking or weakly supported--the information gathered during the characterization phase usually being oriented towards only biological and economic data. The farmers' and governments' objectives often are not fully considered by research teams. This problem seems to be related to a scarcity of sociological and/or anthropological expertise on research teams and the resulting difficulty in gathering pertinent information. Furthermore, the farmers' objectives and goals in mixed-systems farming probably have been more difficult to conceptualize and describe, compared to goals of traditional biological research. Another complicating factor in the definition of the objectives for the mixed systems is the relative lack of "unifying" (or common-denominator) factors, such as energy requirements, protein yields, or net income per farm.

Proposed Solution: In the characterization phase, information should (as a minimum) document:

- The farmers' expressed needs and their perception of the problems, of productivity, of the crop-animal relations, and of their farming practices.
- Government plans for the area.
- Market potential of the area.
- Prospects for change. (For example, under present circumstances there might be no potential for a particular modification on the farm. But if changes are imminent in the production and market environment, the modification might be viable.)

The data described above, integrated with the general research objectives and information obtained on productivity, complementarity, and competition of the subsystems, should provide better definition of the desired production goals.

Stage 2 - Identifying Constraints

Problem: The incorrect or inadequate definition of the objectives contribute to the general problem of constraint identification; however, specific difficulties stem from the kind and quality of information generated by the baseline or monitoring studies.

Survey questionnaires are generally an efficient means of estimating production coefficients and obtaining data for cost/benefit analyses; however, identification of constraints usually requires familiarity with the farm operation. Information needed to assess constraints is multifaceted, often subjective, and tends to be related to questions of how, rather than what, products are produced. This information is best obtained by involving the research team in first-hand observations of the farm operation.

Although a one-visit survey allows for the study of a relatively large number of farms, the data obtained are only approximate and do not lend themselves to sophisticated analysis. On the other hand, multivisit surveys are rather costly and may not render the information required.

Systems researchers often note the need to quantify the flows between the subsystems (crops and animals). However, because a full year of multiple visits to the farms may be required to obtain this information, the question is raised as to whether it is imperative to wait for the quantification of these flows, or whether the design process can start without that knowledge.

Proposed Solution: To increase the effectiveness of the surveys, the same specialists who will eventually participate in the design process should be included in visits to each farm. Two or three visits (at several month intervals), although costly in terms of financial and human resources, should ensure more useful recommendations, inasmuch as the production data would reflect changes over time.

The design phase might be begun earlier in the research program, perhaps in the characterization phase. The design phase (and even the testing) allows the team to better characterize the systems by helping identify useful and relevant variables of the system. In addition, new variables might be suggested for development during the design phase.

As the team becomes more familiar with the problem area, the required changes are easier to identify. The options are tested as soon as they are identified, with the results helping identify additional alternatives. Thus, as the team gains experience within the area, the farmer follows a parallel path, testing increased levels of technology as his experience and confidence grow.

Stage 3 - Obtaining Appropriate Technologies

Problem: Technology for alternatives can be obtained from the team expertise, knowledge of key indicators of farming systems performance, and experience from other research activities. The technology obtained will reflect the interactions and flows of information between the team members. The information generated at one site may be scarce, limited in applicability to a few areas, or may not address the relevant problems. Teams often operate in countries where communications and access to technical literature are poor. For mixed-system research, the problem is more severe because of the greater diversity of information needed. New ways of information processing must be developed.

Proposed Solution: Communication difficulties among the team members can be enhanced by a well-organized information retrieval and distribution service and frequent visits to and from headquarters as well as between research sites.

Stage 4 - Design of Technology Screening

Problem: Experiences in farming system research by the three institutions participating in this Workshop suggest that the screening procedures for the proposed technologies have been rather intuitive, i.e., clear criteria for testing have been frequently lacking as have means of applying these criteria. For example, criteria to assess new technology must determine whether it will affect the whole farm, in what direction, and to what degree. A farm model will facilitate these decisions; however, the use of farm models has not usually been a part of the overall research strategy even when computation facilities and know-how are available.

Proposed Solution: The group defined the screening criteria for proposed technologies as follows:

- Ecological suitability.
- Adoptability.
- Availability of agroservices.
- Prices and supply elasticities.
- Time interval between implementation and realization of results at the farm level.
- Productivity of land, labor, and capital under constraints of the present production systems.

Models aid the rapid screening of technologies; however, the elaboration of a complex model (including all possible inputs, outputs, and interactions) is impractical under most conditions. Thus, the Group recommended that standard models be developed, including the principal production processes with their effects measured at the level of the whole farm (simulation). This model should preferably be sufficiently simple for use on a desktop, programmable calculator. The screening procedure for any new technology might then involve estimates of its effects on the main processes--followed by estimates on total farm output.

Dilemma: Adoptability Versus Productivity

Problem: In seeking technologies which will be most readily adoptable by small farmers, there is a tendency to design technologies which do not differ greatly from the farmers' present practices. These technologies may be suggested from the intensive survey of a relatively few farmers, but because of their similarity to traditional practices they may stimulate only small increases in productivity. Such small changes may be barely measureable, thus are difficult to evaluate objectively. Many potentially useful technologies may be overlooked because of perceived lack of fit to traditional farming systems. On the other hand, bolder technologies may be designed which potentially have a greater impact on productivity in comparison to traditional levels. However, these more radical departures from traditional practices may be less readily adoptable.

The researchers' dilemma in dealing with the small farmer is that they may choose to recommend small easily adoptable changes whose effects on production are not easily measured, or to recommend greater changes with more easily measured effects, which may not be readily adopted. In both cases, the researchers' objectives may not be met.

Proposed Solution: To resolve this dilemma, researchers could attempt to design alternatives closely related to the present situation of the farms, while at the same time designing bolder alternatives that would necessarily go through a process of trial and error before being incorporated in the design process. Due to the complexities of mixed systems both approaches should be undertaken.

Work Group 3 Report

Testing Of Technological Alternatives

PARTICIPANTS:

Carlos Burgos, CATIE (Chairman)
Richard Carew, CARDI (Reporter)
Oliver Deaton, CATIE
Nestor Gutierrez, Winrock
Pascal Osuji, CARDI
Manuel Ruiz, CATIE

THE PROBLEM

In the testing phase of farming system research, technological alternatives proposed as an output of the design process are evaluated objectively. Testing can be done on-farm, on the field station, or within computer models, and is the equivalent of testing and accepting or rejecting a hypothesis in the traditional scientific method. Few well-developed methodologies have been developed for the testing of crop or animal technology on mixed farms with crop-animal interaction, or for the testing of complex crop-animal systems.

GROUP OBJECTIVE

To identify: (1) methodological problems that have occurred during the testing phase of the on-going farming systems projects at the three participating institutions, (2) methodological problems that are specific to the testing of crop-animal systems, and (3) potential solutions or guidelines to resolving the problems that have been identified.

METHODOLOGY

The work group identified and discussed the following important issues:

- Criteria for evaluating technological alternatives.
- On-farm testing.
- On-station testing.
- Evaluation using computer models.
- Operational problems that occur during the testing process.

GENERAL STATEMENTS AND ASSUMPTIONS

Testing of alternatives is a process during which the technology is applied to the farming system. Since this stage must occur prior to the technology-transfer stages, testing must rely on actual farm-level responses. However, more complete evaluations of the alternative's performance can be achieved by concurrent testing of the same alternative under more controlled conditions. That is, in some cases, simultaneous testing at the experiment station or via simulation exercises may be warranted, for example, when there is an interest in the biological aspects of the evaluation (e.g., technical coefficients). Thus, alternatives can be tested on-farm, concurrently with complementary on-station testing at experiment stations or with the use of simulation techniques. Figure 3.1 depicts these various stages of testing.

Although the testing of alternatives usually is done on the farm, the need for complementary on-station testing (including simulation studies) will depend on the knowledge available. On-farm research is justified where more relevant information is necessary regarding the economic and social system. On-station research is justified when the assessment of technological alternatives requires a greater degree of management. Although modelling plays a role in the design of alternatives, it is used primarily as a tool for testing alternatives.

EVALUATION CRITERIA

The identification of alternative technologies stems from the diagnostic and design stages of farming systems research. Alternatives are defined as a set of management techniques to complement or change the original system. This may be an entire subset or a component.

There are several criteria for evaluating alternatives, including:

- Biological suitability.
- Economic feasibility.
- Social acceptability in terms of weighing the short-run private benefits versus the long-run social costs.
- Allowance for equitable benefits between different social-economic strata.

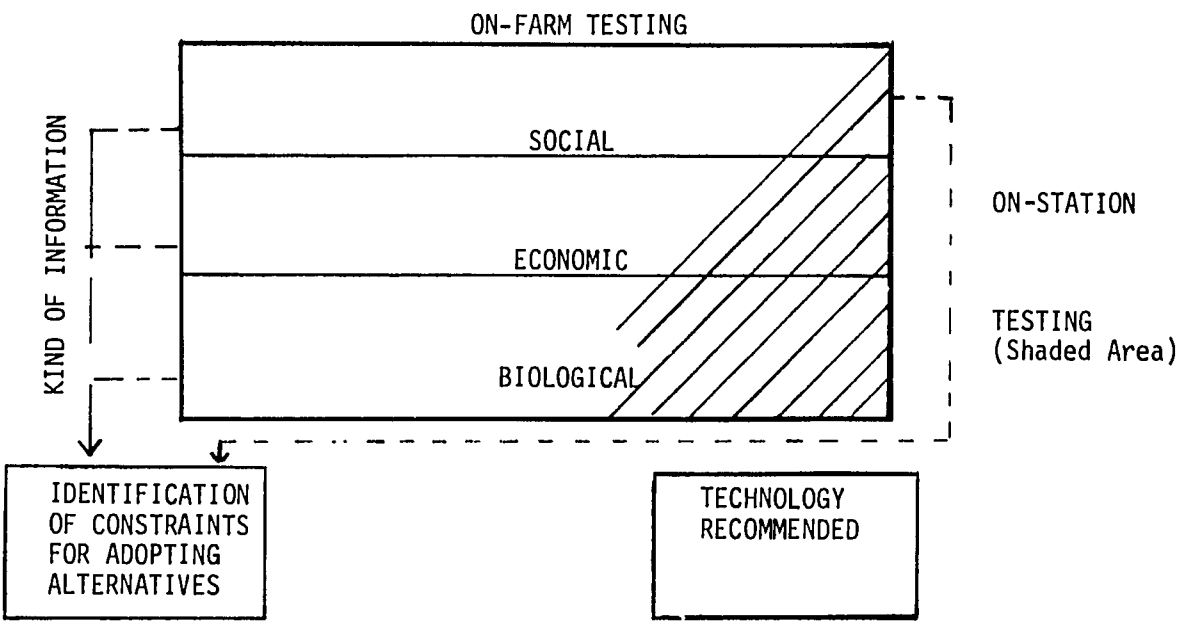
These criteria must be compatible with farmers' objectives and attitudes to risk and uncertainty.

ON-FARM TESTING

Before on-farm testing is begun, agreements should be reached on the conditions or circumstances for which the alternative was developed, i.e., the production complex to which the alternative is applicable.

Figure 3.1

COMPLEMENTARITY OF THE TESTING PROCESS



- Among-farm Testing

  Among-farm testing requires farm homogeneity, with use of at least two farms and a control treatment. Limitations include natural heterogeneity of farms, high cost of materials, and lack of technical resources. The advantages of this approach are precision of evaluation and the information obtained on the ranges of conditions to which the technological alternative can be applied.

- Within-farm Testing

  Two types of within-farm testing are (1) testing at the same time (in the same season) and (2) testing at different times.

  Testing of alternatives within the farm during the same season requires homogeneous plots, replications, special care to maintain the specified conditions of the control treatment, and farm components for both crops and animals. Disadvantages of such testing are that it requires a larger experimental unit (farm), is more expensive to establish the trial, is more complicated to manage, and is impossible to evaluate on the whole farm. The advantages of this method are that it reduces plot variability and requires less of the research workers' time.

  Testing of alternatives within farms over time requires participation of collaborating farmers over a relatively long time because the system must be evaluated prior to the actual testing of an alternative in that same system. This method also requires that the chosen evaluation parameters not be affected by events occurring outside the system that might confound the evaluation. The main disadvantages are the possible variations between years with respect to climate, prices, marketing, and labor availability, and the tendency of some farmers to make modifications before the data are collected. The advantages of this method are that plot variability and the number of farms needed for the testing phase are minimal.

- Predicted versus Observed Testing

  In a third type of testing, comparisons are made of a predicted vs an observed outcome. This implies the use of a validated model into which a set of techniques is introduced to obtain a predicted response. The results are then used as reference values for the evaluation of the performance of the alternative under farm conditions.

- "Have" versus "Have Nots" Testing

  In a fourth type of testing, farms that have selected alternatives are compared with farms that do not have the selected alternatives. This method takes advantage of the research and experiences that farmers have gained through the years, which have resulted in improved techniques. As these techniques are already incorporated into their farming system, the end result is similar to that obtained by means of among-farm testing. The difference between these two methods is that there are fewer costs in setting up the testing when using the "have" vs the "have nots" method. A further possible bias is that such a comparison probably reflects a subtle former personality difference, rather than difference in the systems *per se*.

EVALUATION WITH COMPUTER MODELS

The *ex ante* evaluation of designed technologies is becoming more common. The use of simulation when crops and livestock interact in the system helps to abstract the main interactions and effects of these two activities on the farm. With the use of maximization techniques, optimum allocation of resource could be recommended as well as the timing within practices. When the interaction between subsistence is extremely complicated, simulation helps the researcher to keep track of the flow of information.

Simulation is especially useful when quick results are needed and sufficient preliminary technical coefficients are available. Simulation is useful in both crop and livestock enterprises, but it is especially useful for long-term experiments with livestock that require a large investment for a long time. Another advantage is that it allows researchers to consider many interactions at the same time. The most promising alternatives can be pretested with simulation, including external factors such as market prices and credit policies. When simulation is used for ex ante analysis and there is some range of variation in the parameters, triangular type analysis is recommended for greater precision.

The participation of the farmer is required during the testing stage--although when simulation is used, the farmer's participation is indirect.

A model can be used to compare different situations, for example, improved systems vs traditional or unchanged systems, either within farm or across farms. Data requirements for testing by means of simulation techniques depend on whether a biological model or an economic model is used; these two models have very different uses and data requirements. Most of the biological models require detailed information on flows of energy, feed supply, etc., which are not easily obtained. Economic models require data on prices, quantity of inputs, etc., which are readily available. An economic evaluation would be made of the performance of the production system, as well as of production techniques or components.

ON-STATION TESTING OF ALTERNATIVES

Alternatives vary in complexity; those alternatives that consist of a change in one technique, or that probably would not have an effect beyond a single subsystem, may be tested with farm trials or on the experiment station. Those that are complex, and that could have an effect upon the whole farm system, must be evaluated at the farm level--never relying solely on tests at the experiment stations. However, because of practical constraints imposed by on-farm testing, it is probably necessary to do some testing at experiment stations or by using simulation techniques.

Thorough testing of alternatives may require very precise data on biological relationships; thus parallel testing combining on-farm and on-station evaluations may be deemed necessary. If this approach is used, system prototypes (or "modules") can be structured to replicate or resemble actual farm situations. On-station testing should always be complementary to on-farm testing.

OPERATIONAL ASPECTS OF TESTING ALTERNATIVES

Two types of interactions occur when cropping systems and animal systems are combined: competitive and complementary. The methodology to test an alternative includes parameters specific to the quantifications of such interactions and their effects on the whole farming system.

- Competitive Interaction: interactions in which two or more factors affect the productivity of the system so that the new level of productivity is inferior to the sum obtained when each factor's productivity is evaluated independently of the other factors

- Complementary Interaction: interactions in which two or more factors affect the productivity of the system so that the new level of productivity is superior to the sum obtained when each factor's productivity is evaluated independently.

Taking into account the above interactions, testing of alternatives addresses two situations: (1) the reallocation of production resources (land, labor, capital) to increase productivity; (2) increasing the level, or intensity, of allocation of the production resources.

Work Group 4 Report

Organizational Problems Affecting Crop-Animal System Research

PARTICIPANTS:

Rowland Fletcher, CARDI (Chairman)
Hank Fitzhugh, Winrock
John Hammerton, CARDI
Eduard Muller, CATIE (Reporter)
Luis Navarro, CATIE

THE PROBLEM

Difficulties arising from the organization of research on crop-animal systems occur at both the institutional and individual level. Institutions may not be organized to give appropriate support to multidisciplinary long-term research on crop-animal systems, and administrative boundaries often inhibit easy collaboration between scientists. In addition, differences among institutional goals, policies, and operating procedures may create difficulties in collaboration among institutions.

GROUP OBJECTIVE

To clearly define the organizational problems that limit the effectiveness of crop-animal systems and to develop relevant recommendations for resolving those problems.

METHODOLOGY

The group addressed itself to the following organizational factors:

- Team structure and organization.
  - a. Authority and team leadership.
  - b. Qualification for team membership.
- Stability of team membership and consistency of approach.
- Communication among team members.
- Administration of interdisciplinary teams.
- Institutional interrelationships.

STRUCTURE AND ORGANIZATION OF THE TEAM

Research to develop technology for mixed crop-animal production systems is directed at a target group of farmers and is organized according to their resources, knowledge, and objectives as producers. This type of research generally requires the combined and synergistic inputs from crop, animal, and social sciences. This requirement would probably require a minimum team of three scientists with each representing one of the basic disciplines and each prepared and willing to conduct interdisciplinary research.

Members of the team should have a general expertise in the broad spectrum of specialties within the "disciplines" of crop, animal, and social sciences. In addition, they should be generally familiar with the terminologies and research processes of the other disciplines. This familiarity may come from both work experience and academic training. It will facilitate understanding of the complex research subject and better communication among team members, as well as better communication with consulting specialists. Such communication capability is essential for interdisciplinary work and for effectively directing the work of the different specialists who would be asked to assist the team during different phases of the research.

Team members also should be willing to work as part of the team, interacting with other team members in reaching agreement on research objectives, methodologies, and individual work responsibilities needed to achieve common objectives. Since the research will involve on-farm activities, team members should be capable and interested in working directly with farmers.

Qualifications for Team Leadership

Characteristics of an effective team leader include 1) willingness to lead, 2) administrative and organizational capability, 3) experience or training in interdisciplinary farming systems research, 4) ability to motivate team members and generate team spirit, 5) ability to communicate and work effectively with people within as well as outside the team, particularly with farmers, and 6) general understanding of all aspects of the target systems in order to direct efforts of team scientists with various disciplines and short-term consultants. Scientists from any of the disciplines represented on the team may have these characteristics needed for effective leadership.

Qualifications for Team Membership

A basic assumption is that all team members are competent scientists within their particular disciplines. However, this professional competence does not necessarily equip the scientists to fulfill their roles as core members of a crop-animal systems research team. They should also be:

- Conversant with the technical terminology of the various disciplines involved in the project.
- Familiar with the general characteristics of the system.

The above capabilities can be gained in the following ways:

- Previous experience--the scientist may have worked on a similar team or related project to develop the necessary expertise.
- On-the-job experience--often less desirable because the project may suffer during the period that the individual is in training.
- Overview courses especially designed to build up the general background of the individual and to equip him or her for the specialized area of activity. Such courses are highly desirable and should be included in the institutional framework of the project.

It is also important that prospective team members understand and accept that involvement in the project team will require the sacrifice of some personal academic and/or professional desires and ambitions in favor of the requirements and demands of the project. The desire to work on the team connotes support of the goals, objectives, and methodology of the project.

Some individuals find it difficult to work in interdisciplinary groups and are more effective working on their own. An obvious personal and positive willingness to be a team member should be a requisite for team membership.

COMMUNICATION AMONG TEAM MEMBERS

Communication among team members is essential. Team members must be involved in planning, scheduling (e.g., developing a work plan within a time frame), and reviewing all stages of the project.

At the outset, team members must aim to acquire, by both formal and informal contacts and meetings, an understanding of the terminology, working methods, and objectives of their team colleagues. This understanding will be easier if team members are "generalists" or have a broad base within their own disciplines and have acquired a working knowledge of disciplines other than their own.

Familiarity with the working methods and objectives of their colleagues will lead to more effective collaboration and "cross-fertilization" of ideas. Thus, for example, both the social scientist and crop scientist may be interested in labor use for weed control; they can collaborate in collecting data in the characterization phase, in the design phase, and in the testing phase of weed control interventions or alternatives.

The team must agree on the objectives--both general and specific--and on the work plan and time schedule. Thus, the animal scientist may be unable to proceed with a part of his planned work until one or more colleagues have reached a particular phase of their work. It is important that the team understand the interrelation of their individual work components and their role in the overall program.

This interchange of ideas, communication, and discussion of plans and methodologies should lead to a synergism in which the total effort and result will be greater than the sum of the individual efforts and results. Thus, the team must

meet regularly, after the work plan and targets have been agreed upon, to discuss and review progress, problems, and successes, any rescheduling needed, and the need (if any) for consultants or additional back-up services. Such meetings need not be time-consuming or structured, but should be held regularly. They should help to motivate team members, maintain and stimulate their interest, and ensure their continued loyalty. It is incumbent on the team leader to ensure free discussion of progress and problems, etc.

Where a project is "multi-site," such meetings--and such team participation--should be at the "site level." Meetings of all teams from all sites are less likely to be productive and will be expensive and time-consuming.

Regular internal review meetings should include any consultants then working on the project (the term "consultant" should be taken to mean any specialist from within or outside the executing agency), plus the overall coordinator--if available. The initiative for scheduling meetings and developing agenda should be the team's prerogative; once again, emphasis is placed on giving the team a measure of autonomy and the leader sufficient authority.

REPORTS

Aside from communication among the team members, there must be some systematic reporting at several levels. These reports are a necessary but time-consuming activity. Often the services of communications specialists can assist in prompt, clear reporting from the project.

Informal Reports

Primarily for internal use, informal reports record what was done, how and why, with a summary of the main results. These can be written at irregular intervals, but preferably as soon as each activity is concluded. Such reports serve to keep team members informed of progress made and current operations; they also facilitate the preparation of the annual report and ensure that--should a team member leave--the incoming member can be readily briefed on what has been done and achieved. They also serve to brief consultants on project activities.

Reporting to Funding Agencies

Funding agencies are likely to require a regular reporting several times a year on specific topics. Responsibility for these reports lies with the team leader; however, team members should be involved in this exercise and should not feel that they are being "reported on" by the team leader.

Annual Report

Project reports will probably be included in the institute's annual report. Such reports can be time-consuming, but if each team member has consistently maintained written reports and has not allowed a backlog of data to accumulate, reports need not be a burden. Time must be allowed for regular writing and recording. Such Annual Reports are an important and integral part of the scientific literature and allow scientists to share experiences, methodologies, and results.

Scientific Reports

Well-documented, objective reports of procedures and results contribute to the scientific literature. They provide a means of acquainting other scientists with the knowledge generated by the research effort and stimulate critical review of methodologies and recommendations.

Extension Reports

Ultimately, research results should be communicated through extension offices to the farmers. These communications must be in understandable form and language.

Publications for extension officers and for farmers on a range of topics (e.g., progress within the project, results of surveys, interventions, etc.) can be time-consuming. Ideally, a communications specialist should be brought in to help the team of scientists prepare these reports.

INSTITUTIONAL RELATIONSHIPS

The scope and complexity of crop-animal systems research are generally such that several different institutions will be involved in the research program. For example, a project could involve:

- International donor agencies providing funds to support research.
- Regional research institutions providing scientists to conduct research.
- National institutions providing scientists, support personnel, facilities, animals, and contact with cooperating farmers necessary for the research.

To facilitate continuity of a research program and successful implementation of results, the group should encourage active involvement of national staff in the research activities. If national personnel with required expertise and experience to serve as members of core teams are not available, personnel from national institutions should join the team for training purposes.

Because the research projects are likely to be complicated, expensive, and long term, it is essential that all institutions remain committed to the goals of the research program. Obviously, the project goals must be compatible with the respective goals and policies of each institution.

Because individuals, not institutions, make decisions to support or not support the research project, those individuals representing the involved institutions must be knowledgeable about project activities, problems, accomplishments, and needs. The communication necessary to ensure full and continued knowledgeability are a responsibility of both the researchers and the institutional representatives. These communications are neither a simple nor automatic process. All persons involved must work hard to ensure good communications through group meetings, progress reports, and other oral and written briefings.

Occasionally, differences may arise among institutions in their attitude toward and support for the research project. Top priority must be given to rapid resolution of these differences to regain consensus support for the research project goals and procedures.

ADMINISTRATION OF INTERDISCIPLINARY TEAMS

The traditional structure of many institutions in which crop, animal, and social scientists are administered by different departments is often not conducive to operation of interdisciplinary research teams. To be effective, these teams require some measure of administrative autonomy.

Members of the team may participate on a full or part-time basis, as appropriate. However, to the extent of their time committed, team members should be responsible to the team leader. Appropriate means must be developed to ensure both accountability and recognition (credit) of team members for their contributions to the team efforts.

Team members may be drawn from different institutions (e.g., counterparts from national institutions). In such cases, it is even more critical that administrative authority for team members be delegated to the team leader. Similarly, when team members come from different institutions and from different departments within institutions, it is especially important that the team be organized as an administrative unit for the lifetime of the research project. Such organization is necessary for implementation of team work, and will also ensure that the research project obtains the necessary logistical support for implementation of research procedures.

The research team should have a stable core staff representing animal science, crop science, and socioeconomic components represented by one or more scientists in each area. This group should be aided by more specialized consultants who will be called in for specific purposes as they are required. Continuity of the core staff should be maintained as far as possible--and this can best be facilitated by an assured continuity in the leadership.

Changes in the core staff should be kept at a minimum; but, when necessary changes should be made gradually. To assure continuity and timeliness of the research process, an internal information mechanism should be designed to document each step. Thus, when a staff member is replaced, the incoming scientist can more easily become a member of the team and will require less "training" time from other team members. This documentation will also be very useful in keeping the research going in a steady, well-organized manner.

A certain flexibility in the research project is required to allow a response to the different problems that will arise as they are diagnosed by the staff. To facilitate this process, work phasing is recommended. The use of models for each corresponding work phase and a build-up of a general research model will help orient the core staff and give some indications on the specific needs of the

consulting staff. Group meetings should be held periodically to discuss the necessary changes, ease the elaboration of the information process, reorient the core staff, and incorporate the necessary consulting staff. A good deal of effort and creativity is necessary to minimize the time-consuming process related to the documentation of crop-animal systems research.