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International Development Research Centre

MANUSCRIPT REPORT

Report of the II Workshop on Tropical Animal Production Systems

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CANADA

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Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.

IDRC-MR62e

REPORT OF THE II WORKSHOP ON TROPICAL ANIMAL PRODUCTION SYSTEMS

Pucallpa, Peru
January 21-25, 1982

Editors: H. Li Pun and H. Zandstra

This II Workshop on Animal Production Systems in the Tropics was organized by the International Development Research Centre (IDRC) and the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA - PERU).

CONTENTS

I N T R O D U C T I O N

Over the years, considerable research efforts have taken place to improve production and productivity of animal enterprises in the tropics of Latin America, in an attempt to reduce the increasing deficits of livestock products in the region. However, many such efforts have been unsuccessful, mainly because of the limited applicability of the research results to the condition of the small- and medium-size farms which constitute the majority in the region, and which contribute significantly to agricultural production.

Aware of this, several groups of animal researchers have decided in recent years to use multidisciplinary and holistic approaches in order to find solutions that would improve the conditions of small farmers. These approaches have been based on the experience obtained in the field of crops, where research on cropping systems has led to the development of technological alternatives to improve production conditions and agricultural productivity on small farms.

The methodology for animal production systems research has followed the same general steps of the cropping systems research, i.e., the characterization of agroecosystems, the identification of factors limiting production, priorization of problems, search for alternatives, on-farm evaluation of alternatives, and the validation of alternatives within the context of the farming system. However, the specific details of all these steps are not equally applicable, mainly because livestock production systems on small farms have different characteristics such as a small number of animals and high animal variability (breeds or crossbreeds, physiological condition, age, etc.) which limit the number and homogeneity of experimental units, the duration of the productive cycle, etc. Because of these characteristics, experiments in cropping systems research and animal production systems research on small farms are different. The latter one being more difficult.

Also, the International Development Research Centre (IDRC) has been supporting the research on animal production systems of several Latin American institutions in the tropics. The researchers from those institutions have identified some aspects of the research methodology for animal production systems on small farms which require further development; they are also aware of the need to exchange experiences between the institutions involved in order to unify efforts which would enable them to better define methodology. To this effect, in May 1981, a group of researchers from the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) of Costa Rica, the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) of Peru and the Instituto de Investigacion Agropecuaria de Panama (IDIAP) met in the city of David, Panama to exchange ideas about the methodology for animal production systems research.

The meeting identified methodological aspects requiring further development, such as the evaluation of alternatives on farms and the linkage between the generation and transfer of technology for agricultural development. Also, it was recommended that the IDRC continue to support these efforts and that the above subjects be discussed at the following meeting (Annex 2).

Consequently, a second meeting of the research groups on tropical animal production systems was planned, and was held in the city of Pucallpa, Peru from January 21 to 25, 1982. Participants from other institutions were also invited to this meeting, among whom were the representatives of Centro de Investigaciones Pecuarias (CENIP) from the Dominican Republic, the Caribbean Agricultural Research and Development Institute (CARDI) from Trinidad, the Instituto Nacional de Investigacion y Promocion Agropecuaria (INIPA) from Peru, the Winrock International Livestock Center from the U.S.A.

This document is a summary of the topics dealt with at the meeting, which included the presentation of work conducted by research projects on animal production systems, the presentation of three documents which served as a basis for discussion, and the discussion sessions. The conclusions reached and recommendations made are also summarized in the present document. The list of participants is included in the Annexes.

I. PRESENTATION OF ACTIVITIES OF RESEARCH PROJECTS ON ANIMAL PRODUCTION SYSTEMS IN THE TROPICS

Amazonian Production Systems Project, Peru

A. Riesco, G. Meini and S. Conzalez*

Background

Peru is divided into three well defined geographical regions:

The Coastal region, west of the Andean Cordillera is a narrow strip of arid land with steep slopes descending into the Pacific Ocean.

The Sierra Region covers the Andean Cordillera. It is the most densely populated region in Peru. The most prevalent form of agriculture is dry farming. This region has the highest concentration of cattle because it contains approximately 90% of the country's natural pastures.

The third region is the Selva, which may be subdivided into two very well defined zones: the Upper Jungle, or "Selva Alta", which covers the foothills of the eastern cordillera, and has its own land and climatic characteristics, and the so-called Amazon region, or Lower Jungle, "Selva Baja", which covers the greatest area of land in the country.

Less thatn 5% of the total area of Peru's land is devoted to agriculture. In the arid coastal region where rain is scarce, agriculture is concentrated along the few rivers which flow down the cordillera into the ocean. Agriculture could only be increased by means of expensive irrigation projects and dams. The Sierra region is already overpopulated and overexploited.

The Amazon region, or Lower Jungle, covers 60% of the Peruvian territory; however, less than 10% of the population of Peru lives here. Considering this and the fact that agricultural land and water in other regions are limited resources, it is evident that the Amazon region is Peru's most important natural resource and offers the best opportunity for agricultural expansion.

A study conducted in this region shows that approximately 20% of the area may be classified, according to its potential use, as pasture or plantation lands. Assuming that only 10% of the 70 million hectares were devoted to cattle-raising on pastures, a livestock population of over 10 million head could easily be supported, instead of the 300,000 now found in that region.

The IVITA has been conducting research on cattle-raising in the Pucallpa Station since 1969. This institution is practically the only one that has been working continuously in the field of cattle-raising in the Peruvian Amazon. Over these years, enough information been generated that can be applied in its area of influence.

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Research has show that the replacement of forest by pastures exploited extensively disrupts the balance of the natural fertility of soils, thereby lowering its level of productivity.

Under these circumstances, it is not surprising that the farms utilizing Hyparrhenia rufa (yaragua) have obtained low returns. However, the IVITA researchers have shown that if this grass is associated with Stylosanthes guianensis and is fertilized with 40 kg pf P_2O_5, production may be three times greater than with the grass alone.

It has also been shown that if higher levels of technological inputs are used with the gramineae Brachiara decumbens, degraded pasture land can be reclaimed and, in general, a more intensive and stable utilization for milk production can be achieved. In the field of animal nutrition it has also been show that the supply of phosphorus increases productive indexes substantially.

Research works has also led to the development of programs for the treatment and control of gastrointestinal parasites, piroplasmosis and anaplasmosis, and major infectious diseases particular to this region.

The project is being conducted at the IVITA Main Tropical Station, located at 8°20'31" latitute South and 74°34'35" longitude West, 59 km from the city of Pucallpa, on the higher to Lima.

According to Holdridge's ecological classification, the Station is located in a Tropical Rain Forest; the average annual rainfall is 1770 mm and there is a dry period from May to September (Map 1). Average annual temperature is 25.1°C. Soils are ultisols.

It is estimated that the results of the research could be applied to the farmers located along a 50 km stretch on the Pucallpa-Lima highway. In addition to this main road, there are two branch roads in operation: one to Tournavista (60 km) to the South and another to Nuevo Requena (19 km) to the North. At present, it may be said that the area of direct influence covers 90,000 hectares. Moreover, the Jungle Border Highway, linking this zone with Puerto Bermudez and Oxapampa in the South, and the secondary road to Curinana in the North are under construction (Map 2). The regional market is mostly concentrated in the city of Pucallpa, which has a population of 110,000 and an approximate annual rate of population growth of 5.5%.

The development of cattle-raising along the Jungle highways is a very recent phenomenon. The first cattle-raising zones were developed along waterways, which are the traditional lines of communication in the Amazon region. The project could have a medium-term impact on farms located along the river banks which fall within the Tropical Rain Forest ecological zone (Map 1).

Results could also be useful in other zones of the Amazon region and in other areas of the Rain Forest where there are ultisols and there are no major hydrological problems.

Cattle-raising in this zone is quite varied: enterprises range from small farms mainly devoted to crops to large cattle-raising farms having more than 1,000 head; from family businesses to SAIS and government production enterprises; some farms are along river banks, and others along the highways.

Regarding the size of production units, over 60% of cattle-raisers have fewer that 25 head; whereas less than 1% have more than 1,000 head (Table 1). Farms having fewer than 100 head, viz, 90% of all cattle-raisers produce only one third of the aggregate supply of beef of Pucallpa.

The production of milk on a commercial basis is in its early stages even though in many small- and medium-size operations milk is only produced for their own consumption and for the production of cheese sold at the local market.

Objectives

General Objective

The general objective of this project is to develop pasture management systems which are economically and ecologically stable and which may serve for the raising of dual purpose cattle.

Specific Objectives

a) To study the utilization of improved strains of grasses and legumes, individually and in combination, as a basis for feeding subsystems.

b) To develop cattle feeding alternatives using pasture silage or supplements which provide nutrients not provided in the pastures.

c) To design health calendars for cattle in the region.

d) To assemble generated information in order to use it in production modules.

e) To conduct an economic evaluation of the assembled systems.

f) To train Peruvian professionals in the field of animal production in the tropics.

Methodology

Technological levels and limitations prevailing on the farms in the region are determined on the basis of the existing background and the knowledge of farming systems based on surveys conducted. Parallel to this, secondary information from other institutions and the analysis of farm diagnosis makes it possible to design experiments to determine the behaviour of some system components.

The design of demonstration modules is based on the synthesis of information from the *ex-ante* evaluation of research components and on the knowledge of the existent technological levels.

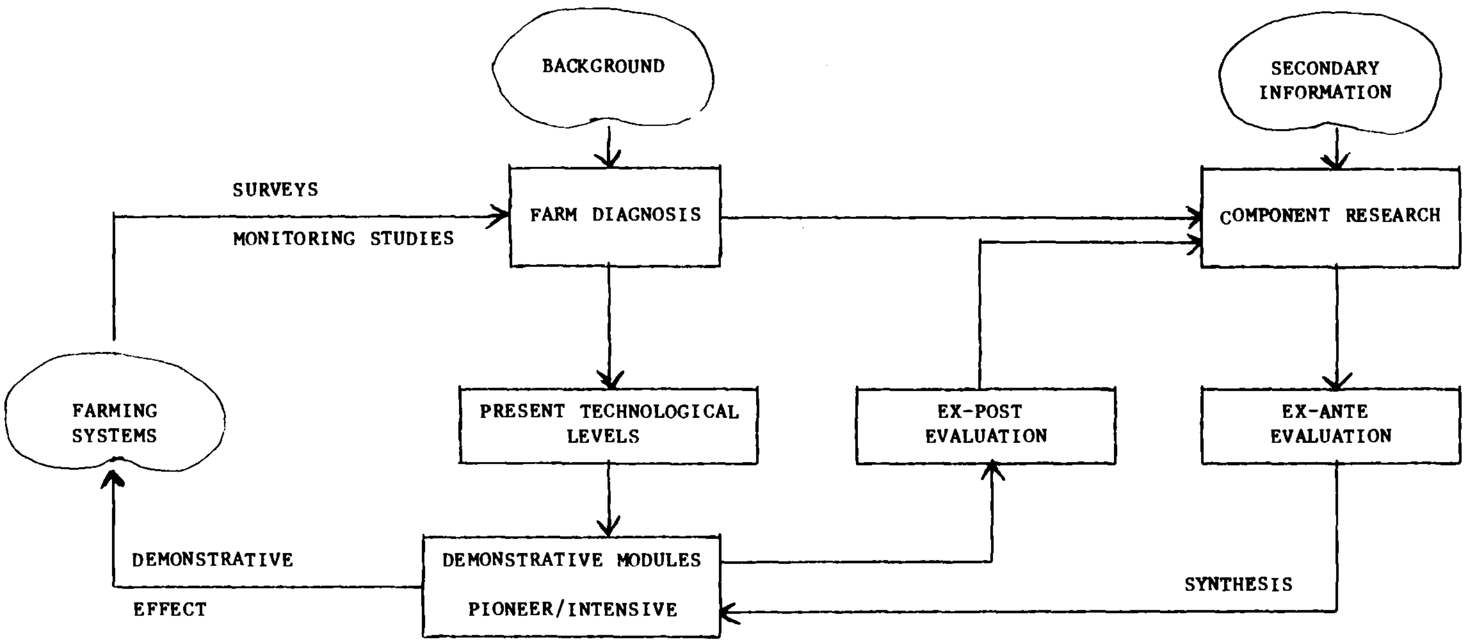

FIGURE 1. General Methodology

Once the modules have been used for a full cycle, an ex-post evaluation is conducted, which makes it possible to redesign research components. Also, the modules play a role in technology transfer, the effects of which will be evaluated during farm monitoring studies.

Progress of Project

Socieconomic Research

Characteristics of the supply of beef in the Pucallpa region. Historic information has been collected on the quantity of meat sold, prices, supply policies, input prices, quantities of other meats sold, seasonality, etc., in order to understand the effects of several factors on the supply of beef in the local and extraregional markets.

Table 2 shows the chronological series of beef on the hook consumed in Pucallpa. Figure 2 shows seasonal variations in source and the volume of cattle for local consumption.

It has been estimated that the total weight ratio between young bulls and cows is 1.04. In other words, production systems used are somewhat inefficient regarding the input-output ratio.

The ratio to be expected should not be less than 2.0. Information is being analyzed.

Diagnosis of production systems. The objective of this study is to determine the physical, human and financial resources of small- and medium-size farmers within the project's area of immediate influence. It also aims at determining the technical coefficients and limiting factors which must be met in order to increase production.

Two different kinds of diagnoses are made:

- static, conducted annually among a total of 60 to 80 farmers.
- dynamic, which involved the follow-up of 4 to 6 selected farms.

Tables 3 to 6 show some results obtained.

Study of the market for milk products in the region. The objective of this study is to determine the present situation and trends with regard to the demand for milk products. Parallel to this, there is another objective: to understand present marketing channels and bromatological conditions of products.

Regarding the different forms in which milk is consumed, surveys were conducted in three neighbourhoods in the Pucallpa region. The information is being processed. However, the amount of milk and cheese consumed is summarized in Tables 7 and 8.

Research on Soil Fertility

Soil typification in the experimental areas. Superficial samples have been collected to analyze soil fertility in the project modules; samples of each soil horizon have also been collected for characterization analyses.

Research on Pastures

Evaluation of germoplasm. The behaviour of 73 ecotypes: 62 legumes and 11 grasses is being evaluated.

At the moment, several ecotypes of *Zornia* are the most remarkable legume because of their good development, vigour and germination characteristics; also, *Stylosanthes guianensis* CIAT 184 free from anthracnose, *Centrocema macrocarpum* CIAT 5056, *Centrocema pubescens*, *Pueraria phaseoloides*, which is the most vigorous legume, *Stylosanthes capitata* CIAT 1315 and *Desmodium ovalifolium* and *heterophyllum* (CIAT 350 and 3782) show promise.

The most remarkable grasses are the ecotypes of *Andropogon gayanus*.

Production of seed. Two aspects must be mentioned here:

a) Production of seed for experiments.
   - *Stylosanthes guiyanensis.*
     The nursery covers 1 hectare and has produced 70 kg of seed with a 95% of purity.

   - *Centrocema pubescens*
     The nursery covers 0.25 hectare and has produced 87 kg of seed with a 92% of purity.

b) Effects of fertilization on the production of seed. This activity is still in the experimental stage.

Research on Nutrition

Fodder consumption and selective grazing in production systems. To measure the selectivity of cattle on various pasture systems, two esophagotomies were performed. Also, two rumenotomies have been performed to determine diet digestibility.

Silage production. The objective of this study is to determine the chances for success in the production of silage in tropical regions using mixtures of grasses and legumes to maintain milk production levels during the dry season.

Health Research

Resistance of ticks to ixodicides. Eight ixodicides (pyrethroid, phosphated and chlorated) are being tested on apparently sensitive strains.

Production Systems

Description. Two production systems which have different degrees of intensification ("pioneer" and "intensive" systems) have been designed; each of the system components are based on the research results and the socioeconomic characteristics of the region.

Steps taken for the establishment of the pioneer systems. Planting of *Stylosanthes guianensis* in the pasture for milking cows using fertilization for establishment.

- building of a milking parlor;

- beginning of grazing.

Steps taken for the establishment of the intensive system. Planting of *Brachiaria decumbens* in milking pastures using fertilization; for establishement of building internal and external fences; selecting animals for the module; planting the cattle pastures for growing cattle and dry cows; building of a milk parlor and a storage room for the conservation of milk; beginning grazing.

Ex-ante Analysis of Systems

a) Economic analysis of pioneer module:

Fixed assets investments		27,721.9 KLW*
- relating to land	5,933.1	
- relating to cattle	17,845.3	
- relating to labour	3,934.5	
Value of production		13,411.6 - 15,577.0 KLW*
- milk	4,411.6 - 5,637.0	
- meat	9,000.0 - 9,940.0	
Production costs		9,486.0 KLW*
- relating to land	3,851.2	
- relating to cattle	9/4.5	
- relating to labour	4,660.7	
Profitability		
14.2	22.0	%

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* KLW - Kilograms of live animal weight

b) Economic analysis of the intensive module:

Fixed assets investments		20,053.5 KLW*
- relating to land	4,139.7	
- relating to cattle	11,979.3	
- relating to labour	3,934.5	
Value of production		15,754.1 - 16,443.4
- milk	9,914.1 - 10,603.4	
- meat	5,840.0	
Production costs		9,044.6 KLW*
- relating to land	2,380.8	
- relating to cattle	2,003.1	
- relating to labour	4,660.7	
Profitability		
26.5	28 or 29	%

c) Input Utilization:

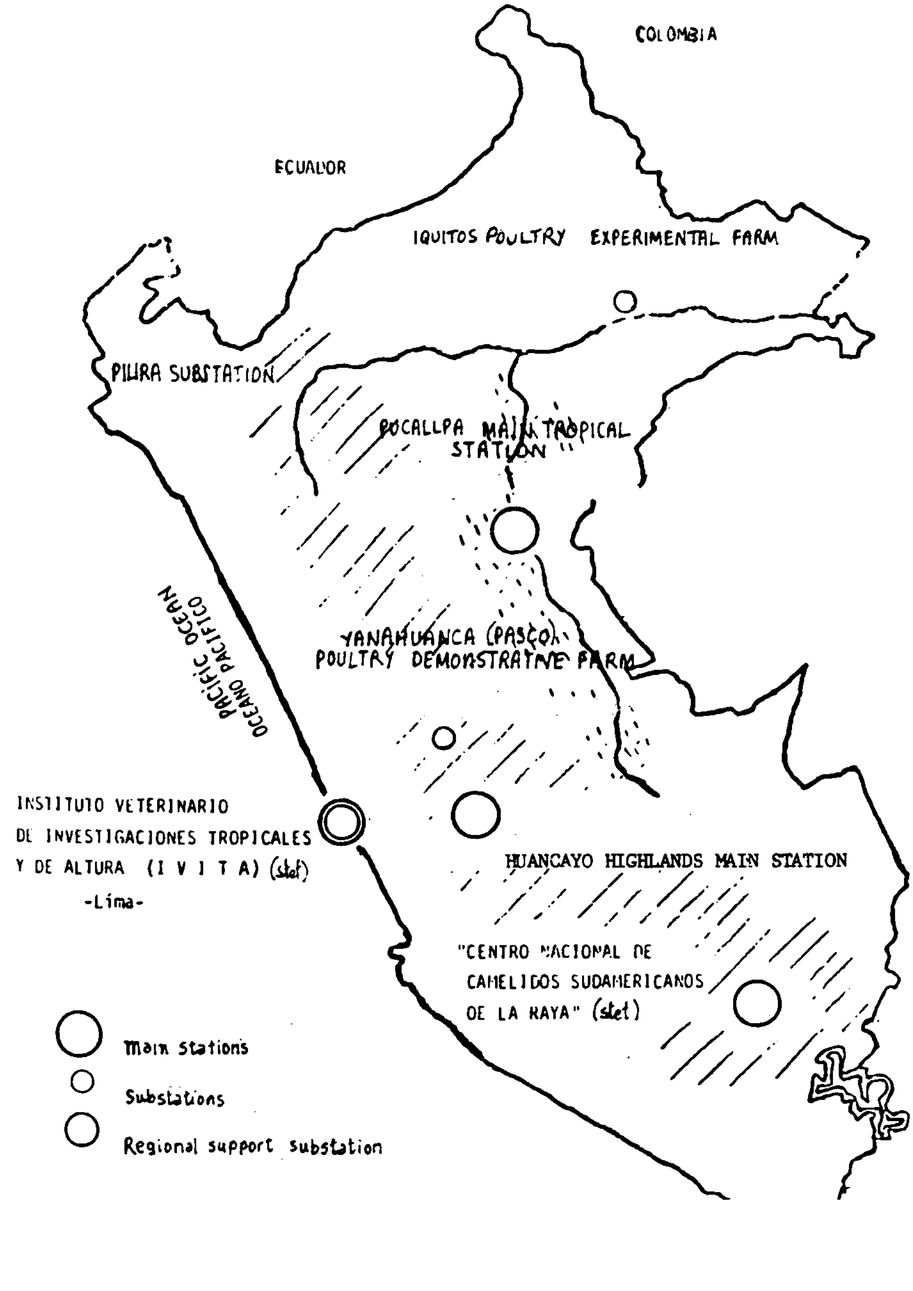
Nitrogen fertilization. From agronomic functions, empirical results of milk production in IVITA and basic nutrition functions, it has been determined that the threshold of the price/urea/milk ratio is between 3.5 and 3.7 which justifies the application of up to 400 kg per hectare/year.

However, an application of 280 kg of N per hectare/year has been done by IVITA for several years and has demonstrated its profitability.

Higher levels would be less attractive for small- or medium-size farmers at the present time.

Use of electric fences. An increase of 17% in herd size is required to justify the introduction of electrical fences. Also, farmers would likely not accept electrical fencing since it has not shown significant effects on business profitability; taking into consideration the present level of input utilization in dual-purpose cattle production in the Jungle region.

* KLW - Kilograms of live animal weight



MAP 1 : Location of IVITA's main tropical station and its area of influence.

MAP 2: Area of Project's Direct Influence

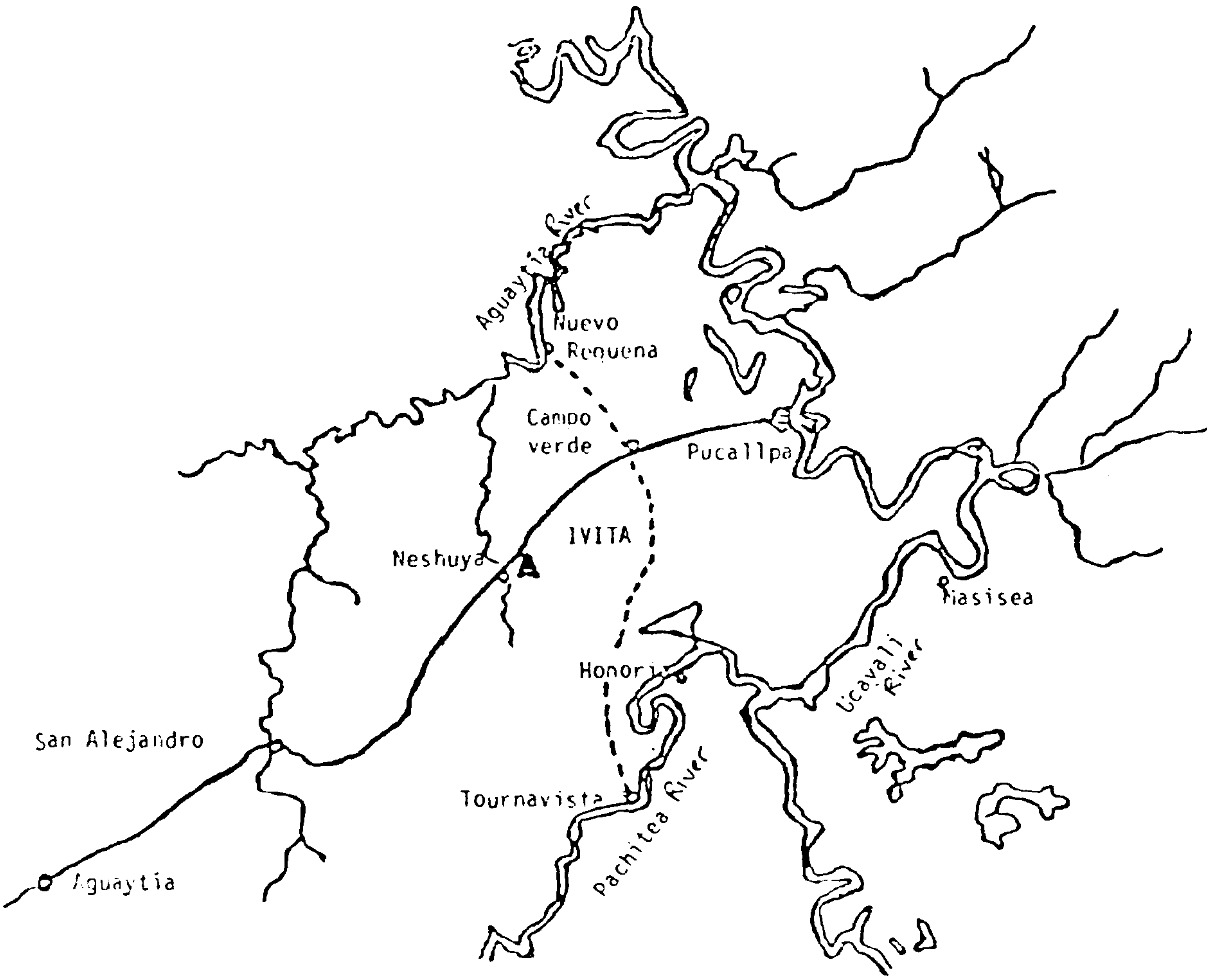


TABLE 1 SIZE OF FARMS AND THEIR CONTRIBUTION TO THE SUPPLY OF BEEF IN THE PUCALLPA REGION. DATA IN PERCENTAGES.

Size of operations (No. of head/unit)	Ratio and total units of production	Contribution to the suply of meat %
* to 25	62.64	5.8
25 to 100	29.12	26.8
100 to 1000	7.69	44.7
> 1000	0.55	22.7

* Number of head

TABLE 2 CHRONOLOGICAL SERIES OF AMOUNT OF BEEF ON HOOK CONSUMED IN PUCALLPA

Semester		Beef sold (M T)	Adjusted price[1]	Season[3]	P. A. Index[2]
71	1	261.79	20.4	A	11.4
	2	324.82	22.6	B	10.9
72	3	291.63	21.7	A	10.5
	4	336.93	20.5	B	11.1
73	5	331.34	19.3	A	10.4
	6	394.87	18.9	B	9.27
74	7	375.82	17.0	A	8.2
	8	466.67	22.1	B	7.4
75	9	366.29	19.9	A	10.7
	10	435.67	19.7	B	9.31
76	11	363.79	24.9	A	10.2
	12	363.60	22.4	B	9.0
77	13	352.09	22.9	A	9.3
	14	391.33	19.4	B	7.7
78	15	387.49	16.9	A	6.32
	16	422.76	20.6	B	6.8

1 Adjusted price refers to the ratio between nominal price and the general price index.

2 P. A. index is the ratio between minimum salary and general price index.

3 The later A represents summer and autumn, when precipitation is lower. The letter B represents winter and spring, when precipitation is higher.

TABLE 3 LAND AVAILABILITY AND USE IN THE SURVEYED PRODUCTION UNITS (AVERAGE DATE AND STANDARD DEVIATION)

Size of operations of the cattle component[1]	Total Land (Ha)	Pastures (Ha)	Agricultural crops (Ha)
1 to 10	51.1 ± 43.0	20.5 ± 23.2	6.0 ± 5.2
10 to 25	84.4 ± 42.6	34.1 ± 12.9	4.3 ± 1.1
> 25	108.1 ± 44.1	66.4 ± 25.8	4.0 ± 5.2

1 Number of head per farm.

TABLE 4 PHENOTYPE OF EXISTING MILK CATTLE IN THE REGION COVERED BY THE PROJECT (data in percentage)

Phenotype	Cows+ heifers	Cows	Heifers
Zebu	31.1	33.6	24.5
Zebu x native stock	18.9	19.3	17.8
Zebu x milk stock	37.5	33.7	47.3
Milk cows	5.4	5.3	5.4
Other	7.1	8.4	4.9

TABLE 5 PERCENTAGE OF FARMS WITH SOME PRESENCE OF IMPROVED PASTURES

Size of operations of the cattle component[1]	Grass/legume association	Brachiaria
1 to 10	26.9	34.6
10 to 25	31.6	57.9
> 25	31.3	62.5

1 Number of cows per farm

TABLE 6 IMPORTANCE OF LIMITING FACTORS ON MILK PRODUCTION ACCORDING TO FARMERS (data in percentages)

Limiting factors	Aggregate value	According to size		
		1 to 10	10 to 25	<25
Capital	34.6	37.5	30.8	34.8
Cows	19.8	15.6	19.2	26.1
Pasture	17.3	15.6	19.2	17.4
Labour	7.4	9.4	7.7	4.3
Technical knowledge	4.9	9.4	3.8	0.0
Bulls	4.9	3.1	7.7	4.3
Profitability	4.9	3.1	7.7	4.3
Marketing	3.7	6.3	0.0	4.3
Soil	1.2	0.0	3.8	0.0
Health	1.2	0.0	0.0	4.3

1 Number of cows per farm

TABLE 7 DIFFERENT FORMS OF MILK CONSUMPTION IN PUCALLPA

Kind of milk	Consumer families	Consumption by families	Aggregate consumption (g/day/person)	Consumption in equivalent fresh milk (l/day/person)
Powdered	31.8	10	3	0.024
Fresh	12.1	140	15	0.015
Evaporated	87.9	108	91	0.180
TOTAL				0.219

TABLE 8 CONSUMPTION OF CHEESE IN PUCALLPA

Type of cheese	Consumer families (%)	Consumption by families (g/month/person)	Aggregate consumption (g/month/person)
Fresh	68.8	350	249
Processed	27.7	120	36
TOTAL			285

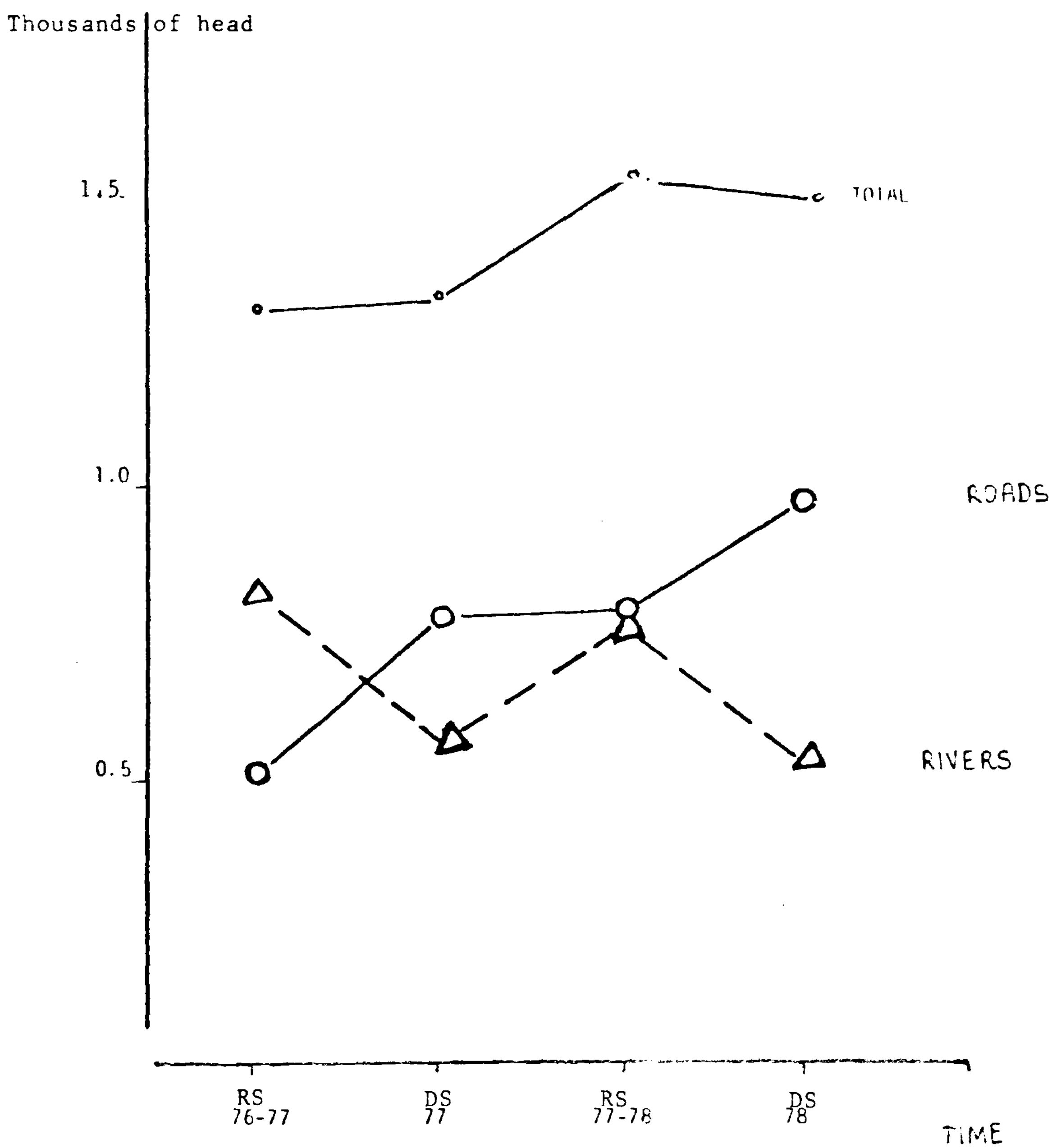


FIGURE 2 Source of Cattle Supply for Slaughter in the Pucallpa Region.

RS = rainy season; DS = dry season

* Figures from representative quarters

Dairy-Beef Feeding Systems Project, Panama

Manuel De Gracia, Miguel Sarmiento, Santiago Rios, Carlos Ortega*

Background

During the past few years there has been a significant drop in milk production in Panama; the reduction is estimated at about 50% of the average national demand. One of the causes of this reduction is the apparent inefficiency of dual-purpose cattle farms, which account for over half of all production.

Dual-purpose cattle-raising farms are usually small- and medium-size operations. Animals generally are Zebu x Holstein and Zeln x Brown Swiss crossbreds. The dominant pasture is the Faragua (Hyparrhenia rufa, (Nees) Stapf). In some areas during the dry season agricultural residues and agroindustrial byproducts of low nutritional quality are used without any supplement. In other areas where fodder and residues are scarce, production stops all together during this season. It must also be pointed out that sanitary controls are insufficient and the use of mineralized salt is uncommon. Herd and pasture management practices require better technology, if average production, which is now 4 litres/animal/day and approximately 500 litres/ha/year, is to be increased.

In order to generate and adapt new technological alternatives to increase productivity on the farms mentioned above, research efforts were intensified and strengthened with the support given by the International Development Research Centre (IDRC) to the Instituto de Investigacion Agropecuaria de Panama (IDIAP) through the Project "Research for the Improvement of Dual-Purpose Cattle Production Systems".

This project had the following general objectives:

1. To generate technology suitable for dual-purpose farms in order to improve animal feeding and, consequently, milk production;

2. To contribute to the transfer of technology generated using demonstration units

3. To train technical and support staff in dual-purpose cattle production.

Specific objectives were:

1. To increase the carrying capacity of the Faragua from one to two head/ha/year;

2. To increase milk production from 450 to 900 litres/ha/year within three years;

* Instituto de Investigacion Agropecuaria de Panama, IDIAP

3. To increase birth rate from 50% to 75%;

4. To reduce the calving interval from 23 to 16 months.

International organizations such as the Instituto Interamericano de Ciencias Agricolas (IICA) and te Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) collaborated in the execution of the project.

The Research Project for Improvement of Dual-Purpose Cattle Production Systems began in February 1978 and lasted three years. It was conducted in three areas, located in the provinces of Chiriqui, Veraguas and Los Santos.

According to the methodology established at the outset, the activities of the project were classified under the following four subprojects:

Diagnosis of Dual-Purpose Cattle-Raising Farms

The first stage of this subproject was the identification and characterization of prevailing production practices during this study, i.e. Static Diagnosis. Factors limiting production were detected.

In the second stage of this project, a continuous characterization of production practices was conducted, which supplemented information obtained during the Static Diagnosis.

The objective of the second stage was to increase existing information regarding parameters which could not be accurately estimated from a static point of view, and also to identify some attitudes of farmers regarding decision-making with respect to their farms. The Dynamic Diagnosis was started after determining that, in the areas covered by the project, it was necessary to disseminate information on IDIAP activities and improve communication with the farmers to obtain collaborators for the present study and for other complementary ones.

Validation and Evaluation of Production Practices

This subproject was subdivided into three lines or phases: bioeconomic evaluation of typical production practices; evaluation of proposed production alternatives, and a comparison of both.

In order to evaluate information obtained during the Static Diagnosis on production practices prevailing in the areas, and compare them with improved practices, it was necessary to choose a farm in each area, the management of which was representative of the modality; these farms are referred to as a "pilot farms."

It was also necessary to establish another farm referred to as "validation farm" on which new simple and improved practices having the potential to increase productivity of predominant systems were introduced.

In each work area both a pilot farm and a validation farm were established. At the end of each production cycle, bioeconomic evaluations and comparisons were made between the farms in each area to analyze and determine progress made.

Generation of Information on the Components of Production Sytems

Once the factors limiting production in the prevailing productive system were detected, research was oriented towards the search for alternative solutions to these problems. Thus, the results of continuous experimentation, together with available information, were used to implement the alternative solutions which appeared to be most suitable for these limiting factors. These alternatives were aimed at improving the prevailing technological level, increasing production and system productivity and, consequently, the general standard of living of the majority of farmers for whom cattle-raising is the main economic activity.

Technology Dissemination and Transfer

The dissemination of the project's objectives and goals was envisaged, among both farmers and technicians in the agricultural sector, in the work areas. To this effect, talks, field days, and visits were organized, technical meetings were held, and printed material was distributed. "Pilot" and "validation" farms were used as demonstration units.

Also, other activities more directly related to the transfer of technology were carried out: some technological practices were implemented on some farms, which also served as demonstration units during field days.

At an international level, the results of the project were disseminated by participation in international scientific meetings, visits to similar projects in other countries and visits of personnel from foreign institutions. During these activities, information was shared concerning the activites and results of the project.

Although the above research project was originally planned for a duration of three years, the generation and evaluation of bioeconomic information on farms was done only for two years. Nevertheless, it is expected that the preliminary promising results would be confirmed, to the advantage of cattle-raising farmers of limited resources.

Moreover, research conducted during the above project has raised many questions, the answers to which may be sought on the basis of the infrastructures developed and the receptive attitude of the farmers towards the methodology used. Consequently, it was considered appropriate to request financing from the IDRC for the second phase of the project, which started in November 1981.

Objectives

The second phase of the project is based on the above background and considerations, and has the following objectives:

General Objectives:

1. To contribute to incorporate component research of production systems through continuous study of production practices developed in order to increase the farmers' income;

2. To generate alternative solutions to technical and transfer problems, derived from working directly with farmers;

3. To intensify the transfer of generated technology, to small- and medium-size farms, within the new organic structure of IDIAP.

4. To evaluate the impact which the introduction of new technologies may have on the production system of small- and medium-size farms.

Specific Objectives:

1. To characterize continuously the production systems of dual-purpose cattle farms in three areas in Panama; this would serve as a source of information and an instrument to evaluate the impact which the production of improved practices may have on these production systems;

2. To generate technology which would contribute to the rational use of resources on the farms of small- and medium-size farms;

3. To contritute to the training of technicians and farmers in the three areas where the project will be carried out;

4. To establish demonstration modules on some farms, in order to introduce simple and improved variants into the existing production practices, which would increase the biological and economic efficiency of resource utilization.

Methodological Framework

In order to reach the proposed objectives, the actions to be taken are set out within the methodological framework which appears in Figure 1. As can be seen, activities have been sequentially and systematically subdivided into stages which are chronologically linked to each other. The activities to be developed in each stage are briefly described below.

First Stage:

Assuming that the Static Diagnosis has already characterized existing farming systems in each region, a certain number of farms will be chosen.

The farms chosen must represent the system typical of each region, and their production system must have favourable characterictics which would permit research to be conducted. Some of these characteristics depend on the personality of the farmers, for example: cooperative attitude, receptiveness, trust toward the institution, good capabilty to conduct test controls, ability to provide required information, capability to disseminate the results obtained from experimentation, etc. Other characteristics depend on the location and general condition of the farm, such as: good acces roads (year round), good general physical characteristics of the farm, etc.

Once the farmers who will participate in the project have been chosen, the phase of recording information, which will make it possible to conduct biological and economic evaluations of each farm, will begin at the end of one production cycle. In this regard, a simple and functional record system has been developed, which includes:

- resource availability

- zootechnical aspects of production

- expenses and revenue

- reports of visits made by the project coordinators and other researchers involved.

- additional studies concerning some specific aspects of the farmer and his production systems.

It is expected that the continuous gathering of data during a production cycle will contribute to a realistic determination of the facts which limit production and productivity on the farms.

It is well know that, depending on his income, a farmer may invest a part of his income towards providing a higher level of social and nutritional well-being to his family; for this reason it would also be advisable during the study, to gather information regarding the family's present condition in this respect.

Second Stage:

In the course of the first stage, some of the factors limiting production can be determined a priori, on the basis of the information gathered during the visits of researchers to the regions and the partial analysis of information gathered through complementary records and studies. Thus, tests can be conducted, or information can be gathered regarding certain alternatives which show a potential solution to problems detected. This will create a data base which, once systems are better understood, will make it possible to choose those alternatives which would have the greatest likelihood of success when implemented among farmers. That is to say, that if all of the gathered information were used, and the principal uniting factor(s) for each component were known, a list of the alternatives within each component for each component of the production system, i.e., nutrition, genetics, deferred grazing of pastures, drought-resistant species, calorie-protein supplements, etc. could be analyzed to reduce feeding problems during the dry season.

Technological alternatives which may provide a solution to the problems will be subject to an ex-ante evaluation. Here, the alternative to be chosen must meet the following requirements:

a. provide the most benefits with the least input utilization and cost

b. have a better adaptability to the present system in which is it to be introduced

c. improve productivity within a short term

d. be easy for farmers to implement and adopt

e. have the lowest risk possible when implemented by the farmer.

Once the alternatives have been chosen, they will be implemented on the collaborating farms in such a way that they meet, to some extent, the minimum requirements so that logical comparisons between them can be made, in order to be able to determine later which alternatives are the best, or at least, to be able to classify them according to their suitability. This implies that during this stage farm activities must be followed-up continuously in order to be able to gather the information needed to conduct a final evaluation of each farm studied, to compare them to one another, to compare the initial condition of the farm and its condition after the alternative (or combination of alternatives) has been introduced and, at the same time, to make any required adjustements to the proposed alternative(s) before they are disseminated among most farmers.

Third Stage:

This stage includes the period of evaluation and comparison of zootechnic and economic indexes of farms before and after the alternative(s) to the production system have been introduced. On the basis of the results obtained, all those aspects relative to the introduction of the alternatives on the farm may be definitely considered and, at the same time, the bases guiding further research will be laid.

Even though comparisons will be done over a period of time, farms can also be compared within the same period of time with or without the introduction of alternatives. This is possible because the selection of farms for the study of production systems and research on alternatives is a continuous process and there will be farms involved in each stage throughout the duration of the project.

The following are some of the indexes which will be used to conduct evaluations and comparisons:

Biological Indexes	Units of measure
- milk production	
- cow/day	litres
- hectare/year	litres
- birth rate	%
- mortality rate	%
- calves at weaning	kg
- age at first calving	days
- length of lactation	days
- calving	days
- carrying capacity	number of animals/ha/year

Economic Indexes	Unit
- net income	B/.
- net income/hectare	B/.
- net income/day	B/.
- profitability	%

Sociocultural Indexes

- food habits
- health
- housing
- educational level
- subjective aspects with regard to the well-being of the individual and the farmers' atitutudes towards decision-making

In addition to these studies, which are the main focus of the project, additional research will be conducted which will deal with basic aspects of proposed alternatives, such as: study of digestibility and fodder consumption, study on the management of improved natural pastures, cut and carry forages, legume-grass associations, chemicals found in crop residues which have potential toxic effects on animals and human beings; animal health, animal management, etc.

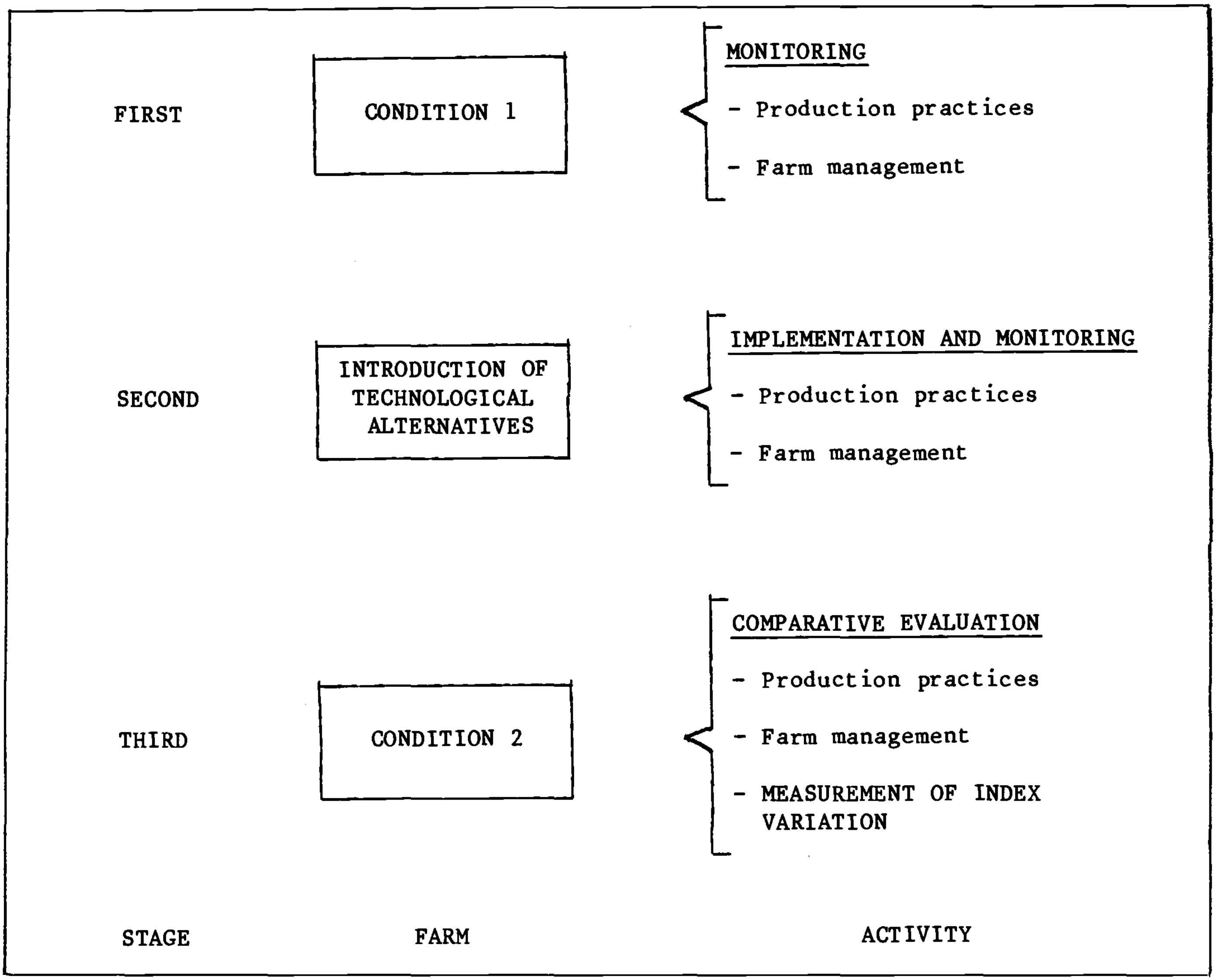


FIGURE 1 - Methodological Framework for the Evaluation of Production Alternatives on the Dual-Purpose Cattle Farms - Small- and Medium-Size scale

Dairy-Beef Production Systems for Small Farmers in Central America

Danilo Pezo, Arnoldo Ruiz, Manuel E. Ruiz*

Background

Since 94% of the agricultural sector population in Central America lives on farms of less than 35 hectares and produces 55% of the total income for this sector, the CATIE (Centro Agronomico Tropical de Investigacion y Ensenanza) considered that one way to increase agricultural production in the area was to generate technology capable of improving the bioeconomic efficiency of the production systems presently used on these small farms.

To this effect, an agreement between the IDRC and CATIE was signed on December 17, 1976, which provided financing for the First Phase of the Research Project on Dairy-Beef Cattle Production Systems to be conducted primarily in Costa Rica. The results obtained during the first phase contributed to the description of the production systems most often used on small farms, and also to the identification of factors which limit the bioeconomic efficiency of those systems. The diagnostic work on farms led to a series of guidelines for biological research, and also to more emphasis being put on the study of dual-purpose systems and the original hypothesis that the utilization of crop residues are a viable alternative by which farmers can improve their animal feeding subsystems. Biological research conducted during the First Phase made it possible to find answers to a series of questions regarding availability, quality and utilization of a series of products and crop residues, some of which are usually found on small farms, and others of which have the potential to be used intensively on those types of farms.

It was evident from this that the activities of the project had to be extended to a Second Phase, which would make it possible not only to improve upon the process of biological research, making it increasingly more realistic, but which would also make it possible to test the usefulness of farm dynamic diagnoses. Thus, in August 1980, a renewal was signed to extend the Second Phase of the project for a duration of three years.

Objectives

General Objectives:

A) To contribute to the development of integrated production systems suitable for small- and medium-size farms in Central America

B) To contribute effectively to the creation of an integrated and multidisciplinary action aimed at development of rural areas.

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Specific Objectives:

A) To conduct a study of small- and medium-size farms in Central America to identify existing production systems.

B) To study variants of the dual-purpose system in selected areas.

C) To determine the food value of crops, residues, byproducts and cut hay used in conjunction with or in substitution of grazing

D) To produce suitable technology for the efficient management of dual-purpose systems, emphasizing the feeding component

E) To contribute to research and technology transfer activities conducted by national institutions.

Methodology

Figure 1 shows the conceptual framework used as a guide for the activities of the project. The diagram shows, step-by-step, the different aspects the project has considered in its research; also indicated are some aspects where information could be obtained using feedback mechanisms.

Despite the growing interest in helping small farmers, little is known about the reasons or circumstances which lead them to manage their resources in the way they do. To remedy this situation, the project began a diagnostic farm study from which an important mass of data was obtained regarding the production systems actually being used by small farmers. The information obtained is not only descriptive and limited (static diagnosis), it also makes it possible to analyze the changes which occurred on the farm throughout the year (dynamic diagnosis).

The diagnosis has served not only to identify the target population of the project, but also to determine the nature and approach for biological research activities. To determine this last aspect, a detailed analysis was conducted of the small farmers' present situation and their most important problems. Research must be conducted to find solutions to these problems.

Solutions derived from research activities must be validated in order to eliminate those solutions whose applications among farmers would be unfeasible because of their complexity, high cost, low impact, etc. Such a validation may be caried out at experimental stations or on the farms of the collaborating farmers, depending on the degree of accuracy desired. Validated solutions must be integrated into the set of practices or techniques relating to the animal component which, in turn, is associated with other components such as crops, forests, or both, depending on the characteristics of the farm.

As set out in the agreement, project activities have emphasized aspects such as production and utilization of resources other than pasture as food for cattle, which involves research in the field of agronomy.

Diagnosis Methodology

As can be seen from preceding paragraphs, farm study or diagnosis is subdivided into two stages. The first stage is static; it has wide coverage (10-15% of relevant farmers), and it aims at identifying those production systems most often used by them while giving, at the same time, a general description of how resources are managed. Obviously, the farm is not static over a period of time, but rather is subject to a series of changes resulting from the interaction of the farmers' interests, the government, credit policies, and the environment. In order to gain a solid understanding of their decision-making process, and the criteria they use to arrive at decisions, the static diagnosis was followed by a dynamic diagnosis. The dynamic diagnosis involved the selection of a few farms, representative of the original universe, which were followed up for a full year with weekly visits during which an information recording system was used.

Diagnostic activities have led to the definition of the following aspects:

a) On small farms, farmers try to minimize risks; to this effect, they try to diversify their farming activities. Technically, cattle-raising is the only economic activity for 24% of the farmers studied in Costa Rica.

b) Among the various cattle-raising activities of the farmers, dual-purpose cattle-raising is the most frequent, found in 87% of farms studied. It should be pointed out that the cattle production system to be used is not determined by the breed composition of the animals.

c) Small farmers are not reluctant to use credit; it has been found that approximately 40% of dual-purpose farmers and 60% of those who specialize in milk production have used credit. It should be stressed that this credit is not associated with technical assistance programs.

d) Regardless of the cattle production system used, pasture is the basis for cattle feeding. In addition to pasture, 37% of farmers use other foods; the most important of which are banana pseudo stems, sugar cane tops, molasses and commercial concentrates. The latter two are used in quantities lower than one kilogram per animal per day.

e) Overgrazing is a problem on these farms; this can be illustrated by the fact that 74% of grazing area is natural pasture, as well as by the fact that only 18% of farmers fertilize grazing areas; however, they maintain 2.5 A.U./ha/year.

f) Milk production per cow-herd and hectare is low (2.6 and 4.8 litres/day, respectively), as a consequence of a high proportion of unproductive animals in the herd (animals with reproductive problems, short lactations, maintenance of a large number of replacements). Milk production per lactating day has been estimated at 1.2 litres.

g) The most important product of cattle production activities is milk, which accounts for 90% of the value of cattle production.

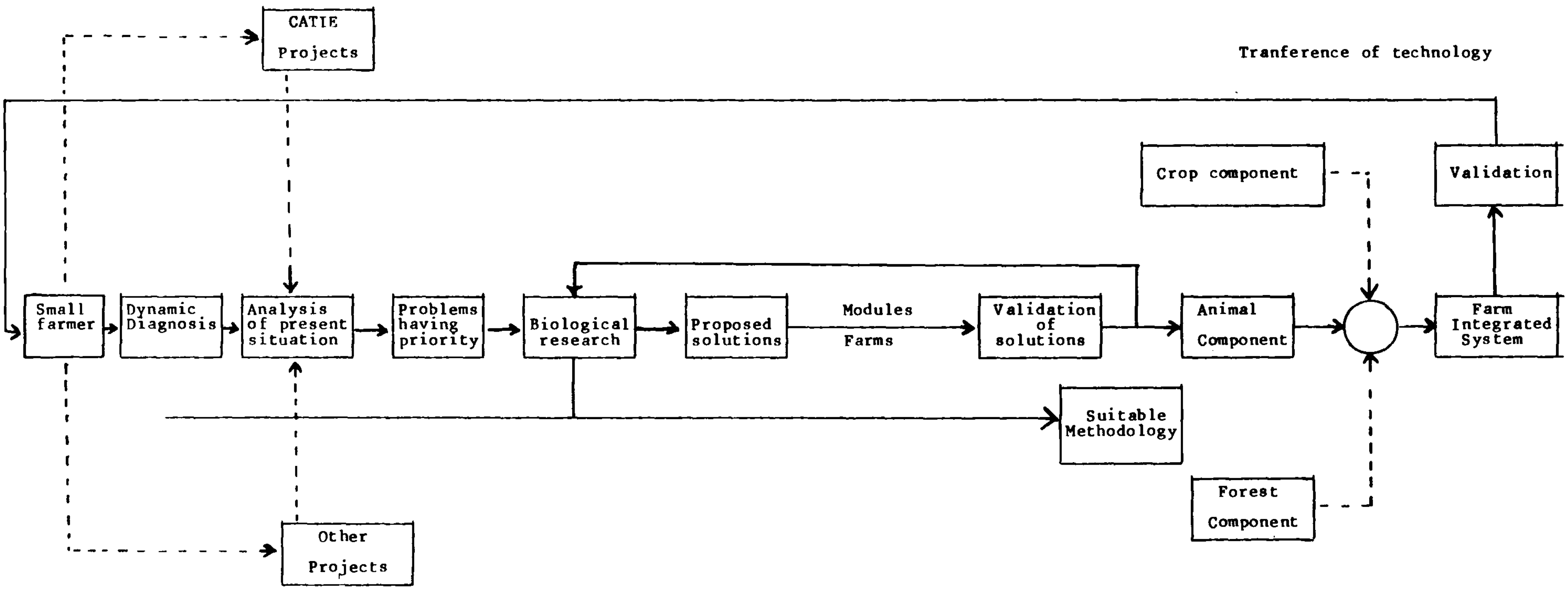

FIGURE 1. Conceptual Framework of Project

h) There is an average of 3.3 pigs and 21.0 birds on these farms, however, these animals produce only 18.6% and 5.0% of a farm's total net income, respectively.

i) Production value, proportion of marketed products and return on production factors were higher on farms which also had perennial crops.

Biological Research Methodology

Regarding biological research activities, the main thrust of the project is concentrated on the generation, validation and integration of biological knowledge in dual-purpose cattle production systems (emphasizing the use of resources other than pasture, as feed for cattle). Figure 2 shows the general direction the project's biological research activity has followed.

Agronomical Evaluation Phase. This phase is the first step in a continuous process of selecting potential resources which are typical of small farms in Central America. Different agronomical variables, both quantitative and qualitative are studied, then evaluated in terms of total biomass or the different products obtained: marketable products, products for consumption by farmers, fodder residues and concentrate residues (those not directly usable by man). It also considers those crops (including cut and carry forages) planted for the sole purpose of producing feed for animals.

The phase of agronomical evaluation emphasizes the study of the effect the above variables may have on total biomass yield. The evaluation of the potential production of residues from agricultural crops is based mainly on the information generated by CATIE's Department of Crops Production.

The following results are typical of the information obtained during this phase.

a) It is possible to double, and even to triple, the production of cassava leaves by increasing planting density (3.309 vs. 9,965 kg DM/ha for densities of 10,000 and 11,100 plants/ha, respectively) without negatively affecting amount of root yield. However, this kind of management conspires against the production of marketable roots (72.1% and 28.9% for the densities indicated above).

b) Apparently, production of sweet potato leaves can only be increased by cutting the aerial part two or three months after planting, leaving at least one residual stalk and cutting it again at the end of the harvest. This management results in an increase of almost one ton of fodder/ha/vegetative cycle; however, tuber yield is two tons lower than when managed without defoliation.

In addition, while pruning makes it possible to produce superior material from a nutritional point of view, the advantage tends to be less important when the quality of material obtained without pruning is considered. All this indicates that partial pruning is not recommended when the sweet potato leaves constitute a residual crop rather than the main crop.

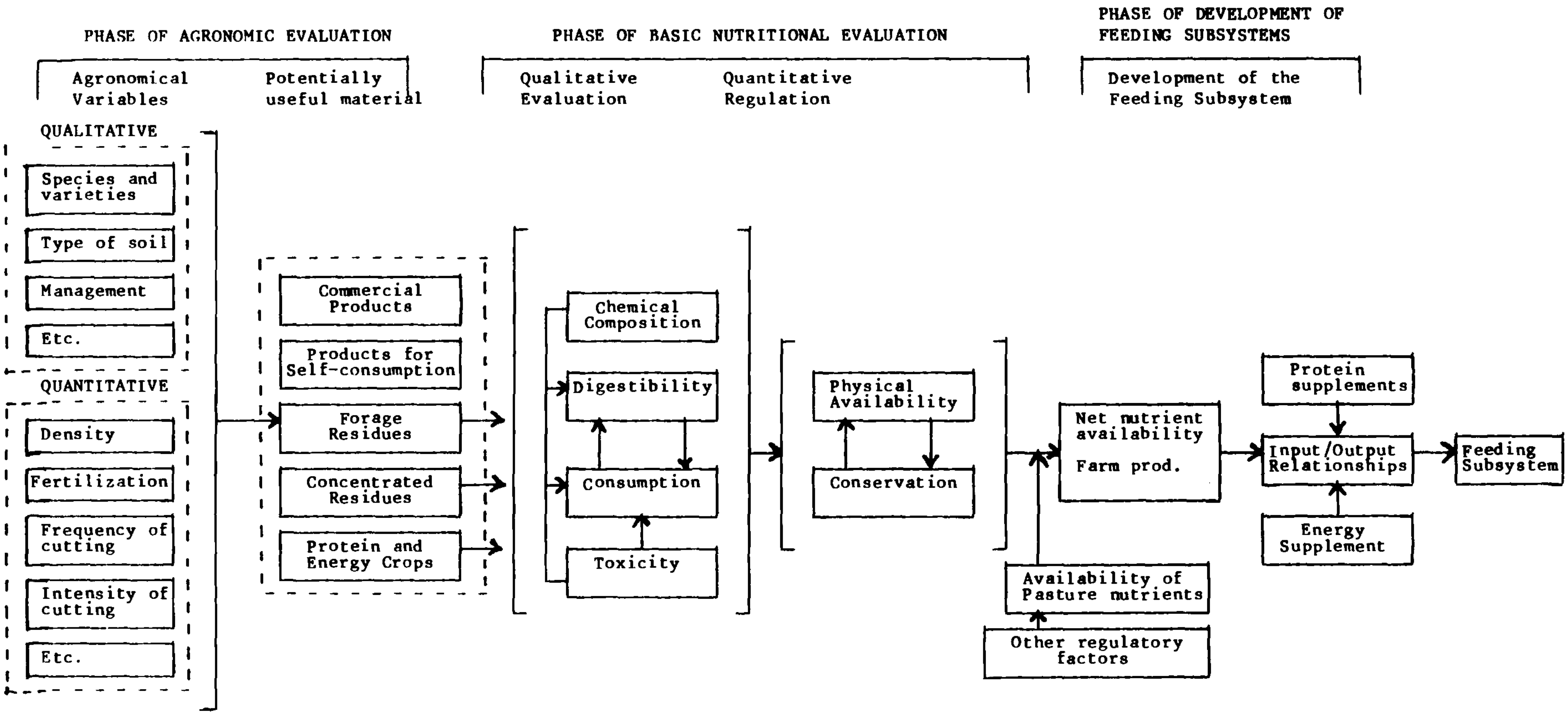

FIGURE 2. General Diagram of the Research Program for the IDRC-CATIE Project, Second Phase

Phase of Basic Nutritional Evaluation. This phase aims at evaluating those resources which prove to be promising during the phase of agronomical evaluation. Studied in this phase are chemical composition, digestibility, and consumption, as well as the interrelationships between these parameters. This phase also takes into consideration another important aspect, viz., the study of techniques for the conservation of crop residues, since normally crop harvest takes place in a very short period, and all the residues produced cannot be utilized when fresh. If suitable conservation techniques are not developed, most of these residues will be lost.

The following has been determined from basic nutritional studies:

a) The higher efficiency that has been found in the use of foods when a source of starch is added to the diet, is due, at least in part, to a higher growth of microbe mass in the rumen. The same starch composition has a significant influence on microbe growth; it has been found that the most suitable ratio is 75% to 95% of amylopectin and 25% to 8% of amylase.

b) When urea and non-marketable sweet potatoes were used as additives in sweet potato fodder, it was determined that urea tends to increase the final pH of silage; that losses due to putrefaction were higher; and, that the *in vitro* digestibility of the final product is not affected, despite the fact that protein content is increased. Likewise, the addition of tuber does not have major effects on the quality of silage, and judging from the quality of the material obtained without using additives, sweet potato fodder can be efficiently conserved without doing so.

c) *In situ* digestion studies (using the dacron bag technique) have shown that the use of a source of starch negatively affects the digestion rate of foods high in fibre such as sugar cane tops, corn stubble, and banana pseudo stems. However, the use of the same source of starch does not affect the ruminal digestion of fodders rich in protein such as leucaena (*Leucaena leucocephala*), poro (*Erythrina poeppigiana*), madero negro (*Gliricidia sepium*) and sweet potato (*Ipomoea batatas*) fodder.

Food Subsystems Development Phase. Once the advantages and limitations of crop residues are known, one can evaluate animal response according to milk production, weight gain, as well as to the utilization of those residues, either by themselves (as pasture substitutes) or mixed with pasture (as supplements), and also in combination with energy and protein sources. This type of study makes it possible to define input/output and input/input ratios which can, in turn, be used to conduct an economic evaluation of the use of these residues in feeding subsystems.

This phase also includes other basis work which permits an evaluation of the causes of the responses obtained, or ways to improve the bioeconomic efficiency of the utilization of crop residues. Thus, this last phase of research is the conclusion of a selection process whose final result is the recommendation of food subsystems. This phase is oriented towards the improvement of existing subsystems, rather than the design of new subsystems.

As feeding was only one of the several subsystems involved in the production system during this phase, some incursions are made into other fields deemed necessary, such as cattle management practices and health.

The following will illustrate the work conducted during this phase:

a) When discarded green banana was used as a supplement to grazing for cows having an average milk potential, it was determined that the highest responses are obtained when the supplement is given within the period of one month before to three months after calving using an amount of 1.5 kg of fresh banana/100 kg of live weight.

b) When kidney bean stubble is used, it has been found that despite its apparent physical and chemical limitations, it is possible to establish drought feeding subsystems which lead to weight gains of: 60 g/animal/day without supplements, 400 g/animal/day when low levels of protein and supplementary molasses are given, and approximately 750 g/animal/day when given high supplements of molasses and moderate levels of protein. This phenomenon is due, in part, to the animal's high selectivity for empty pods, the component which is more easily digestible.

The formulation of biological research is based on the experience generated by the project itself and the information derived from cooperative projects, and is never rigid.

Projections

From the information presented above, it is evident that most project efforts have so far been concentrated on the phase of Biological Diagnosis and Research, rather than on the integration of information at the level of subsystems. Also, during the past two years, the project has stressed biological research almost exclusively, since other CATIE projects have continued the diagnostic work in other areas of Central America, adopting the methodology developed in this project. For the resons set out above, the aspects of ex-ante selection and evaluation of alternatives and the study of their behaviour (validation) on the producers' farms will be emphasized during the final stages of the second phase of the project, and eventually during a third one. There is not available methodology for the evaluation and validation of alternatives on-farm in animal production research; thus, one of the byproducts of this effort must be, indeed, the design of such a methodology.

Although the challenge is difficult, it may be met through exchange of opinions with other colleagues at CATIE, with other staff working on IDRC-funded projects aimed at developig animal production systems, as well as through the contribution of external consultants.

II. DOCUMENTS FOR DISCUSSION

A Methodological Approach for the Development and Evaluation of Alternatives for Animal Production Systems for the Small Farmer

Rolain Borel, Manuel Ruiz, Danilo Pezo,
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Research Geared to the Development of Production Systems for the Small Farmer

The Small Farmer: Subject and Target of Agricultural Research

It is difficult to give a precise definition of "small farmer"; such a definition, however, is not necessary to be able to understand the way of life and the importance of the small farmer in developing countries. From an economic viewpoint, the main characteristics of the small farmer are his limited access to resources and his low income.

In general terms, the small farmer owns a tiny parcel of land whose soil has low potential due either to soil composition or to intensive exploitation; his human working capital (education, knowledge and health) is low; he suffers chronically from a scarcity of capital and he has limited access to credit and inputs. In addition, he faces unstable markets and prices, he receives very little technical support and because of his lack of economic clout, his participation in the control and operation of agricultural institutions is limited (Dillon an Hardaker, 1980).

Since the majority of rural population is made up of small farmers, many national, regional, and international institutions have shown some interest during the past few years, and made efforts to study the small farmer and his system, in order to improve the well-being of him and his family. In this regard, Wharton (1969) suggests that about 50% of world population depends on subsistence agriculture; that almost 40% of cultivated land is in the hands of the small farmer, that he represents 60% of the total number of farmers and produces less than 40% of total agricultural output. In Central America, for example, 94% of the population of the agricultural sector lives on farms smaller than 35 hectares, own 27% of the area devoted to agricultural activities and generate 55% of the total income for the sector (SIEGA-GAFICA, 1974).

The Need for a Change of Researchers' Attitudes Regarding the Problems of the Small Farmer

Traditionally, the systems of the small farmer have been considered to be archaic and inefficient, and should therefore be upgraded. The main characteristics of the proposed alternative systems, the so-called "modern technology" are: a high use of inputs, a low use of labour, and a tendency to maximize net income (Navarro and Moreno, 1976). The natural response to these technological innovations has been indifference, and, accordingly, "modern technology" has seldom been adopted.

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Different explanations have been given for the slight impact of "modern technology" among small farmer, viz., the physical environment on the farms is not suitable, institutional aspects of market infrastructure do not encourage them to adopt "modern technology"; small farmers are not trained to adopt "modern technology"; programs for technology transfer are not effective, etc. Each of these explanations is partially valid; however, the main problem lies in the fact that the development of the so-called "modern technology" has not taken into account that one of the limiting factors among small farmers is lack of capital, that their most abundant resource is the available manpower, and that the maximization of net income is not always the main objective of their system.

The foregoing suggests that before initiating any research program to improve upon the system of the small farmer, it is necessary to understand his physical-biological and socio-economical environment, how he functions and what his goals, attitudes, and technological knowledge are (Zandstra et al. 1978). This effort is also valuable, because it will make it possible to define the present condition of systems, which would be used for comparison, since the objective of the research must be to transform the system, from its "present" condition to an "improved" one. However, the "improved" condition of the system should not be the maximum that can be attained through substantial modification; on the contrary, that maximum should be the incentive to progressively transform the existent system (Navarro and Moreno, 1976; Navarro, 1979 a).

A progressive transformation would be something familiar for the small farmer, since to a considerable extent, his present system is the product of modifications made by him and his ancestors over the years, in order to adapt to changes in the environment.

Transformation involves "adaptation" of improved technologies, which imposes a special demand on research, since the technologies to be generated, in addition to being technically superior to those already used by the farmer must also be suitable for adoption by him. This implies a departure from the traditional method of technological transfer, which has involved:

a) Generation and evaluation by the researcher in the experimental station;

b) Dissemination by the personnel in charge of the transfer of technology programs (extention workers);

c) Adoption by the farmers - sometimes considered automatic - involving a higher interaction between the elements mentioned (researcher, extension worker and farmer), during each phase of the research process (Navarro, 1976 b).

Reductionistic Approach vs. System Approach in Agricultural Research

Agriculture, in its widest sense, comprises very complex physical, biotic and socioeconomic processes; the phenomena it comprises range from the physiological processes of plants or animals to the world market conditions for an agricultural product (Hart, 1979). Therefore, it is hardly surprising that in agricultural research these phenomena have traditionally been divided into units and processes small enough to be understood. In other words, the reductionistic approach, or discipline research, has traditionally been adopted by agricultural researchers.

If we analyze a typical reductionistic approach, i.e., traditional and discipline-oriented, the sequence of research steps would be as shown in Figure 1.

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Reality            Problems            Results            Partial
                                                            Knowledge
      ---|Analysis|---    ---|Analysis|---    ---|Analysis|---
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FIGURE 1. Simplified diagram of analytical research (Gastal, 1975).

From Figure 1, it is evident that the basis problems are: first, the lack of a comparison between the knowledge generated and the conditions where the program was identified, and second, the risk that the knowledge being generated deviates increasingly from reality. That is to say, that since one of the logical consequences of research is the detection of new unknown factors, it is probable that the new knowledge generated may become a source of problems and lead to new research. This, however, involves the risk that the researcher will lose touch with the conditions upon which he should be operating. Another possible consequence is that the researcher contributes to reducing the efficiency of the real system when he gives information to the extension, information, and credit agents who would then use techniques not suitable to the conditions. This could be one reason why some farmers do not trust extensionists. In some instances, the application of the plan shown in Figure 1 has included a comparison with real conditions. However, the insistence on a discipline-oriented approach always involves some risk that the researcher may lose touch with reality.

On the other hand, it must be admitted that the traditional approach has led to thorough studies on specific aspects of the professional field. The results of this kind of research, such as those upon which the so-called Green Revolution were based, have had a strong impact on agriculture in temperate zones or on large farms in tropical areas. These two kinds of agricultural production have in common a low degree of complexity and a high availability of economic resources which are a result of production specialization. Since there is a relatively low interaction between activities or enterprises and between the economic processes which occur on those types of farm, the adoption of technology generated using the reductionistic approach has been rather easy.

In contrast, production systems on small producers' farms in the tropics usually involve a diversity of species during the reproductive period. The association of varieties, intercropping, crop successions and rotations are common practice among small farmers, which apparently is an expression of their willingness to include in their systems the wide range of populations found in tropical ecological communities, which are in dynamic balance with their environment (Navarro and Moreno, 1976). Further, in addition to crops, most small producers' farming systems also include different species of animals (Avila et al. 1979; McDowell and Hildebrand, 1980); also, cattle production activities are mostly dual-purpose (pezo et al. 1979) which accounts for a larger number of food products on the farm.

The foregoing emphasizes the need to adopt the system approach when small farmers are the target population of research. This does not mean that the reductionistic approach is useless, but rather, that it is inadequate for the purposes discussed above. Further, this should not be construed as meaning that the study of specific disciplines must be completely abandoned, but simply that it should not be so strongly emphasized, since it is useful for long-term prognosis, or as a support to applied knowledge generated during system-oriented research.

When the system approach is adopted in agricultural research, researchers pay particular attention to the farm as a whole. In this respect, according to the Technical Advisory Committee of the Consulting Group on International Agricultural Research (CGIAR-TAC, 1978), the farm is a complex structure in which the following elements are combined and interact: soil, plants, animals, implements, workers, other inputs and environmental influences under the control and management of the farmer who, on the basis of his preferences and aspirations genérates products from inputs and technologies already available to him. This definition shows clearly that the farm is a system, since it involves the basic elements (soil, plants, animals), the interactions between them, inputs, outputs (products) and limitations; in addition, the farm operates as a unit (Hart, 1979 b).

The farm is really the interaction of several forces promoting change or stagnation, several measurable factors (inputs, outputs) and non-measurable ones (goals, aspirations, the needs of the farmer and his family). Norman (1976) summarized his study on the multiplicity of factors which determine an agricultural system in the slightly modified diagram appearing in Figure 2.

The agricultural system is determined by environmental quality. Briefly stated, environment includes both technical and human factors. Technical factors determine the type of animal production (or agriculture) and the production potential; technical factors include physical and biological factors which, to a certain extent, can be modified by man.

The human component includes exogenous and endogenous factors.

Exogenous factors basically cannot be controlled by the individual since they are the social environment in which the farmer lives; however, exogenous factors also determine the direction and scope of his production system. Exogenous factors cover social structures, beliefs and social habits, institutions which regulate credit, production and marketing. The institutions which regulate credit, production and marketing are, to a varying degree, under government control.

The farmer can only control endogenous factors, since he decides which systems he wants to implement on his farm, taking into consideration the limitations and characteristics of the environment.

Thus, Figure 2 stresses the fact that any given system, at the farm level, is merely the result of many intervening factors. Many non-traditional researchers believe that the development of suitable technology requires consideration of the global context of the farming system. This, however, raises the question: to what extent is this possible considering that not all research institutions have the technical capacity (qualitative and quantitative) to attempt such a task?

The adoption of the systems approach in research does not mean that research should be conducted on the entire farm. Although it is quite possible to divide up the system, and work only on, or even within, one of the components, one must always bear in mind that the said component is merely a part of a whole and frequently interacts with other components. It is obvious that such an activity is, by its very nature, multidisciplinary (Dillon and Hardaker, 1980); this means that agricultural research based on a sytems approach involves a team of researchers who are specialized in different fields with the systems approach thus becoming an integrating tool (Navarro, 1979 a).

On the other hand, research on small farmers' production systems involves the farmers' active participation in the process of technology generation and evaluation. In this respect, there are some valuable experiences regarding crop production, such as CATIE's Project on Cropping Systems for Small Farmers; the International Rice Research Institute (IRRI)'s Cropping Systems Program; agricultural research conducted by the Guatemalan Institute of Agricultural Sciences and Technology (ICTA) and the Mexican Puebla Plan (Navarro, 1979 a). Experiences regarding animal production are more limited; thus, the present paper is a conceptual contribution to the Evaluation of Alternatives on Producers' Farms.

A Methodology for Agricultural Research

General Remarks

It has been shown that any research program must be based on the real conditions of a small farmer's production systems, however, it has not yet been determined how the process should be conducted.

Hart and Pinchinat (1980) proposed that the organizational aspects of a research strategy based on the systems approach must not only be hierarchical, but also chronological. On that basis, CATIE's Department of Animal Production modified and adopted its general methodological plan (Figure 3), which is more specific than Norman's modified plan (1976) shown in Figure 2.

Hart points out that although all hierarchies (region, farm and specific subsystems) do not necessarily have to be covered by research, they must all be taken into consideration. For example, if the main focus of interest is the farming system, the inputs and outputs of the farm must be

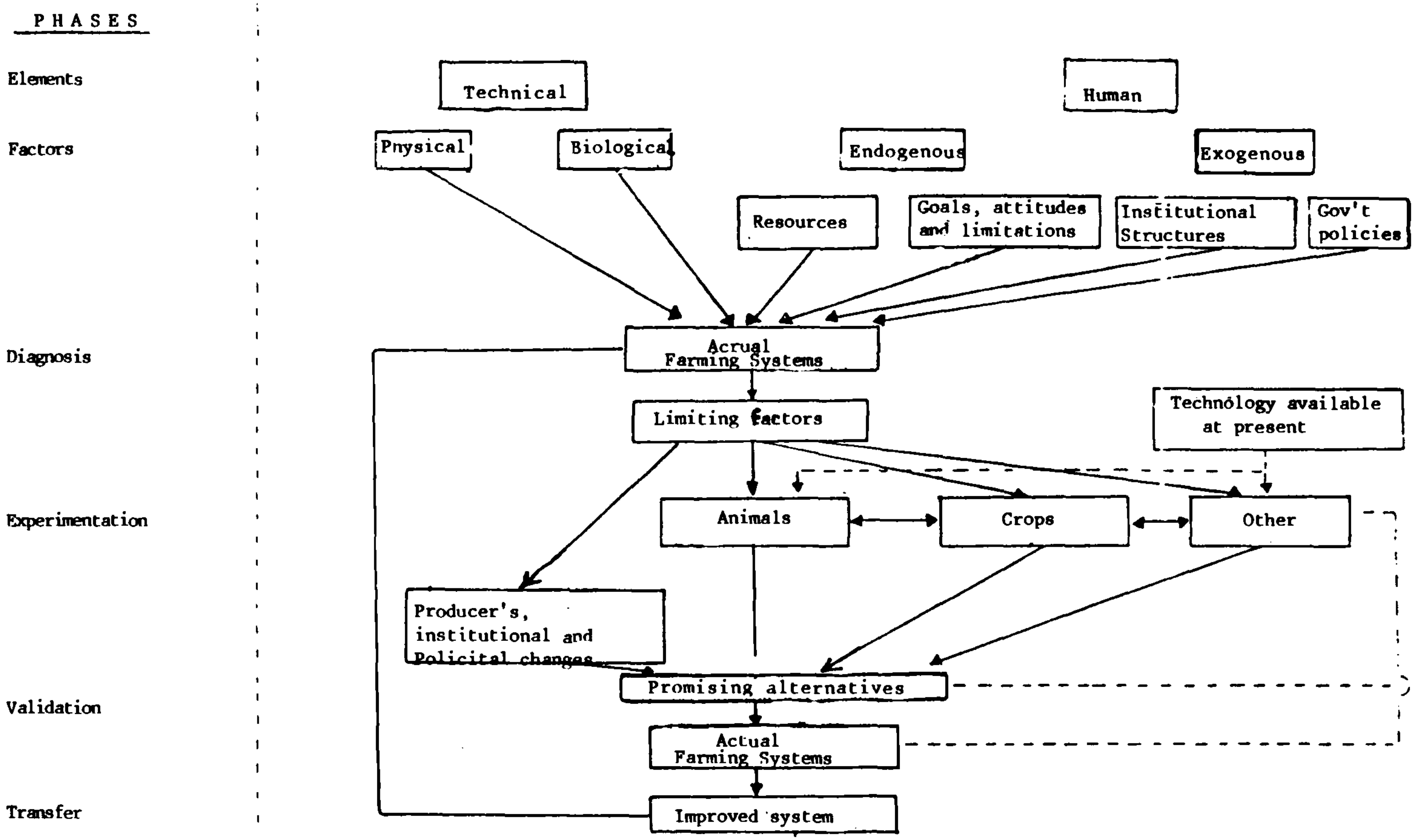


FIGURE 2 Conceptual Framework to Generate and Disseminate Suitable Technologies (Based on Norman's model, 1976)

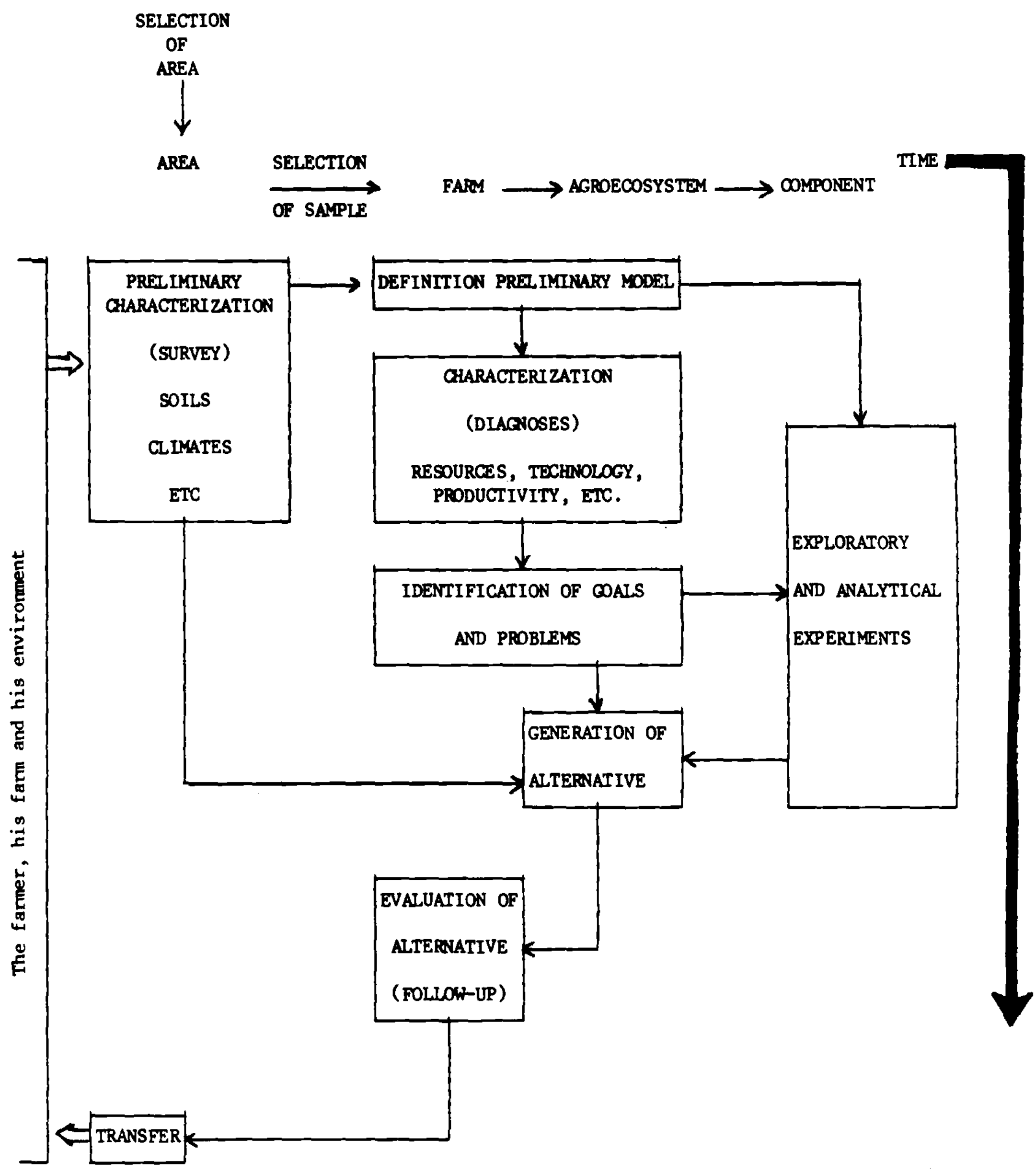


FIGURE 3. Stages of a research methodology in animal production (Modification and expansion of a proposal by Hart and Pinchinat, 1980)

known; this would involve a study of the larger system (the region) where the farm is located. Also, in order to be able to understand and describe the farming system, it would be necessary to study the subsystems comprised therein.

Figure 3 shows that at each level, or hierarchy, there is a sequence of methodological research steps or phases in the research plan. The time required to complete each stage is longer for animal production systems than for cropping systems; this is due mainly to the longer duration of an animal's life and productive cycles.

Stages of the Research Plan

Since it is not possible to cover the whole area of a country with the limited resources of research institutions, the first stage involves the selection of areas or regions. Also, the fact that work is being conducted in well-defined areas increases the applicability of proposed alternative(s) since it is assumed that farmers' conditions in a specific area are relatively more homogenous.

The next stage is the characterization stage, which allows researchers to understand the range of production systems comprises in the universe of farms that may interest them. There is no substitute for knowledge gained directly in the field. The researcher must understand biological, physical and social aspects; to a large extent this knowledge must be derived from farm diagnosis. The last activity in the characterization stage is to identify the problems to be solved at the farm or component level.

There are no differences between the stage of generation of alternatives and the process usually called model development or engineering. The information derived from the diagnoses (both at farm and at region level), the results of exploratory and analytical experiments and the elementary model developed at the beginning of the experimental phase must be taken into account. The resulting model, which must be measurable, is later used for developing the alternatives.

By "alternatives" it is meant a modification of the typical production system. The degree of change may vary depending on whether the alternative involves only one technique or a group of techniques.

When only one technique is involved (i.e. supplementation of milking cows), the effect on the system component directly related to the technique can be significant, whereas the impact on the total system can be rather less important, as a result of the compensation which occurs between system components. Also, the test of a single technique has an advantage in that its individual effect can be isolated, and, consequently, its relative weight on the productive process can be determined.

In practice, however, the alternative ususally involves a group of techniques (or "technological package") which can either be strongly interrelated (i.e. supplementation and carrying capacity) or have little or no correlation (i.e. time of siring and health calendar). The group of techniques can be applied to a single farm subsystem (i.e. raising replacement females) or to several subsystems at the same time. It is

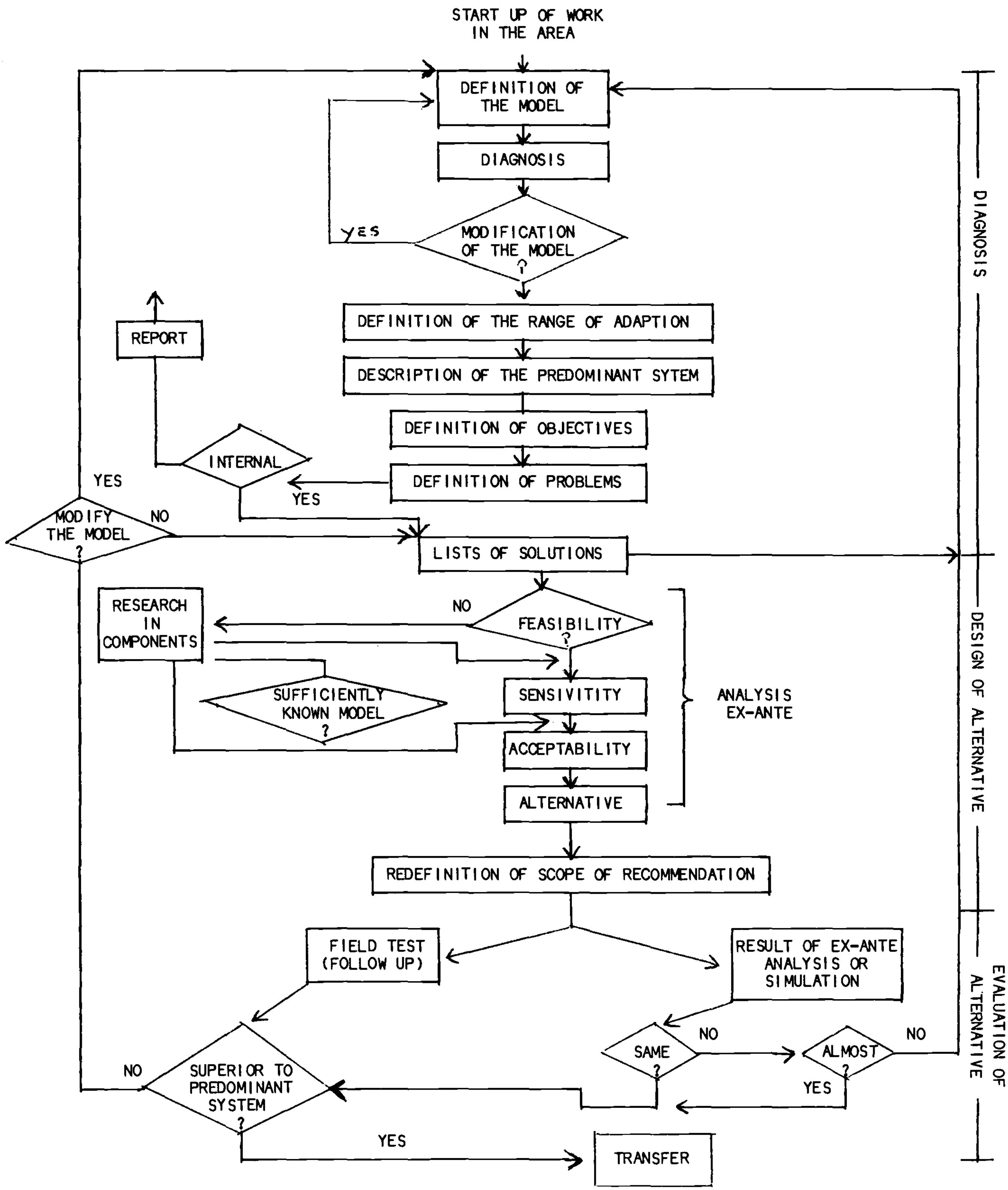


DIAGRAM OF THE DESIGN AND EVALUATION OF ALTERNATIVES obvious that when the alternative involves a number of techniques, the individual effects of each technique cannot be evaluated since the effects are compounded and confounded. The question then arises as to how acceptable it is for the researcher to work and evaluate unclear effects. No doubt the answer will depend on the goal of the research and on the degree of precision required for the observation of the internal mechanisms of each system.

Also, if the alternative involves very few techniques (three or less) and if it is necessary to evaluate the relative weight of each technique, it might be advisable to use a "Missing Element Design" (No. of treatment = "K" techniques + 2), similar to the one used in soil studies (Shaw and Bryan, 1976).

The number of techniques involved in the alternative is critical. One the one hand, several techniques ("technological package") must be included in order to take advantage of the interactive effect among them (i.e. fertilization, carrying capacity, and grazing system). On the other hand, however, when additional techniques are included in the package, the benefits decrease; this makes it unnecessary to include many techniques in one alternative. A relatively high number of techniques may also be detrimental to the implementation of the alternative and make it more difficult to accept and evaluate any of them. In short, it is absolutely essential that the techniques be chosen before they are included in the alternative.

During the evaluation of alternatives stage, two actions are contemplated. The first action involves testing the model developed during the previous stage, to determine both its ability to predict real system production and model feasibility and accuracy. The second action during this stage involves the evaluation of the potential adaptability of the technological alternative thus developed.

Selection of Areas

Selection Criteria

Considering that research is usually subject to budgetary restrictions, and also that there is a limited availability of highly trained personnel, the characterization of the target rural population must begin by choosing the areas where the diagnostic work will be concentrated. If Hart's formulation (1980) is adopted, the main criteria to be considered for the selection of a given area are area representativeness and the nature of the subsystem involved (i.e. the types of farms which correspond to the objectives of the research program). If the main interest is the small farmer, it would be useless to choose an area having a farm population in which small farms are not represented.

Although the principles mentioned above for the selection of regions are valid, in certain instances the selection of an area does not adhere to such considerations, but rather it is imposed by the government or the institution in charge of agricultural activity. If the area thus selected does not meet the technical requirements, decisions must be reviewed on the basis of technical reasons.

Other criteria to be considered when choosing an area include: the concentration of small farms, land communication facilities, credit support facilities, the presence (or the possibility thereof) of national co-participant institutions, potential productivity of land, and the existence of secondary information about the area. It is obvious that this phase does not involve the farmers' participation, but is, rather, a process of consultation between the research institution, government agencies, and sources of secondary information. An example of this procedure as used in Panama can be found in a recent summary by Sarmiento et al. (1981). It may often be necessary to make short inquiry visits to the areas having some possibility of being selected, particularly if the sources of secondary information are not reliable or comprehensive.

Definition of Rural Sector and Sampling

The selection of an area involves the characterization, even if only in general terms, of the type of farmer targeted, which, in turn, depends on the objective of the research or transfer of technology program. At the beginning of this paper, it was pointed out that small farmers can be both the subject and the target of any research program on production systems. Although a precise definition of the "small farmer" cannot be given, it would be possible to cover a sector of small farmers by choosing certain characteristics which are common to all of the members. For instance, in Central America, Avila (1980) proposed that such definitions could be applied to between 60% and 80% of the number of cattle farms in the region when the sector under study includes cattle farms with the following characteristics: (a) a minimum of one cow; b) a maximum of 50 adult cows, and c) at least 50% of the family income comes from the farm.

Once the area has been defined, the selection of farms in the area is made; this can be done at random (if a complete census is available) or using the sample framework method (Houseman, 1975). This method is based on land use and involves identifying shapeless sectors on the basis of certain key production variables, thus studying thoroughly a small area. The reduction is based on aerial photographs, surveys, topographic maps and road maps. The goal of either method is to select a set of farms which are actually representative of the area.

This phase is conducted entirely by researchers in the field of biology, sociology and economics. In the event no secondary information were available, it would be necessary to conduct a full census, and, thus, the farmers would play an active role in this stage; this measure, however, is very expensive. Therefore, in order to render this measure unnecessary, one of the criteria for the selection of an area is, precisely, the existence of secondary information about it.

Characterization

The characterization stage can be subdivided into several phases. The first one is a survey of the area, which makes it possible to make inferences about the preliminary production model. This preliminary model is the basis for gathering information or for making a diagnosis at the farm level. In addition, it makes it possible to identify research subjects in components for a better understanding of the model.

The information obtained at farm level must be combined with a characterization of agroecosystems, or, in some cases, the system components. The diagnoses at farm level tend to be static, whereas the characterizations at the agroecosystem or component levels involve dynamic diagnoses (CATIE, 1976). Later, parallel to this, the following steps are considered: definition of field of applicability, identification of goals and objectives, and identification of problems which may interfere with attaining the objectives (Figure 3).

It must be stressed that the diagnoses at the area, farm, and agroecosystem levels become more complex at the higher levels. However, all information gathered must be used strictly in the generation of the alternative. It is advisable to start with a small number of data, to which new information is added during the interactive process between the characterization and generation of alternatives.

Survey at Area Level

This is the first step following the definition of the target sector; and it can, in fact, be based upon the same information. Sources of information are mainly secondary, and include surveys conducted among authorities, key persons, or relevant institutions in the area. The information gathered deals with climate, soils, population, land ownership, communications, marketing, education, structures, etc.

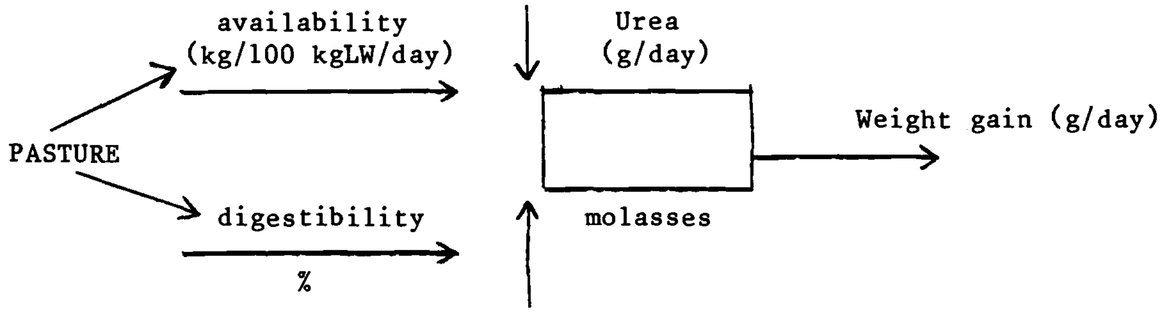
Definition of a Preliminary Model

The information from the area enables the multidisciplinary team to prepare a preliminary model representative of the system(s) prevailing in the region. As Dillon and Hardaker (1980) point out, the development of a model can have one of three objectives: a) it can be an end in itself; b) it can be a research tool to explore the operational conditions of a system, or c) it can be a means for determining the structure of the situation under study and thus, become a guide for attaining a better identification of the problems and better gathering of information. At this level of the research methodology, the third role is more interesting. During the verification and validation phases, the model would be dealt with having the second objective in mind.

Although it may at first seem illogical, it is necessary during the early stages to have an idea of the production model before beginning the collection of data at the farm or agroecosystem levels. Obviously, at the outset, the model will be very general, however, as progress is made, it will become more refined. The model discussed above does not automatically imply a complex mathematical model with perfectly defined internal relationships. It could be a flow chart, or even a list of variables and factors considered important for the definition of the production model for the area.

In fact, this is done the moment the survey tool is structured.

As an example, let us assume that the objective is the design of an alternative for fattening young bulls by grazing. For this purpose, the following model is developed:



Many other factors could be included in this model; let us assume, however, that the factors shown are the only relevant ones.

Thus, the first effort to structure a representative model must lead to a classification of problems to be researched and the identification of solutions already found both by the farmer and by the scientific community. However, it is not redundant to stress that the solutions must be justified in the physico-biological and socioeconomic contexts; this implies further meetings with farmers in order to discard solutions that may not be feasible from those that are.

Farm Characterization

The objective of farm diagnosis is to supply the multidisciplinary research team with information regarding the hierarchical levels of the farming system, i.e. on the higher level (exogenous factors affecting the farm) and on the lower level (subsystems which form the farm). The information must not only be descriptive, as is usually the case with quick surveys, but must also include the analysis of activities on the basis of time; this last element is essential when it is decided to adopt a systems approach in research. Researchers redefine and re-orient their research plans on the basis of the information gathered.

The tool used in farm characterization is static diagnosis, which includes one-visit inquiries whose main criterium is wide coverage rather than a thorough analysis of the farms. The diagnosis allows to better understand farm production sytems, their resources and inputs, marketing aspects, general technological level, identification of macro-problems, farmers' attitudes regarding institutional services, their neighbours and the future.

Since the survey is conducted only once, and the surveyor and the research technicians do not always carry with them the survey forms, the quality of information can be affected by the farmers' lack of trust and by the researcher's lack of experience during the conduction of the survey. However, the information gathered contributes to clarify the research plan and to render more precise the methodological bases for the dynamic diagnosis.

It is obvious that during the phase of static diagnosis, the farmer plays an active role, for the first time, in the general research work. The degree of farmer participation will depend on his previous experience in this kind of activity, the level of instruction, and the attitudes and skills of the technicians responsible for carrying out the diagnosis.

Characterization of Agroecosystems

This is the most detailed subphase in the characterization process. In this subphase the interrelationships between subsystems and components are discussed and analyzed. Its throughness facilitates the identification of factors which limit production (Avila et al. 1980) and future transference actions (CATIE, 1978 a).

The key factors in agroecosystem characterization are length of time and thoroughness; radius of coverage is, therefore, reduced.

What is to be learned is not just "what the farmer does" as was the case in the farm static diagnosis, but rather "how and when he does it", "how much he produces and when", etc. Information is gathered using not only surveys, but also measurements or estimates made by the surveyor. As an example, the technology "to bathe cattle" can be described in terms of:

a) presence or absence;
b) frequency;
c) product (type, dosage) or form (pump calibration, batch coverage, climatic conditions, etc.).

Item c) is an important as, or more important than, the others. However, the determination of this aspect requires several visits and direct observation.

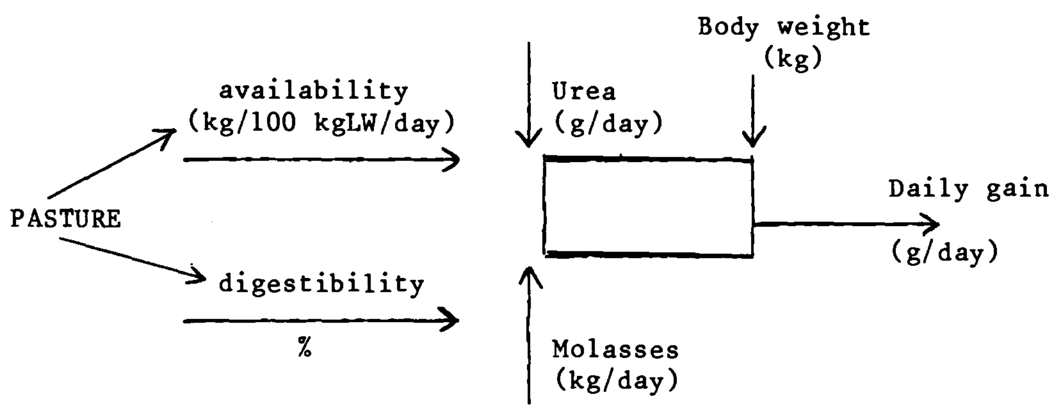
Thus, at this level, the procedure to be followed involves dynamic diagnoses, i.e., repeated visits spaced over a lengthly period, possibly for as long as a year. According to the experience of the CATIE/IDRC Project in Costa Rica, it must be admitted that a considerable length of time should be devoted to establishing trust between farmers and researchers. The length of this period depends on several fctors; in Costa Rica it took six months. During that period, weekly visits were made, farmers were offered services (soil analysis, recommendations on how to plant coffee trees, etc.) which did not affect the characteristics and dynamics of subsystems dealing with animal production. Once an atmosphere of trust has been established, farmers cooperate with researchers, listen to their advice and show interest in their objectives. It is at this point that farmers volunteer the most relevant information. Even years after the diagnostic process has been completed, farmers remember the researchers with whom they worked and continue to seek their advice and cooperation.

To a certain extent, the positive image described above is the opposite of the lack of interest shown by technical assistants who had kept records for a long period in the research conducted in Caqueza, Colombia, as reported by Zandstra et al. (1979). The difference might be accounted for by the fact that in Costa Rica, data collection was combined with technical support activities for farmers, which may have made work more interesting and satisfactory. The Costa Rican experience showed clearly that while the farmer was able to recognize the problems, the researcher helped him to identify the causes, and in some cases, to determine which actions should be taken to solve the problem(s). Researchers found that the most urgent problems were not necessarily the ones that had been theoretically identified. That is to say, operations showed a high degree of compatibility.

Since the diagnosis covers several aspects of production, both the preparation and interpretation of questionnaires must be done by a multidisciplinary team (specialists in management, nutrition, pastures, genetics, health, socioeconomics, etc.). Farmers play a key role, in close collaboration with the surveyors and the technical team, during the intense process of collecting data on the farm. In order to reach conclusions, researchers use techniques such as regression, variance analyses and simulation, whereas farmers use their expertise, intuition and common sense (Avila et al., 1980).

Regardless of whether one is using a mathematical model or simply a list of variables and factors, the first question to arise after the diagnosis, or even while it is being made, is whether all the relevant variables, and only the relevant variables, are being studied. If such is the case, research proceeds, or the necessary modifications are made, and the required information is gathered.

In the example mentioned previously, which deals with the fattening of young bulls by grazing, let us assume that during the diagnosis a high variability in animal body weight has been observed, which makes it necessary to introduce this new variable in the model, since it is known that this new variable affects weight gain.



Definition of Field of Application

If future recommendations are to be applied, research must be restricted to a limited number of farms within the region, which are characterized as to their resources (animals, area, type of soil), the technology used and the production trends.

Table 1 shows a classification of the farms in the Costa Rican region of Monteverde based on farming and cattle production system. The Table shows that 17% of farms are devoted to a dual-purpose system and the remaining 83% specialize in dairy farming. Thus, the differences regarding use of technology and production tendencies are important enough to warrant their being considered different fields of application.

TABLE 1 CLASSIFICATION OF FARMS IN THE MONTEVERDE REGION (COSTA RICA) IN TERMS OF FARMING AND CATTLE PRODUCTION SYSTEM (PERCENTAGE OF FARMS)

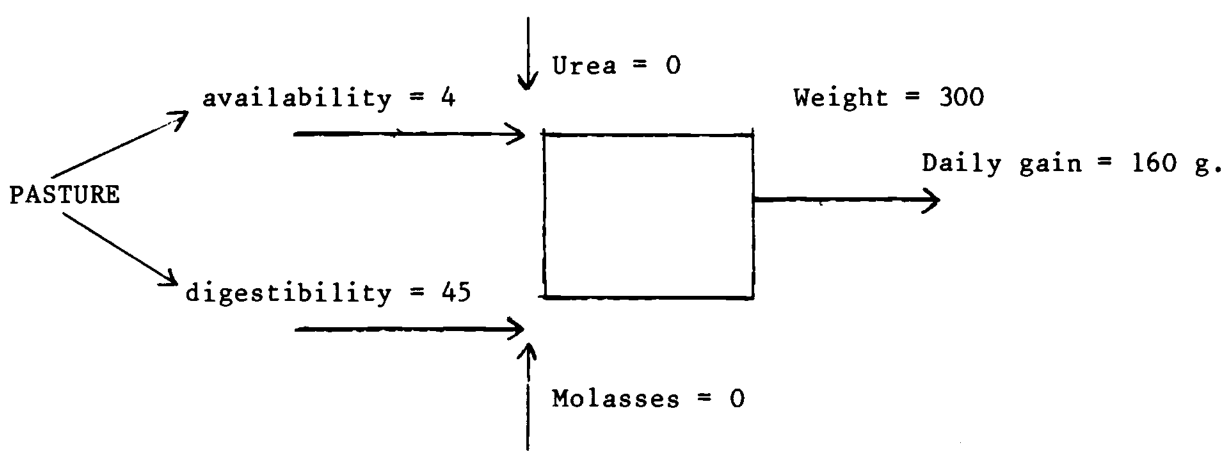
Farming System	Cattle Production System		
Cattle production only	Specialized in milk production	Dual-Purpose	Beef
Cattle only	47*	11**	-
Cattle + annual crops	24	6	-
Cattle + annual crops + perennial crops	12	-	-

* Field of Application 1
** Field of Application 2

Description of Prevailing System

One product of the diagnosis is a description of the prevailing system. The system may be mathematical (simulation model) or purely descriptive. It seems more advisable to express the various parameters in terms of the mode rather than of the mean, since this last statistic may turn out to be biased when used with small samples having a high degree of variability. In the description of the prevailing system, the main parameters are: resources, zootechnical indexes and economical indexes.

In the example being used, let us assume that the values observed during the diagnosis are:



Identification of Objectives

The next step is to define the farmers' objectives, general goals or aspirations (higher income, better nutrition, etc.) and also their specific goals (i.e. to increase milk production/ha or decrease production costs). In light of the objectives or goals, the obstacles or problems can be detected and overcome.

In our example, let us assume that the general goal is to increase income, while keeping real costs low, with the specific objective being to increase daily weight gain.

Identification of Problems

Once the obtained diagnostic information has been combined with other sources of information, the experience of the multidisciplinary team, and common sense, it is analyzed to determine the limits, problems, and advantages of the production system on the farm. The priorization of problems will depend on the objectives defined above, and the parameters of the prevailing system will be compared with the established patterns for animal production which are suitable to the region under study.

In our example, the problems identified are:

- low daily gain;

- low pasture availability (very high stocking rate)

- low quality of fodder.

However, since the most important aspects a researcher has to solve depend on the list of problems, it is very important that the technical team compare its points of view with those of the farmer. Often, this comparison can be made by including in the questionnaire to be answered by the farmer some questions on the biological, physical, and socioeconomic problems affecting his production. The comparison and discussion of the multidisciplinary team's points of view in front of the farmer is something even more interesting, for both the farmers and the researchers. Obviously, this would require a solid feeling of mutual trust, as referred to in our discussion of dynamic diagnosis.

The comparison of the points of view of the farmers and the researchers lays the basis for a further phase involving technology transfer and adoption, which will be discussed below.

It should be pointed out that if it is determined during this stage that problems are exogenous (market, prices, or other government policies), it could be decided to transfer the problem at other levels.

Generation of Alternatives

The generation of alternatives (see Figure 4) begins with a list of possible solutions to the problems detected. These solutions should meet three types of requirements before they can be adopted as an alternative:

First, feasibility, which may meet the requirement of component research; second, the sensitivity for each technique and its acceptability by farmers is tested; third, the definition of the alternative, end result of the process.

List of Possible Solutions

The solutions to the problems detected in the previous stage can be generated in different ways, viz:

- experience and data in literature;

- additional component experiments. (Basic information may be available, but is not adapted to the specific conditions in the area, or perhaps some data essential for the understanding or functioning of the model are lacking);

- analysis to correlate a farmer's use of technology and the parameters which are considered good indicators of success on the farms. Table 2 gives an example of how this technique can be used, showing the correlation between some resources and zootechnical indexes with gross income her hectare. This table shows that the variables which had a significant correlation with gross product/hectare (an indicator of success) were the following: area of improved pastures, stocking rate and investment per hectare; therefore, the list of possible solutions should include sowing pastures, stocking rate control and perhaps a better subdivision of the farm (investment on fences).

TABLE 2 CORRELATION BETWEEN RESOURCES AND ZOOTECHNICAL INDEXES (x) WITH GROSS PRODUCT PER HECTARE (y) ON 25 FARMS
(Adapted from Indarte and Marsal, 1970)

Variable	Significance of "r"
Improved pasture area % of total	0.01 (+)
Stocking rate, AU/ha	0.01 (-)
Investment, $/ha	0.01 (+)
Young bulls/milking cows	N.S. (-)
Sheep/cattle	N.S. (+)

Another important aspect during this phase of analysis is the identification of solutions generated by some farmers themselves, or handed down by their ancestors. As Loomis (1976) put it, the present farming systems are the result of an enormous experimental effort made by the farmers themselves. One of the advantages of this is that all systems presently used by small farmers have a low risk level, an essential characteristic of the systems to be developed. For example, farmers developed the concept of multiple cropping, considered until recently by researchers to be primitive and incompatible with modern agriculture (Norman, 1980). Regarding animal production, it should also be mentioned that farmers developed the dual-purpose system, which is now praised because there is little requirement for investment, a low risk level, little demand for "advanced technology" and a diversity of products.

All of the above indicates that some of the solutions to the problems found in the production systems of small farmers are already available on the farm itself. The researcher's task is to identify the solutions and find their technical justification so as not to "reinvent the wheel" in the experimental station.

Regarding the example of fattening cattle by grazing, the following solutions could be set out:

- fertilization, to increase availability from 4 to 6 kg/100 kg LW/day and to increase digestibility from 45% to 55%.

- reduction of grazing pressure (to an availability of 6 kg)

- supplementation with 100 g of urea and 2 kg of molasses/animal/day.

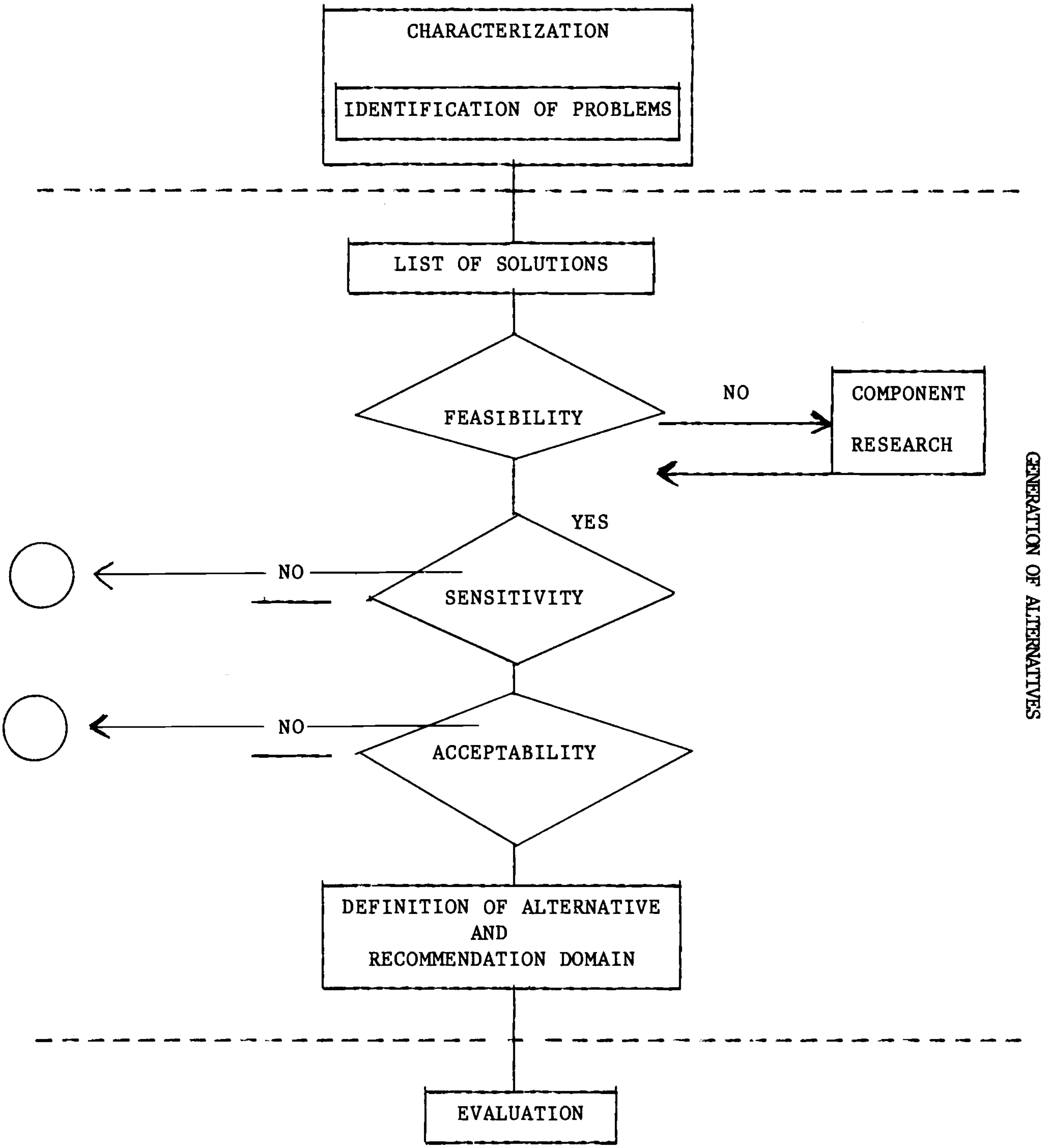


FIGURE 4 Subphases for the Generation of Alternatives

Feasibility

To determine whether each proposed solution is feasible and, therefore, can be considered as a technique, it must be established that the experimental base of each solution is solid and can be applied in practice. If this is not the case, some research must be conducted on that component to set it on a firm foundation.

Research can range from the testing of solutions about which some doubt exists (particularly in the mind of the researcher, when the solution is that of the farmer), to the search for new solutions, in the direction of the provisional model. One possibility is research aimed at adjusting or completing information derived from the farm and which it is impossible to collect on the farm itself. This would be the case, for example, with the so-called Dual-Purpose Module used in the CATIE/IDRC Project (CATIE, 1978 a) which has many functions; one of which aims at explaining, to a high degree of accuracy, an average farm, in order to supplement technical information such as the calving intervals, calves' milk consumption in dual-purpose herds, etc.

To the extent that it is possible, the experiment must be conducted on the farms of the collaborating farmers. The advantage of this is that the variables or techniques are evaluated in the same environment in which the best solutions will eventually have to operate, under the management of a farmer and within the structure of a real farm. Also, this kind of research makes it possible to identify institutional support which may be required to facilitate the adoption and persistency of a technology.

In order for the investigation to be conducted on a farm, farmers must be chosen carefully. A series of criteria can be developed to reduce the risk of having experiments end uncompleted, or be affected in some way or another. For example, for a technical assistance project in Honduras (CATIS, 1978 a) criteria for the selection of farmers were developed based on the following aspects:

- Receptiveness: encompasses evaluations of a farmer's enthusiasm, residence stability, dedication to farming, interest and cooperation.

- Leadership: considers that farmers who have a certain leadership and self-assurance will cause the multiplicative effect of technical activities on the farm to be magnified. That is to say, the technology being tested will spread to other farms.

- Geographical location of farm: the farm under study must not only be the centre of a subregion of which the farm is representative, but must also have certain communication facilities.

- Size of farm: according to the definition of the "small farmer" in the regin of interest. However, in the case of a research project, it will almost always be found that small farmers do not have the minimum number of animals and facilities necessary to conduct experiments having a certain scientific seriousness. Consequently, for the phase of generating new information, the researcher must depend on research conducted on medium-size, and even in some cases on large farms, where a sufficient number of animals may be used. In some extreme cases, component research must be conducted in the experimental station.

According to Navarro (1979 a) the selection of farmers could also be based on other criteria such as physical gradients (i.e. farms having different types of soil) or socioeconomic gradients (i.e. farms with different investment capabilities). When deciding to conduct experiments on producers' farms, a researcher must also restrict himself to certain limitations.

Some of these limitations are:

- The experiment must not involve economic risk for the farmer. In an experimental station, it is conceivable that experiments would be conducted which include "stress" treatments and which could even lead to an animal's death. This, however, would have terrible consequences if conducted on a farm (even if the owner received compensation). Naturally, this restriction significantly reduces the range of possible treatments that may be studied. However, the farmer must understand that the results of the experiment being conducted on his farm are not known beforehand.

- The experiment must be easy for the farmer to understand and must be a response to the problems identified on the farm.

  Farmers tend to consider any technical activity conducted on their farm, even if only for research purposes, to be assistance for the improvement of the farm; therefore, work must be thought of in terms of transfer of technology.

- The experiment must not involve division of the herd into groups which are treated differently. Experience in Central America has shows that when a farmer notices that one treatment is more effective than another, he may decide to apply the best treatment to all of this animals, thus undermining the experiment.

- The total cost of the experiment must include the participation of the farmer. His participation may involve some investment for the purchase of posts, for payment of labour, or simply for having his sons gather data, etc. What matters is that the farmer feels (and in reality is) a part of the experiment and not just a bystander who has little or no interest in monitoring the experiment and ensuring that it is being conducted according to the original plans.

- Both researchers and farmers must participate in the decision-making process; in cases where no agreement is reached, the opinion of the researcher shall prevail.

The more basic experiments would be conducted in the experimental station. Essentially, these experiments are aimed at identifying and quantifying the input/output relationships necessary for a better determination of event occurring within the system. Statistical analysis for the tests to be conducted at the experimental station and on the farm may follow traditional design plans; this does not preclude using the systems approach to research, as shows by Anderson and Dent (1972). Experiments conducted both on the farm and in the experimental station may be either exploratory or analytical. The exploratory experiments are aimed at determining the behaviour, first of all, of a given treatment or component, by changing one or several fators under similar conditions (Otero, 1980). These experiments are not intended to achieve very precise evaluations, but rather to indicate the general trend of the behaviour of the treatments or variables.

Exploratory experiments are usually followed by analytical experiments which are aimed at supplying quantitative information on the behaviour of the component or variable, under different levels of treatment or different conditions. These experiments must be conducive to the formulation of a hypothesis about the configuration and operation of the system which would lead to a revision of the original model and transform it at a level which permits evaluation. There is not doubt that when the input/output ratios are analyzed, some information will be obtained on the interrelationships between two or more factors which make up the ecosystem.

Sensitivity

Sensitivity tests are used to evaluate the ffect of each technique on the partial output of the ecosystem which is most directly affected by the technique, as well as on global farm production. The effects that several price levels may have on the behaviour of the technique are also studied. The conduction of the sensitivity analysis requires a clear intuitive understanding of the way the model operates in order to predict (within a certain degree of accuracy) the effect a given technique may have. It is relatively easy to evaluate the direct effect of a technique on the component of the subsystem affected, particularly if it is shown in terms of rank. However, it may be considerably more difficult to estimate the effects of partial changes on the whole system because of the many compensations which occur within the system.

At this level, if not simulation facilities are available, a calculation routine for small programmable calculators may prove very helpful. As an example, Otero (1978) developed calculation routines to evaluate what effects the calving interval, the mortality of young bulls during the first year of life, and the age at first birth may have on the structure of the system, on productivity, and on profitability. Table 3 shows this example; it can be seen that reduction of mortality/calf is not particularly advantageous unless the meat/milk price ration is very high (a case not show in the Table).

TABLE 3 EFFECTS WHICH THE EXTREME VARIATION OF THE REPRODUCTION, MORTALITY AND PRECOCITY FACTORS MAY HAVE ON SOME BIOLOGICAL AND ECONOMIC INDICATORS UNDER STUDY

Factors -------	Calving intervals	Morbidity, %	Age at first birth
Indicators	17-----13 (%)	30--------10 (%)	36-------30 (%)
Milk production/ herd-year	+11.8	- 6.0	+ 9.2
Meat production/ herd-year	+36.3	+36.4	+22.8
Gross income/ herd-year	+14.5	- 1.9	+10.5
Gross income/partial cost ratio, herd-year	+18.4	- 1.9	+12.7

Sensitivity analyses include not only biological analyses but also economic analyses. When conducting economic analyses, it must be taken into consideration that yield variability may be found during the application of a given technology; any such variability must itself be considered in an economic analysis (see analysis of minimum returns in Dillon and Hardaker 1980). Also to be taken into account are possible variations in product prices and input costs. In this respect, it is convenient to use complete or partial budgetary techniques. Apparently, in most cases partial budgets would be more convenient because they are easier to implement and adapt to a wider range of farm situations that are complete budgets. The specific partial budget methodology to be used (gross profit, cash flow, or input/output) will depend on the data base available (Dillon and Hardaker, 1980).

The sensitivity analysis must lead to a classification of techniques. This may include combining techniques in terms of the effect the analysis may have on the measured variable used as a reponse.

In the example of the fatenning of young bulls by grazing, the proposed techniques (or combination thereof) are classified as follows:

Technique(s)	Relative value*
Control	100
Stocking rate (SR)	138
Supplementation	188
SR + Supplementation	206
Fertilization + Supplementation	263
Fertilization	406
SR + Fertilization	456

* Values obtained are based on a simulation model developed by Romero (1977)

The information generated during the sensitivity tests, after being selected by the research team and "translated" into simple terms, must be presented to the farmer and to pertinent members of his family, in order to obtain their comments.

Again, in the example of the fattening of young bulls by grazing, let us assume that most farmers rejected the "fertilization" technique because it involved the investment of too much money and the purchase of fences. They also rejected decreasing their stocking rate, because they considered this to be a sort of "decapitalization" which would lower their status in the eyes of other farmers and reduce their farm production.

Definition of the Alternative to be Evaluated

Those techniques which have met the three different types of requirements can become alternatives to be tested after the package of techniques has been checked again to verify that it really makes it possible to reach the goals to be attained.

In the fattening young bulls example, the alternative would be "supplementation with molasses and urea".

Evaluation of Alternatives

Figure 5 shows the subphase of evaluation of alternatives.

The following three types of tests can be conducted for the evaluation of alternatives in the field:

a) Simulteneous comparison of different units (Alternative vs. Control);

b) Sequential comparison of the same units (Before vs. After);

c) Comparison of expected results with the ones obtained (Model vs. Reality).

It must be pointed out, however, that, within certain limits, simulation models can be more efficient than field evaluations. In fact, the field evaluations can seldom be conducted over very long periods; so, the period over which they are conducted may be favourable or unfavourable. Simulation makes it possible to test the model under all possible conditions, thus covering a period of "many years". Also, the duration of the field test involves the risk that exogenous factors foreign to the system (i.e. prices, political conditions, etc.) may change, thus rendering the alternative less attractive. Simulation has a further advantage in that production factors can be "observed" within their range limits, something often impossible on the farms. According to Dent and Anderson (1974), simulation is a supplementary tool, but one which is necessary in systems research. The practical implication of this statement is that the data collected during the evaluation must also meet the requirements of model development and ajustment.

Test of Alternatives vs. Controls (A vs. C)

These comparisons can be carried out on one farm or among several farms.

Evaluation on the Same Farm. The implementation of tests shows great methodological differences for agronomical or animal production alternatives. It is relatively easy to divide up the crop component on a farm in order to study the system and its alternatives; however, this kind of fragmentation is more difficult to do when dealing with alternatives relating to the animal component. The situation becomes more complicated when dealing with small farmers, who frequently do not have pens or divided pastures. It must also be remembered that a farmer considers cattle to be valuable "capital", which he would not risk in an uncertain venture.

Finally, the nature of the treatments is different. For example when a farmer notices that the alternative (i.e. mineral salts) would simply decide to give that treatment to the control group. This has proven to be the case on many occasions.

In theory, any variable or factor could be tested by dividing the herd. However, the main difficulty with this procedure is that it does not allow for observation of the effects the alternatives may have on the global performance of the system.

In summary, it is clear that it may be advisable to divide the herd in those cases when it is feasible to compare alternatives on the same farm. This is particularly true when it is desired to confirm whether the results obtained in the experimental station can be duplicated under conditions having a wider variability.

Evaluation Among Several Farms. This procedure involves the introduction of an alternative on several farms and the simultaneous follow-up of the control farms. As with any comparison of averages, the number of farms in each category will depend on the extent of the differences to be demonstrated and

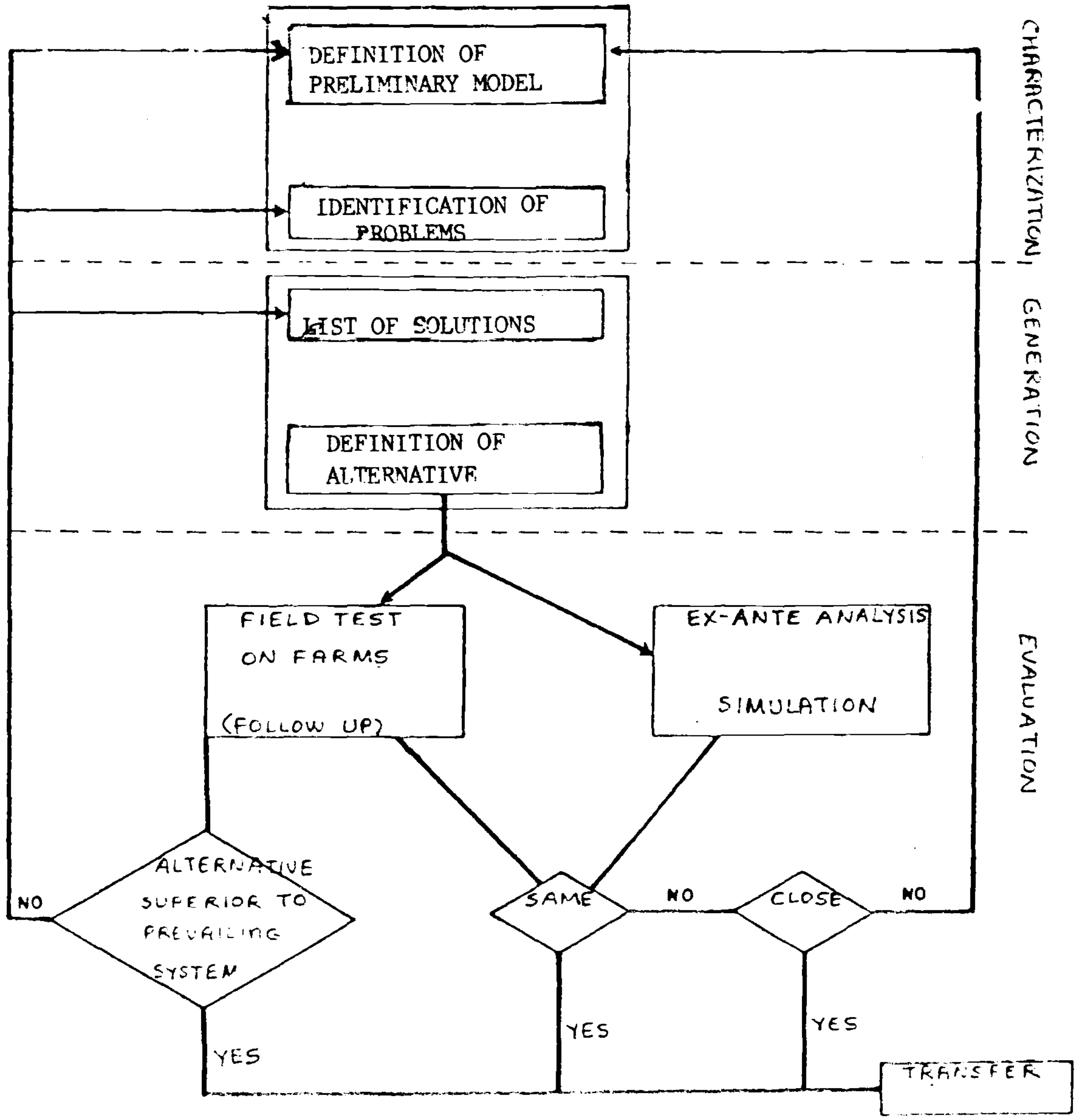


Fig. 5 Subphases of the Evaluation of Alternatives

variability of parameters. According to traditional statistic techniques (Onoro, 1979), the number of duplications (farms) can be determined by using the following formula:

$$r > \frac{2\ (t_1 + t_2)^2\ (VC^2)}{D^2}$$

where: t_1 = Value of Student "t" for the degrees of freedom from error and probability chosen for Type II errors.

t_2 = Value of Student "t" for the degrees of freedom from error and probability 2 (1-p), where p = probability of Type I error

VC = Variation coefficient

D = Expected difference, expressed as a percentage of the mean.

The approximate formula below can also be used:

$$r > \frac{10VC^2}{D^2}$$

The diagnosis experience at CATIE shows that the variation coefficients for zootechnical and economic indexes measured on farms often range between 80% and 120%; thus, in order to detect a 20% difference, 250 farms would be required; and 63 farms would be required to detect a 40% difference; while only 10 farms would be required to detect a 100% difference. Of course, there are also techniques for reducing the variability and, consequently, reducing the number of experimental units.

Moreover, the need for a statistical indicator is less evident when the expected difference is large (probably higher than 30% or 40%). In addition, if several of the variables measured show a significant change, even when there is a high variability between farms, this would be a good indication that the alternative is actually different.

In this regard, another critical aspect is the duration of the evaluation. Admitting that variations do occur from one year to the next and that the effects of some treatments become evident in the long term, then the more time an evaluation covers, the more reliable it will be. The minimum period seems to be three to four years; however, projects seldom contemplate such lengthy durations. There are other practical questions to be considered, such as: would a farmer agree to let his farm be used as a control for a long period of time when he can see that the alternative has been successful on other farms, and what are the changes that the farmer may, during the evaluation, adopt a technology different from the alternative, thus invalidating the comparison? Would drastic changes in input and output prices lead to major changes in the traditional system?

Before vs. After Tests (t_1 vs. t_2)

Sequential evaluations (before vs. after) on the same farm have the advantage of considerably reducing the problem of variation among farms; however, they do not modify the effects of the time factor and, in some cases, make it even more critical since they require a follow-up before the alternative to be evaluated can be introduced.

Results Obtained vs. Expected Results (O vs. E)

This test involves predicting the behaviour of the alternative and comparing this prediction with conditions on real farms where the alternative has been introduced.

This procedure eliminates the need to have control farms and makes it possible to reduce the test period.

Accuracy can be increased if the expected solution is not estimated in a general way for all the farms on which it is to be applied, but rather, on each farm where the evaluation is to be conducted.

The behaviour of the alternative is predicted on the basis of the production system model, and the test is conducted in order to detect the degree of correspondence between the model and the real system.

Two aspects must be clarified before an opinion can be given (rejection or acceptance of hypothesis) regarding the validity of the model: one involves the degree of similarity between the response offered by the model and the response found in the real system. The model is said to be valid when both are identical (Spedding, 1980). In this contest, the word "similar" should not be understood in absolute terms. The decision regarding similarity of responses must be based on an interval of confidence involving one or more comparisons. If the responses are not identical, it is clear that one must return to the previous phase. All this suggests that the validation process must be conducted only on the farms of those producers who collaborate in the experiment and that the experimental station plays no role. The other aspects involved in the testing of the model is verification of the model, i.e. the degree of correspondence between the model and the dynamics of the system operation must be determined. To simplify the explanation, it is possible to have two valid models when the response they provide is similar to the one provided by a specific real system; however, if the system is modified, and the response varies, one, and in some cses, both models may now fail to produce a response identical to the new one. If such is the case, this would indicate errors in the conception or calculation of the interrelationships and/or quantifications of relationships between the system components. The verification of the model makes it possible to determine the degree of reality of the internal mechanisms of the model. If the answer is affirmative, the model is verified and validated and can be used to predict the behaviour of the system when the system is modified. This is not possible with only validation (without verification).

It is more advisable to conduct the process of verification in the experimental station rather than on the farm because of the many measurements involved. However, the final decision would depend on the degree of complexity of the model, or the alternative, and the mechanism chosen to verify it.

Farm stratification

The objective of farm stratification are to increase the applicability of alternatives and to reduce the variability within strata. Stratification may be based on many different criteria:

- resources (land, labour, animals, management capability);
- technology (use of different production techniques);
- productivity (technical indexes both for the components and for the whole farm);
- profitability (gross profit, gross income, net income, etc.).

The main objective of the evaluation of alternatives is usually to observe the effect technology may have on farm productivity; therefore, these criteria will be the most useful for stratification. In this regard, on farms where rudimentary management practices are carried out, all of the techniques included in the alternative would likely have to be implemented; whereas on more sophisticated farms, the alternative may simply involve refining the techniques already available. Both situations may be illustrated as follows:

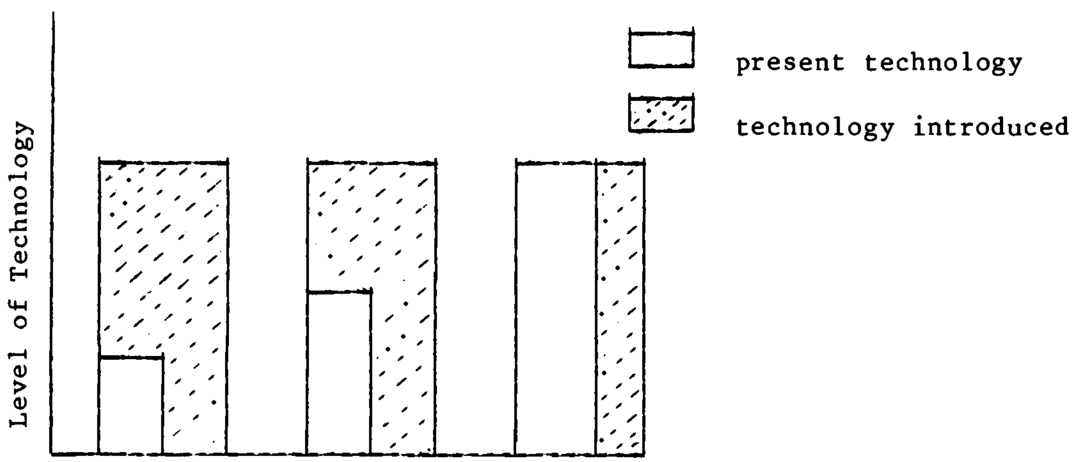


FIGURE 6 Diagram illustrating the degree to which technology is introduced depending on the technological level already present on the farm.

In order to render the estimates of the effects of the alternative more accurate, it is advisable to compare each farm with another comparable farm having an initial stage similar to the one existing before the alternative was introduced. In such a case, the evaluation can be made using the matched observations test:

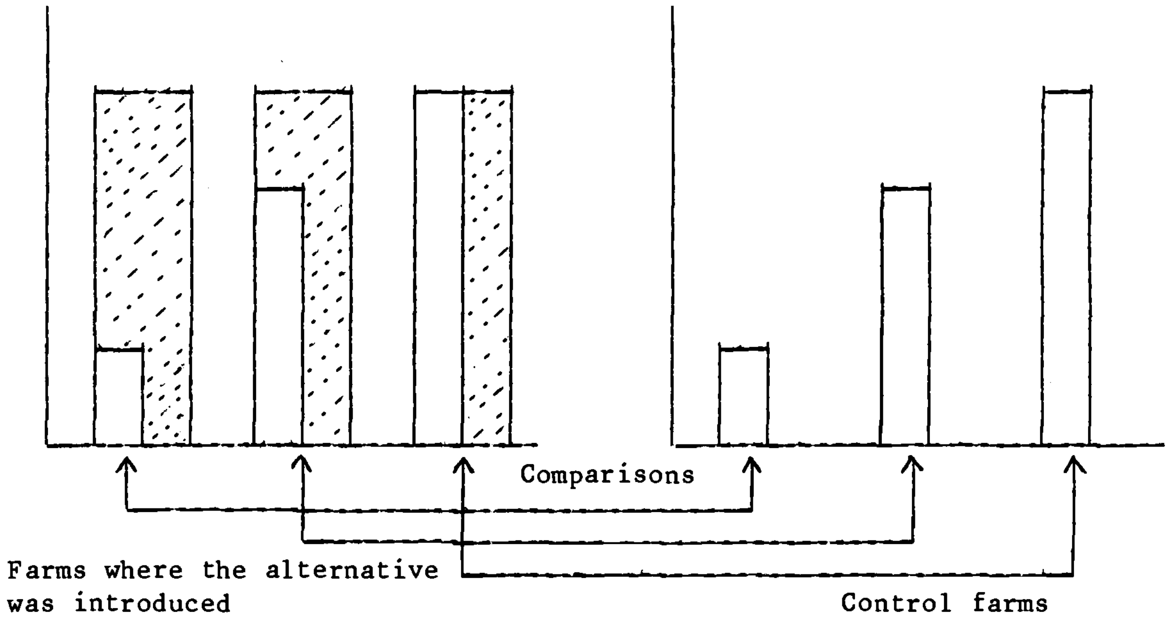


FIGURE 7 Representation of Matched Comparisons Between Comparable Farms, During the Evaluation of Alternatives.

It must be pointed out that the matched observations are sensitive to information loss due to non-completion of the test, which would affect not only the farm opting out, but also the other member of the pair, since there would be no control left.

Regarding sequential time tests (Before vs. After), stratification has many advantages, since there are fewer being followed up at the same time. In this case, comparisons are made according to the following plan:

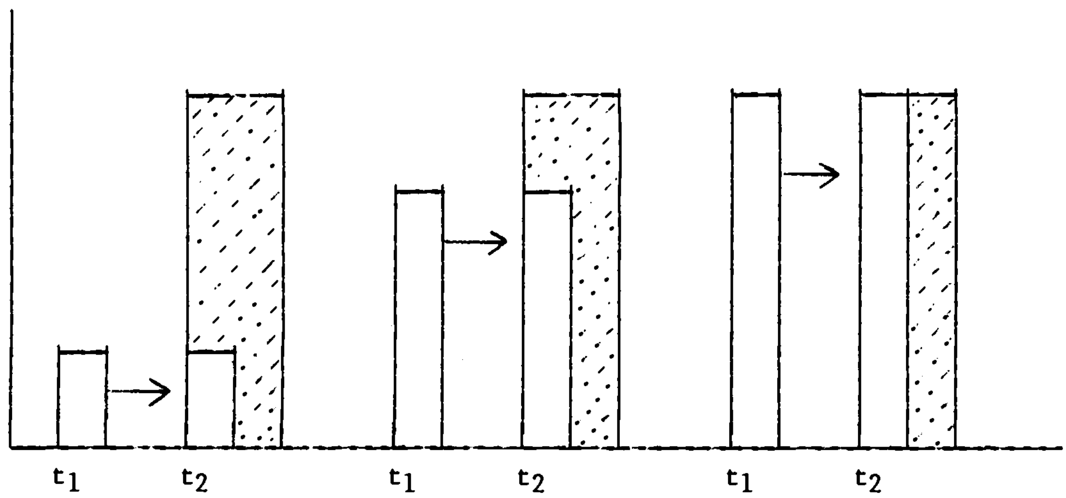


FIGURE 8 Comparisons Over a Period of Time Between the Status of a Farm Before an Alternative Was Introduced (t_1) and After the Treatment Was Applied (t_2).

Regarding the Results Obtained vs. Results Expected tests, the validity of the stratification would depend on the capacity of the model to estimate the results on each particular farm. If this possibility did not exist, neither the stratification nor the matched observation technique would be as meaningful since there would be a common denominator for all farms.

Stratification has an additional advantage: it enables observation of the effects an alternative may have on the different levels of technology present on the farms. It might be utopic to expect that the effects of the interaction between the level of technology and the alternative can be measured; however, it still remains a possibility.

Measurements

Variables. The evaluation of variables on farms makes it possible to measure the effects variables have on: the component most directly affected; other system components; and the overall results of the system. This implies that the research conducted is justified only if the most accurate date possible is gathered. At the very least, the parameters to be measured are:

- variables directly influenced by the alternative being evaluated (A);

- some variables related to the subsystem affected by the alternative (B);

- some variables of the system at an immediately higher level (C).

As an example, if the technique being tested is the "supplementation of heifers", the variables measured under (A) would be daily weight gain, mortality, and consumption of supplements; under (B), age at first birth, and ratio of replacements/cows: under (C), milk production/hectare/year.

The persistency and the voluntary adoption of the alternative are other important evaluation criteria; however, they are more difficult to quantify. Persistency can be defined either as the percentage of techniques introduced which are still in use after a certain number of years or as the average life span of a particular technology introduced on a farm after evaluation was completed. It must be pointed out, however, that the alternative may be acceptable, but that due to variations in exogenous factors (i.e. prices) it may cease to be applied after a certain number of years. Voluntary adoption refers to the number of farms near those on which the alternative is evaluated, which adopt a part of, or the whole package without the intervention of the project. Under certain circumstances (i.e. ILCA Research Project on the increase of milk production on the Ethiopian Plateau), voluntary adoption may be a more important indictor of success than a significant statistical index.

Gathering of Data. Data gathering may adopt several forms, among which the following may be mentioned:

- Records kept by the farmers - except in a few isolated cases, this system does not provide good results (CATIE experiences, Caqueza), unless the farmer is given adequate assistance.

- Measurements made by the researcher - these are fundamental when the farmer is not directly concerned with data which are, however, necessary for comprehension of the model.

- Surveys - quotations the surveyor asks the farmer during weekly or bi-weekly visits. These questions may involve some imprecisions, due either to the surveyor (when he is not aware of missing observations in his data) or to the farmer (when he does not remember the data or when he confuses data). These problems may be solved by planning information checks at intervals of not longer than one month in order to check whether the data are complete and whether they fall within the expected ranges. There are computer programs available for the control of volunteered data (J. Lagemann, Personal Communication).

Surveys are useful not only to collect quantitative data, but more importantly, to find out the farmer's opinion of the alternative.

Implementation

Credit, marketing and technical assistance are special conditions for the implementation of alternatives on farmers' farms.

Credit. An alternative can involve a significant increase in the amount of cash and the cost of investments required by a farmer; therefore, unless he is given the right kind of assistance, a farmer may wish not to risk his own very limited capital. Farmers who cooperate in the experiment may be provided with financial support to help them implement an alternative on their farms. This may occur in many ways, some of which are:

- to provide him with the main inputs and investments, free of charge

- to expect the farmer to obtain credit on his own

- to provide him with credit.

The most advisable alternative is the third one. It requires that the research project or institution contact a local credit institution which would administer the credit granted by the project to the farmer who is cooperating in the experiment. The credit institution would charge the administration fees to the project. The involvement of a credit institution is advantageous because it makes it unnecessary for the project to manage the credit, an activity for which research personnel are not trained and which would be an additional responsibility for them.

Marketing. It is necessary for the farmers who cooperate in the experiment to be assured that the increased production resulting from the implementation of the alternative can be marketed. As a last resort, the purchase and redistribution of surplus outputs which cannot be absorbed by the local market should be anticipated in the budget and considered a part of the cost of the project. Naturally, this problem could be reduced if the farms owned by the farmers who collaborate in the experiment are selected on the condition that the market is ready to absorb any production increases.

Technical Assistance. The presence of the researcher, and probably also of a specialist in socioeconomics is necessary during the implementation of the alternative on the farm, in order to ensure that it is being done correctly. Also necessary are periodic visits to check that the alternatives is being applied effectively and regularly, as well as to provide assistance to the farmer regarding practical problems which may show up during the implementation phase. This makes it advisble, and perhaps even essential, that the researchers have first-hand practical experience of farm activities (Dillon and Hardaker, 1980).

Analysis of Information

Decisions Regarding the Alternative. Basically, there may be two kinds of conclusions regarding the alternative:

- The results were either higher of lower than those of the prevailing traditional system;

- The values obtained are, or are not, comparable to the prediction made on the basis of the model.

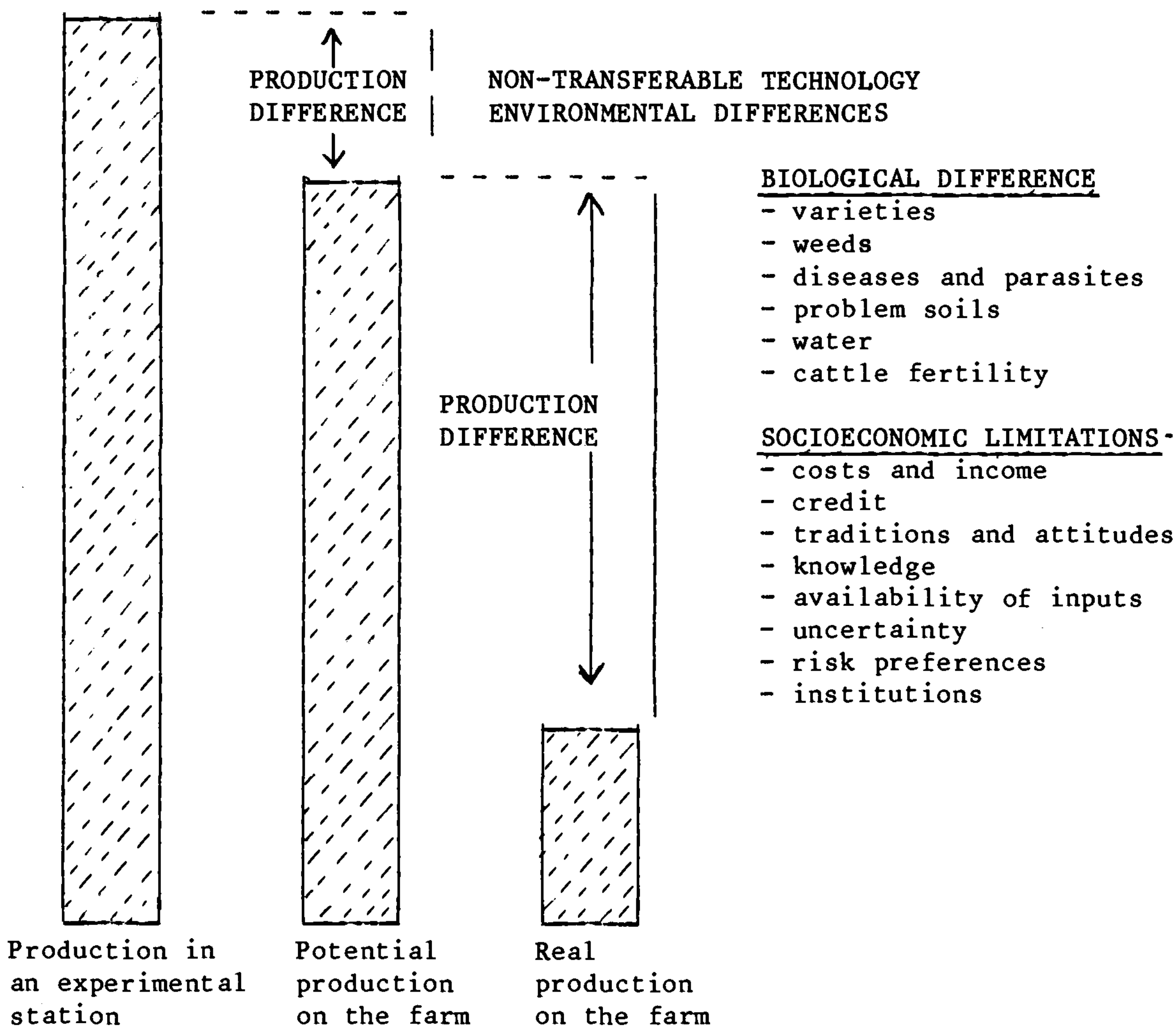
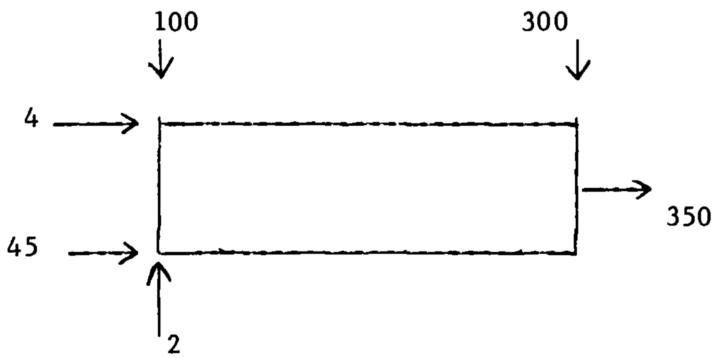


FIGURE 9 Conceptual Model Which Explains the Differences that may be Found, and the Reasons Therefor, Between Production in an Experimental Station and Actual Production on a Farm (based on Gomez' model, quoted by Dillon and Hardaker, 1980)

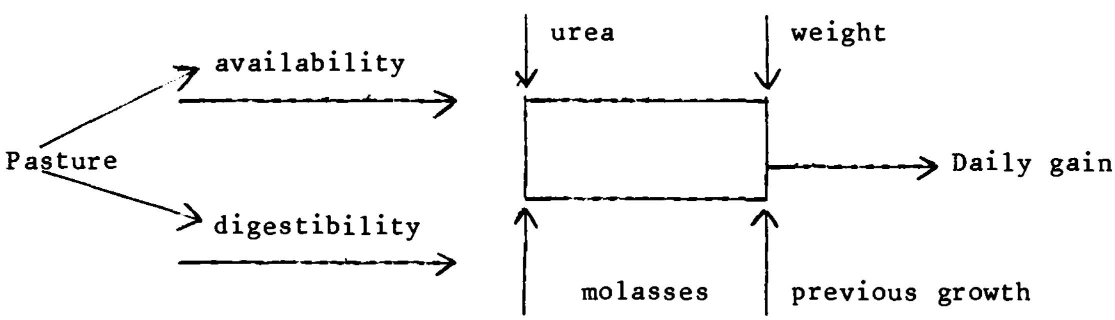
Depending on the objectives of the research, the first type of positive conclusion may be sufficient, even if the values obtained are comparable to the ones the model predicted when the research concluded. However, if it was not possible to obtain a positive response in the second case, it would probably mean that the model has to be modified.

To illustrate schematically, let us assume that an alternative developed in an experimental station yields a product level of "x". When this alternative is applied on a farm, there will always be a difference in yield, even if it is applied under "optimum" conditions. This may be due to the facts that some of the technologies included in the alternative (i.e. milking ability) are not transferable or the environment in the exprimental station is not identical to the environment on the "optimal" farm. Now, when the alternative is tested in real conditions, the level of produce obtained is even lower than the potential of the "optimal" farm. If such were the case, this would indicate that the model is incomplete, that the assumptions are incorrect, or that the mechnicam assumed is invalid. The example (Figure 9) shows that the difference occurred because the model did not take into account biological and socioeconomic limitations. To further illustrate this point, one of the biological limitations might have been the insufficient application of fertilizer, due to a related socioeconomic restriction, such as the lack of agricultural credit, which made it impossible to purchase such an input (Dillon and Hardaker, 1980).

Going back to the example of fattening young bulls by grazing, let us assume that after the proposed alternative (supplementation with 2 kg of molasses and 100 g of urea) was evaluated, the weight gain obtained was 350 g/day.



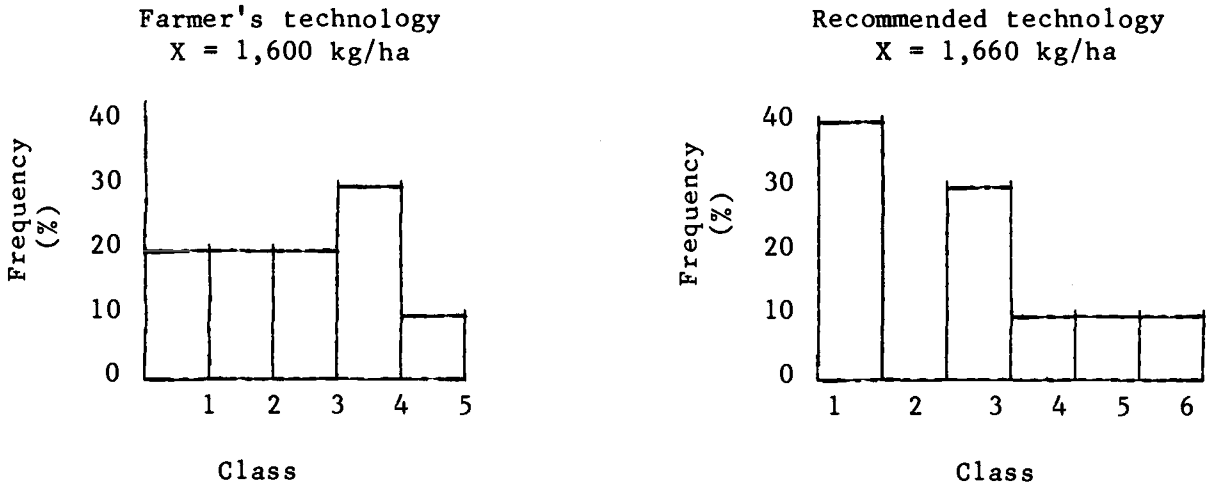
Obviously, the product obtained (350 g/day) was higher than that obtained when using the typical system (160 g/day); however, it differs from the value of the model (300 g/day). For this reason, it is advisable to look for other variables which may have influenced the final result. One of these variables may be previous growth; accordingly, the new model to be generated, verified and validated would appear as follows:



<u>Other Evaluations</u>. Besides biological evaluations, it is also advisable to consider risk and economic evaluations.

Risk can be defined as the probability of obtaining a result lower than a certain level. Figure 10 shows the results obtained by Rodrigues and Legeman (1981) when they evaluated the alternatives proposed by the farmers and the alternative proposed by the researchers for the production of corn. In both cases, the average production of corn was identical (1,660 kg/ha). However, the probability of the yield being lower than 1,200 kg/ha was higher in the case of the researchers' proposed technology (40%) than in the case of the farmers' proposed technology (20%). This example shows that the farmer's technology involves less risk than the one recommended by the research team.

The concept of risk is not limited to the probability of success or failure, although the amount of the losses must also be considered, since obviously investing one dollar does not involve the same degree of risk as investing one thousand dollars. This last aspect has been amply described by Zandstra et al. (1979).



Class	
1	1000 - 1200 kg/ha
2	1201 - 1500 kg/ha
3	1501 - 1800 kg/ha
4	1801 - 2100 kg/ha
5	2101 - 2400 kg/ha
6	2400 kg/ha

FIGURE 10 Distribution of Corn Crop yield Using the Farmer's Technology and the Improved Technology (according to Rodrigues and Legemann, 1981)

Regarding economic evaluations, in general, the methodology described above to determine the economic feasibility of an alternative is also applicable to the evaluation of alternatives once they have been tested and the corresponding data have been gathered. The only provison being that, depending on the objectives of the research, the technique of total budget is more feasible on those farms where the alternatives have been tested since specific information is available.

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On-Farm Research Involving the Animal Component in the Farming System

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A common goal of agricultural research is to improve the productivity and efficiency of production systems. These improvements usually benefit both the farmer and the consumer. The goal is often conditioned by the need to preserve non-renewable resources in order to guarantee the capacity to continue efficient production. For instance, to maintain a sustainable system.

Experience has shown the importance of the systems approach in attaining this goal. This approach is included in the research methodology for farming systems, which provides a framework for the identification of priorities, the attainment of objectives and the implementation of research results.

Research (be it basic, developmental or adaptative) is directed towards finding solutions to the limitations which reduce the productivity and efficiency of the system. These limitations can be either ecological and/or socioeconomic and they can have effects on systems inputs, processes and/or outputs.

Agricultural systems, especially those involving both crops and animal components, are complex (Figure 1). Any modification in the components of these systems often leads to unexpected effects, which are sometimes unfavourable, for the functioning and productivity of the total system. Research aimed at finding the solution to these limitations has often been conducted under carefully controlled conditions in experimental stations. The need to conduct research on farms is increasing because of the need to predict the total effects of modifications on the system components. The present discussion considers the problems, methodologies and analytical techniques to be used in research on farms having an animal component.

Types of Agricultural Systems

The importance of animals as a source of food and income varies from one agricultural system to the next; it ranges from being of little or no importance on farms devoted to commercial crops (rubber, banada, tea, etc.) to being of very great importance on cattle-raising systems which rely on grazing. Specific research aspects to improve the animal component also vary from system to system; however, the general principles and methodology for difference systems are usually similar.

To simplify matters, the target system of this discussion will be a small farm having a mixed crop-animal system, operated by a small family who produce food for their own consumption and who sell a small quantity of agricultural and animal products. This type of farm system has been chosen for the following reasons:

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A. It is the target system considered in several research and development projects presently being conducted in Latin America and the Caribbean (as well as in Africa and Asia).

B. The number of animal units per farm limits the number and kinds of treatment that can be evaluated.

C. Competence and complementarity among crop and animal components raise important research questions.

Types of Research and Suitable Locations

This dicussion does not attempt to cover this subject exhaustively, but rather to review the types of research appropriate to be conducted in experimental stations versus those which are suitable to be developed on farms. In fact, the most effective research programs would involve both types of locations. Results of research conducted on farms (diagnoses, evaluations, etc.) are used to determine the type of research to be conducted in experimental stations, the results of which are evaluated finally on farms.

Experimental Stations

Research in experimental stations, which leads to a basic understanding of biological systems usually requires strict control, technical handling and rather sophisticated equipment. Examples of this kind of research are: the determination of nutritional requirements; the identification of pathogen organisms and the appropriate therapy; and a compositional analysis of food and products.

Often, it is easier to conduct the ex-ante evaluation of possible modifications in experimental stations in order to identify those alternatives which have a high possibility of success. In fact, the main reason why experimental stations receive official support is that experiments conducted in stations minimize the risk of introducing technological modifications of the farmers which lead to lower productivity.

The conceptual and mathematical models, and the prototypes of production systems having established targets are useful for the development of research priorities and for the ex-ante selection of potential alternatives. For the purposes of filtering or selecting technological modifications, the accuracy of the models as emulators of the real system is more critical than precision, since interest will usually be concentrated mostly on modifications which cause major effects (Example: 20% to 30% change in productivity).

The main disadvantage of station research is that its production environment is almost always different from conditions on the farm. The differences can be large enough to render the results not immediately transferable. Technology suitable for the experimental station may either be too expensive or require equipment, infrastructure, manpower or management capabilities which are not available on farms.

On the Farm

The first step essential in production systems research must be characterization of the target system. This includes the identification and description of inputs, processes, outputs, and limitations. Most of this research must necessarily take place on farms, usually conducting diagnoses, although some aspects of characterization research (such as laboratory analysis to determine nutritional quality) can be conducted in experimental stations.

The critical limitations must be identified during the characterization phase. Some limitations, such as the lack of suitable physical resources (land, water) do not require further research. Solutions to other limitations (such as seasonal nutrient shortage, sanitary problems and genetic deficiencies) can be solved through research which is conducted to adapt known technology or to develop new technology.

The decision of whether research would be better conducted on farms or in experimental stations depends on specific circumstances. Among the main determinants to be considered are previous experience with the proposed technological modifications and the degree of knowledge of the systems under study. Unless the likelihood of reducing farm productivity is very small, it is recommended that extensive experiments be conducted in experimental stations. If farm research leads to a reduction in productivity, the farmer's living is adversely affected, a responsibility not desired by the scientists, even if the farmers are compensated for their losses. Furthermore, a loss of credibility may inhibit any future desire on the part of farmers to adopt the technological modifications proposed by researchers or extension workers.

Once the promising modifications have been identified, they must be tested at the farm level to ensure that they are suitable to the farmers' needs and abilities. Farm evaluation of promising alternatives involves a series of human factors (attitudes, management abilities, availability of labour) and other components of the farm system which are difficult to duplicate in stations.

The main objective of this research is to determine whether the proposed modifications are adequate for large-scale dissemination. The potential consequences of erroneous inferences in this kind of research are serious. However, the probability of erroneous inferences (Type I and Type II Errors, in statistical terms), can be minimized using experimental designs, collection of data, and suitable analytical procedures.

Research on Animal Farms

Knowledge concerning research design, conduction and analysis is more advanced regarding crop farms than it is with respect to animal farms (Example: Flinn, 1978; Gomes, 1976; Zandstra, 1981). Important lessons can be learned from research experiences on cropping systems; however, animal farm research involves special problems. These include:

A. Availability of comparable experimental units for the simultaneous evaluation of treatments. The number of animals per farm is usually low (it must be remembered that we are dealing with a small farm system). Animal population is normally limited and is quite varied with regard to species, breed, sex, age, and physiological condition (pregnancy, lactancy, etc.). Consequently, it is often not possible to have identical groups using comparable experimental units on a farm.

B. The environment in which the animals live and produce is highly variable and is frequently not under the researcher's control. The simple fact that animals, unlike crops, are not rooted to one spot, makes it difficult to measure inputs and outputs accurately. For example, unless animals are constantly confined, and are provided with all their nutrients, it is extremely difficult to determine the amount and composition of their diet.

C. Evaluation of the effects which technological modifications may have on productivity throughout the life of the animal may require observations over long periods (five or more years in the case of cattle, for example).

These observations not only drain the researcher's financial resources (and stretch the farmer's patience), but they also increase the change of a break in the experimental design as a result of the death or sale of experimental units.

To improve the productivity of the animal component at the expense of the crop component (or vice versa) is only acceptable if the net effect on farm productivity is a positive one. Consequently, the evaluation and modification of interactions between crop and animal components are the main priorities of the research. Following are some examples of interactions:

<u>Competence</u>

- Farm resources (land, labour, capital) used for food and cash crops and not for fodder crops or animal feed.

- Damage to crops caused by animals.

<u>Complementarity</u>

- Animal traction for crop production.

- Use of animal manure as fertilizer.

- Use of crop residies and crop and pasture rotation to provide feed for animals; conversion of low-value agricultural products into high-value products (food, fibre, work).

- Storage of seasonal surpluses of agricultural products in the form of animal products for utilization or sale when seasonal shortages occur.

- Animal protein to supplement a family diet based on agricultural products.

The characterization of these interactions involves measurements at the station level. However, research to solve competence interactions or complementary increases usually requires experimentation on farms. Consequently, most of the specific problems in animal research will occur on farms, among which are:

1. Selection of experimental units;

2. Selection procedures to ensure that the sample is representative of the target population.

3. Selection of variables and use of analogues for the difficult-to-measure variables.

4. Measurement units and use of indexes.

<u>Selection of Experimental Units</u>

The experimental unit is the unit to which the treatments are applied. In many cases, the treatments of interest in on-farm research are such that only one experimental unit per farm can be considered. For example, the treatment can involve the use of crop residues for feeding animals. Only on rare occasions will the number of cattle having the same characteristics on a a farm be large enough to evaluate different feeding treatments on the same farm. Even in those cases where there is an adequate number of animals of comparable condition (same age, sex, physiological state), the controlled feeding of different rations may be impossible considering the farmer's limited resources (facilities, manpower). In such instances, different feeding managements will be applied on different farms, and on each farm, the herd, as a whole, will be consisdered an experimental unit.

The farmers' attitudes and reactions are important factors which can adversely affect the application of different treatments within the same farm. It is ususally preferable that the farmer be unable to anticipate the results expected from a treatment. For example, if the research involves testing the efficiency of a vaccine, then all of the animals on the farm must be injected with either the vaccine or with an innocuous solution, without the owner knowing which animals really were vaccinated and which were not.

<u>Represenative Samples</u>

In order to ensure that samples are representative, total characterization of the farming system is essential. The characterization must include physical, biological and socioeconomic factors. Given the complexity of farming systems, stratified sampling procedures are usually appropriate. The important criteria for the stratification will be derived from analysis with models and/or the researcher's institution based on his experience. Some examples of the criteria for stratification are:

Ecological: Rain (amount and distribution), temperature, kinds of soil.

Biological: Crops and crop patterns, animal species, and their management, as well as age, sex, breed and physiological condition.

Socioeconomic: Size of family (source and availability of manpower), educational level, income, credit, level of technology being used.

Selection of Variables

The variables to be measured in animals depend on the research objectives; however, those limitations in the ability to make accurate measurements on farm conditions must be considered. The following important variables, which are not difficult to measure under experimental conditions can be considered:

Health: Incidence and causes of morbidity and mortality.

Fertility: Number of animals per litter, interval between deliveries, number of litters per life cycle.

Size and Growth: Weight at birth, at maturity, at slaughter, pre-weaned and post-weaned growth rates.

Lactation: Daily production, duration of lactation.

Other: Number and weight of eggs and duration of grazing cycle.
Quantity and quality of sheared wool.
Type and quantity of animal traction used.

Other important characteristics are not easily measured under farm conditions. For example, efficiency of food utilization for production and maintenance involves knowing the quantity and composition of the diet. Although the sources of food (pastures, crop residues, kitchen scraps) can be determined in general terms at the farm level, research on utilization efficiency must usually be conducted in controlled feeding tests in the experimental station. If this were not possible, indirect indicators of the food efficiency could be determined using correlated characteristics such as growth rate. Food requirements are estimated in terms of metabolic weight (Weight .75).

Another example of indicate measurement of an important characteristic is the estimate of the length of time between birth and conception determined by subtracting the average gestation period for the species from the interval between observed births.

In addition to the measured response to the treatments, other variables must be measured for use in statistical analysis. The efficiency of significance tests on the effects of the treatment improves if one takes into account the sources of non-experimental variation between the experimental units. The effects of the classification variables listed above as the bases for stratification can be removed through appropriate statistical analysis. Similarly, the analysis of covariance makes it possible to remove the effects of continuous variables.

The following is an example of the model for statistical analysis:

$$Y_{ijk} = Y + f_i + p_j + f_{p_{ij}} + b(t - t) + e_{ijk}$$

where Y is the daily milk production of cow i j k.

fi is the i^{th} type of ration.

pi is the j^{th} type of birth.

fpij is the interaction of the i^{th} ration and the j^{th} birth.

b is the linear regression of milk production at an average daily temperature.

eijk is the experimental error associated with the individual k^{th} in the ration-birth class ij^{th}.

Even though the effects of births and temperature may not be especially useful, their non-inclusion in the statistical model (assuming they significantly affect milk production) will increase the experimental error and reduce the efficiency of the hypothesis being tested regarding the effects of the rations.

The appropriateness of the experimental design will depend on the objective of the experiment, the characteristics of available farms, and the animal component on the farms. In many cases, the experiments will be multifactorial. Often appropriate are random block designs (farms as blocks) and variations of the split-plot designs (farms as plots, animals as subplots). Unfortunately, the considerable variations among small farms combined with the selection limitations between collaborators and the lack of experimental control often leads to unbalanced, non-orthogonal sets of data. In those cases, interpretation of the research results will depend on the availability of computer programs for generalized analysis of least squares.

Measurement Units

The simple example in the above section involved the analysis of a single characteristic, namely, milk production. However, as has been mentioned before, interest will usually be centered around farm productivity and efficiency as a whole. Consequently, to evaluate the contribution of one enterprise a total estimation of the farming systems' inputs and outputs has to be made. For example, the value of those foods derived from agricultural and animal products can be expressed in terms of energy and protein. Thus, the relative contributions (and costs) that the different activities make to farm productivity can be compared. Coefficients are needed to convert a kilogram of grain or meat or milk into a common denominator. These coefficients will be obtained through laboratory analysis; usually standard values are used rather than coefficients derived from actual farm production. It must be pointed out that most analytical studies (especially on animal products) are based on experiments conducted in temperate climates and the coefficients may be not be suitable for studies conducted in tropical countries.

It is common to convert inputs and outputs and express them in units which make economic comparison possible (for example, money). Opportunity costs for inputs and outputs are usually based on their market value. These values may not be appropriate for small farms. For example, the necessity of producing food for his family may lead the farmer to assign a very high "value" to a low-risk food crop rather than to another crop (or animal) having a higher market value. In a similar vein, variation in opportunity costs of inputs such as labour between farms (or over a long period on the same farm) make it difficult to btain meaningful economic evaluations.

Often, comparisons are made easier by using indexes which combine several characteristics to determine a product. For example, an index to measure animal weight output (A W O) of the cattle component can be determined by combining fertility (F), survival (S), and growth rate (G).

$$AWO = F \times S \times G$$

where

$$F = \frac{(\text{Calves born/cows considered})}{\text{Calving interval}}$$

S = Surviving calves at slaughter/calves born

G = Weight at slaughter/age at slaughter

F and G are expressed in years, both being multiplied by 365 days.

By converting the slaughter weight into meat using the percentage of yield and the carcass composition, this index could be expressed as meat output. Other indexes could be developed for yearly milk production. These two indexes could be combined by converting meat or milk into energy or protein.

Other kinds of indexes are useful when the interesting characteristics are not easily measurable. Assuming that a set of measurable variables is closely correlated with a non-measurable set, multivariate analytical techniques (Example: canonic analysis) can be used to develop an index of measurable characteristics which may serve as an anology of the set of variables which are non-measurable (Seal, 1966). The term "non-measurable" must be qualified, however, because both sets of data must be available for an analysis of the original data. Consequently, a canonical index for use on farms where the interesting characteristics cannot be measured must be derived from an analysis of data derived from other sources where complete duplications are possible.

Canonical analysis has not yet been applied to the types of situations considered in this discussion.

However, a conceptually similar selection index, used by specialists in animal breeding has been widely applied. For the selection indexes, the set of measurable characteristics are phenotypes and the set of non-measurable characteristcs are the non-additive genotypes to be modified by the selection process.

Conclusions

This discussion has emphasized the research problems and difficulties on animal farms. Research experience on crop based farming systems provides some bases for solving these research problems. However, much more experience with the animal component is necessary. While one can theorize regarding the kind of data, the experimental design, or the appropriate data analysis, the best answers will be those derived from experience. At present, some scientists are conducting research on animal farms. It is important that they share their research experiences and their conclusions. At this early stage of our experience, detailed methodological reports which include all our information should be published so that they can be used by biometrists and others to improve designs and analytical procedures.

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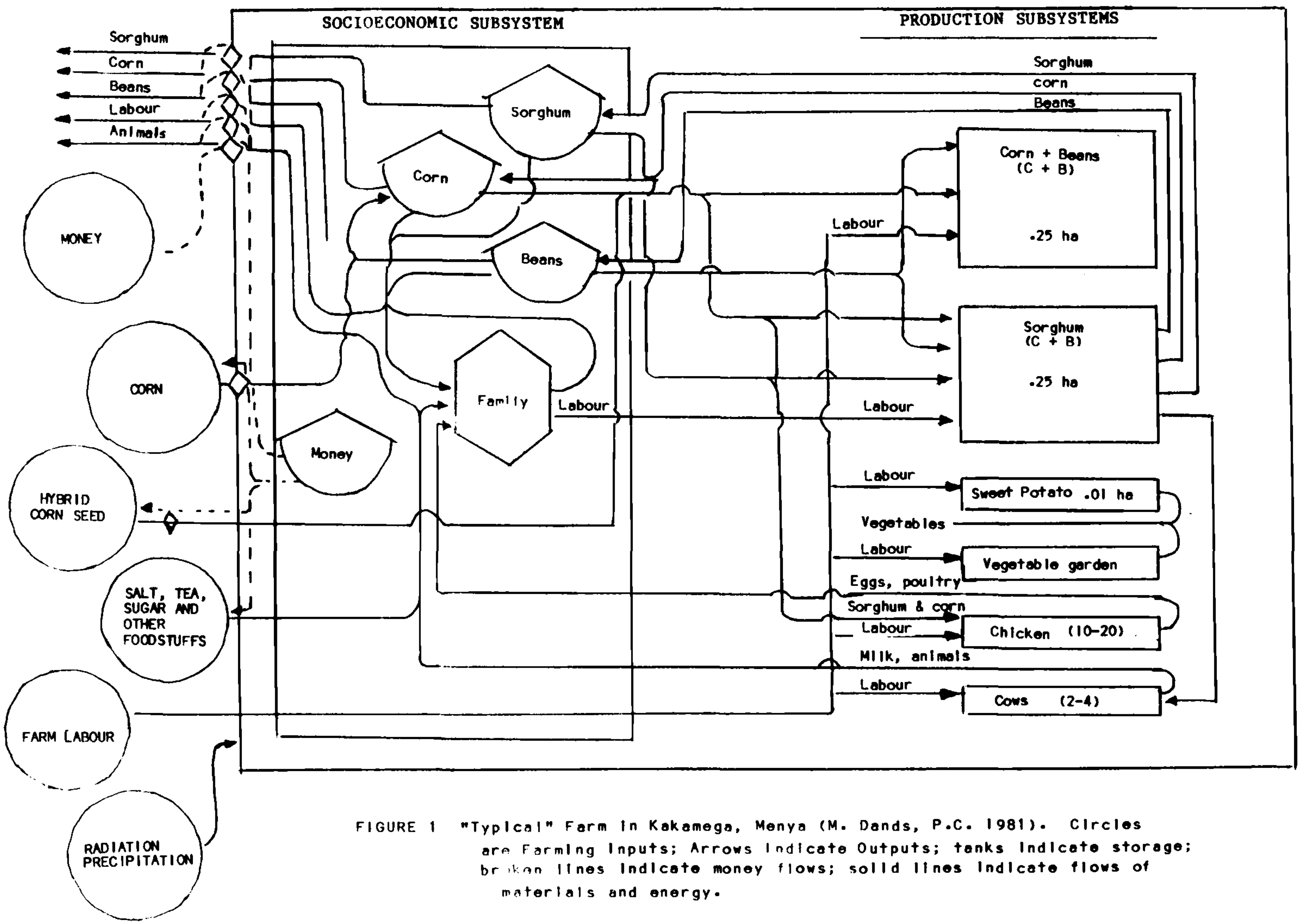

FIGURE 1 "Typical" Farm in Kakamega, Menya (M. Dands, P.C. 1981). Circles are Farming Inputs; Arrows Indicate Outputs; tanks Indicate storage; broken lines indicate money flows; solid lines indicate flows of materials and energy.

Link Between Generation and Transfer of Technology in Agricultural Development

Hubert G. Zandstra*

Introduction

Over the past ten years, agricultural research has gradually evolved from a one-discipline approach based on biology to an approach involving several disciplines, which makes it possible to conduct a simultaneous study of several aspects of an agricultural enterprise. Also, many researchers have been able to free themselves from the confinement of research centres and have discovered that commercial farmers' production systems involve a wonderfully intricate world of biological and socioeconomic factors.

When undertaking the challenge of providing the farmer with improvements to his production system, the researcher also undertakes the responsibility of generating technologies which are acceptable to the farmers. The link between technology generation and transfer begins with the generation of new production techniques which are within the farmer's reach. Therefore, this paper will first analyze the impact which decisions made during the research may have on future extension work.

On the basis of this analysis, this paper will identify certain prerequisites for the generation of new technologies. It will also identify extension programs which, if they are met, will increase the chances of providing the farmer with acceptable new techniques.

In Search of a Recommendation

Researchers are responsible for formulating recommendations. The research process followed usually involves the following steps:

The research process followed usually involves the following steps:

1. Description of the existing production system.

2. Definition of the behaviour of the system when changes occur in production factor levels.

3. Optimization of specific objectives in order to identify a practice which may be recommended under certain limiting conditions.

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More specifically, for a given production system, one objective (Y) can be considered which is related to production factors ranging from x_1 to x_n, and from a_1 to a_m, i.e.

$$Y = f\ (x_1 - - - x_n,\ a_1 - - - a_m)$$

X factors are factors which are considered to be under the "control" of the researcher who, therefore, considers that these factors are modifiable and that they can eventually be included in a recommendation. A factors are non-modifiable factors, i.e. environmental. Although they will have a definite impact on the behaviour of the production system, non-modifiable factors cannot be considered an activity to be included in the recommendation.

In general, the researcher must deal with interactions between environmental and modifiable factors (for example: precipitation and nitrogen response). Therefore, the researcher can optimize the production process only for a given environment, i.e. for the L environment:

$$Y = f\ (F_L\ (x, - - - - X_N\ \ A_{1_L}\ \ - - - A_m\ )_L$$

Objective (Y) is a specific function (f_L) of factors ranging from x_1 to x_m since the values of environmental factors a_1 to a_m are those of environment L, i.e. A_{1_L} to A_{m_L}.

Thus, the conditions limiting optimization are the environmental factors, which cannot be included in the recommendation since such variables are considered by the researcher to be non-modifiable. These determining factors may include precipitation, soil acidity, price of milk, cost of soil preparation, cost of labour, limit of N that can be applied per hectare of pasture, or others.

The need to identify a recommendation which is well suited to the farmer's environmental conditions arises from the fact that the recommended production system must compete with the existing system which has been able to adapt to its environment over the years. When the recommendation is not well adapted, costs and production risks are higher and profits are lower.

The awareness of environmental complexes (Table 1) for which research must specify different recommendations involves greater research difficulty and higher research costs. If conditioning factors are physical, the researcher must often conduct additional tests to evaluate the behaviour of technological changes in different physical environments; including, for instance: fodder legumes on well drained and poorly drained soils. When factors are economic, the recognition of these differences during the analysis to optimize profits will often allow to make the necessary adjustment in the recommendation for each of the conditions, without having to conduct additional biological experiments.

The goal of the researcher is to obtain the maximum return from the recommendation and to get predictable and very similar results from the farmers who will implement the recommendation. Therefore, the researcher tends to include in the recommendation all environmental factors which have a measurable impact on optimal levels of modifiable variables. This involves a great many production functions and recommendations for each set of environmental conditions or specific field of application.

Types of Recommendations

In the context of agricultural development, a suggestion is a piece of advice concerning operations, times, equipment, and material for a production process which is presented fo the farmer as worthy of being adopted. A recommendation for an animal production system comprises a number of components directed toward certain aspects of the production system, such as types of pasture or parasite control methods.

Most components are conditioned, in one way or another, by some environmental factors. The most frequent components in recommendations are:

1. Fixed actions. These are simple recommendations which are applicable to all of a specifically defined geographical area.

2. Actions conditioned by resources considered to be "fixed". Such as type of soil; soil texture; type of pasture; or breed of animals. This stratification comprises a set of simple recommendations, one for each environment. For example: "To purebred Holstein cattle or crossbreeds having at least three quarter Holstein blood, give 2 kg of concentrate/day over the period from two months before to seven months after calving. To the remaining animals, give 1 kg of concentrate/day over the same period".

3. Actions conditioned by events, such as incidence of disease, the presence of certain ectoparasites or the amount of rain. For example: "Sow pasture at the beginning of the rainy season, when the soil is wet to a depth of at least 20 cm."

4. Actions conditioned by "fixed" factors and events. These usually involve complicated recommendations: "For improved varieties, apply 0.75 kg i.a./ha of Endosulphan to control the stem borer, when more than 5% of stems are affected; however, for additional varieties make application only when more than 10% of stems are affected."

The dissemination of type 3 and 4 recommendations involves complex communication and sometimes requires the extension service to conduct a follow-up of certain environmental conditions or indexes in order to be able to advise the farmer of the need to conduct certain management activities.

Obviously, if the extension system were not capable of making many recommendations to the community, the researcher's efforts to stratify recommendations would be a waste of time and without benefit. His specific recommendations must be generalized before they reach the farmer, during which process they lose their suitability.

Therefore, an important step in the link between research and extension work is to reach an agreement regarding the accuracy of the recommendations and the cost involved in increasing their complexity.

In practice, this classification of production systems involves a combination of variables such as climate, type of soil, type of farm (size of herd, kind of management and land ownership, etc.). Sometimes research is aimed at only one set of environmental conditions and, therefore, only one recommended production system is generated; for instance, a dual-purpose cattle production system based on *Hyparrhenia rufa* pastures with a herd size of 20-35 head in a specific zone.

However, to have more impact in a region, research and extension work try to include the majority (70%) of farmers who are involved in a given agricultural area (for example, the dual-purpose cattle production system). Variations in the physical environment and in the kinds of farms may demand that research and extension work activities be directed to two or three farms devoted to the dual-purpose system. Since the cost of research and extension work is high, stratification of the population under study must be done efficiently, avoiding many classes (sets of environmental conditions); classes must be defined so as to allow the coverage of most of the variability in the determining factors of the system under study.

Levels of Institutional Support

Once an agreement has been reached regarding the types of farm, or sets of environmental conditions, research can continue on with the process of identifying recommendations.

In order to make sure that the recommendations are adopted by the farmer, recommended practices and inputs must be within his reach. When an alternative production system is recommended to a farmer, an increase in the utilization of resources is almost always demanded. The new technologies either save labour (mechanization) or increase land resources by introducing capital goods (fertilizers, fences, sources of water, pesticides, new seed). Also, if production increases are really to generate profits, a marketing system and adequate markets for the products are necessary. Finally, it is recognized that an increase in utilization of capital also increases the farmers' risks.

Such an increase in the utilization of resources may or may not be within the limitations of the small farmer (Table 2). Therefore, even if a new technology does generate acceptable returns, its adoption by the farmer still depends on the availability of resources.

The researcher may try to limit his research to designing technology which corresponds perfectly to the limitations which exist on the farms (the research method appearing in Figure 1). This type of research is difficult, takes a long time and usually leads to production increases which are much lower than the increases that might be obtained with a better access to production costs [sic].

As an alternative, the researcher may decide that certain limitations must be modified. The type of limitation and its degree of diminution will have a strong impact on the technological designs that can be evaluated. This decision also has important consequences for future institutional support which will required the introduction of these new technologies in the farmer's system. Obviously, it is not worth generating a technology which depends on the assumption that there is institutional support which does not exist because of institutional or political limitations. Therefore, the research team must be in agreement with the extension team concerning the institutinal support upon which the farmers may rely if they wish to introduce the recommendations.

Nothing is free. Institutional support or the modification of farmer's limitations cost money and supervised credit is expensive to manage. However, the increase in agricultural productivity and the income the farmer will earn as a result of new technologies may be much higher with institutional intervention than without it.

It may be interesting to analyze the decision-making process traditionally used to define institutional support. Usually, the researcher decides, on the basis of certain criteria, that "the level of inputs must maximize a farmer's net profits" or that "this level cannot be increased by more than 25%, 50%, or 100%". On the basis, the researcher looks for an improved technology, which he tries to "sell" to those who make the decision about extension programs. Often the extension worker is not in a position to refuse what the researcher desires. Thus, the extension worker advises the farmer of the recommendation hoping that in one way or another the farmer may be able to find the necessary inputs (there is not doubt that miracles do happen, but they are very few and far between).

Often, the institutions in charge of extension work have no experience in the credit and marketing procedures which are necessary to ensure the availability of resources for the implementation of a recommendation. In that case, the researcher must specifically advise the extension worker not only of the recommendation and the field of applicability, but also of the specific requirements for inputs, seeds and credit support.

Pilot Production Programs

The last phase of research in animal production systems is the testing, on the producers' farms, of the alternative system. Usually, farmers receive support regarding inputs and the management required for the new technology. Often, the research program provides some degree of protection against unexpected losses. In fact, researchers want to study the biological and economic behaviour of the system and they, therefore, provide the institutional support necessary for implementing this system on a limited number of farms.

The results of the tests make it possible to define what the economic advantages of the new system are and what the requirements regarding communication of information, availability of inputs and credit and marketing support may be.

The next step in the research-extension-adoption process is the formulation of a production program specifically designed for handing over the new production system to the farmers. Often, it is advisable to set up a pilot program in which the number of participants is still limited (25 to 100). The institution in charge of extension work must implement such a program, but the team of researchers do participate in the development of the pilot program and in the measurement of the results. The objectives of a pilot program are to define: 1) the intervention activities required to provide the necessary information, credit, inputs and marketing; 2) the management structure necessary to ensure that these production factors are available on time; 3) the responsibilities of each participating institution; 4) the suitability of the extension system through an evaluation of the farmer's opinions on the clarity and usefulness of the recommendations and the availability of inputs in good time; 5) the adoption or non-adoption by the farmer of certain components of the recommendation, and the reasons therefor; 6) the costs and benefits associated with the adoption as compared to those of the existing systems; 7) the additional expenses of the extension program as compared with previous expenses.

The organization of pilot production programs (PPP) and the necessary follow-up is, in itself, a subject of research, the discussion of which lies beyond the scope of this paper. However, researchers should know some of the common reasons why production programs have failed:

- Lack of official support. This is shown by the failure of several institutions to comply with the responsibilities which they theoretically accepted.

- Failures on the part of management. The contributions which each group must make have not been well identified and programmed. The people in charge of participating institutions are not aware of the consequences their participation may have in terms of personnel, expenses and utilization of transport and equipment, and have not made the necessary allocations. Failures on the part of management result in inputs of inferior quality and late or insufficient credit allocations.

- The field extension worker does not understand the recommendation nor the importance of conducting certain operations on time and in the recommended manner.

- Farmers do not understand the recommendation and/or are not aware of the benfits that may be derived from it.

- Farmers do not know the limitations of their obligation regarding the plan; they are afraid of the credit system, and they avoid incurring debts or following instructions given by intruders (government officials).

- Farmers feel intimidated by those landowners, lending institutions, salesmen or intermediaries who feel threatened by the PPP.

- Extension workers favour subgroups of farmers (on the basis of race, religion, political affiliation, etc.) and banks prefer to extend large loans.

Finally, an important cause of the failure of PPP is the behaviour of the recommended technology. The most common defects in technology are:

- Yield is not what was stated in the PPP (whose data were obtained from researchers).

- Predictions made regarding the benefits of technology are not realistic because:

  Product losses are ignored;

  Quality of product is inferior, and, thus, prices are lower;

  Marketing potential is limited, which causes lower prices;

  Costs were underestimated, for example: costs of seeds, sowing, or harvesting, transportation, or getting a loan.

  Technology is complicated or demanding. Example: it involves inconvenient days or hours, requires the use of chemicals and related protection, or relies on rented or complicated machinery.

Obviously, these defects are the result of an incomplete or biased evaluation of the technology during the testing phase.

Conclusion

In order to avoid any difficulties in the formulation, testing, and extension of new technologies, the following precautions must be taken at the outset of the research:

- Research and extension teams must agree on the global objectives of the process.

- The target population and its stratification into subgroups must be well-defined and accepted by both parties.

- The level of institutional intervention and support must have been discussed realistically and established by mutual consent.

- The extension team must definitely be interested in participating, in the future, in the testing phase and in a pilot extension project.

It is important that the extension team participate when the new technology is tested on the producers' farms. This will help them to prepare for any possible future production programs and give them a chance to conduct their own evaluation of the advantages of the technology. Usually the small team of farmers who participate in the verification phase will serve as a starting point for a pilot production program.

Before beginning a production program, it is advisable that the management of the extension system and the institutional contribution be evaluated in a pilot project. Given their intimate knowledge of the new technology, the research team must contribute to the design of the pilot project and participate directly in the evaluation thereof. This evaluation must include measurement of the efficiency of the plan regarding the administration of inputs for technology (including information), measurement of the adoption on the part of the farmer, and measurement of the impact on production.

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TABLE 1 COMPARISON BETWEEN A GENERAL RECOMMENDATION AND SEVERAL STRATIFIED RECOMMENDATIONS FOR THE FERTILIZATION OF CORN WITH PHOSPHORUS

Type of Recommendation	P_2O_5 (kg/ha)		Weighted Average of Net Profit[a] (US$/ha)	Risk[b] (US$/ha)
	Recommended	Needed		
1. General	20	20	8	7.9
2. Two groups of municipalities	0,41	15	13	6.2
3. Three groups of municipalities	0,19,41	18	15	7.2
4. Individual municipalities	0,14,18,20,41	20	16	5.9
5. Soil tests (high and low)	0,58	21	36	1.5
6. Soil tests (high, medium, low)	0,28,68	21	37	0.7

a Assuming that all corn producers applied the recommended rate.
b Expected value of losses among producers applying phosphorus.

TABLE 2. SOME REQUIREMENTS OF THE NEW TECHNOLOGIES AND FARMERS' LIMITATIONS*

Requirements	Limitations
Land	Land availability
Risk	Water availability
Capital	Availability of own capital Availability of credit Capacity to contract debt Real cost of credit
Inputs	Availability of inputs Price of inputs
Labour (monthly)	Availability of labour (monthly) Cost of labour
Markets and marketing	Market existence Product demand Processing capacity Storage capacity
Production risk	Capacity to face risks
Market risk	
Institutional risk	

* According to Zulberti _et al_. 1979

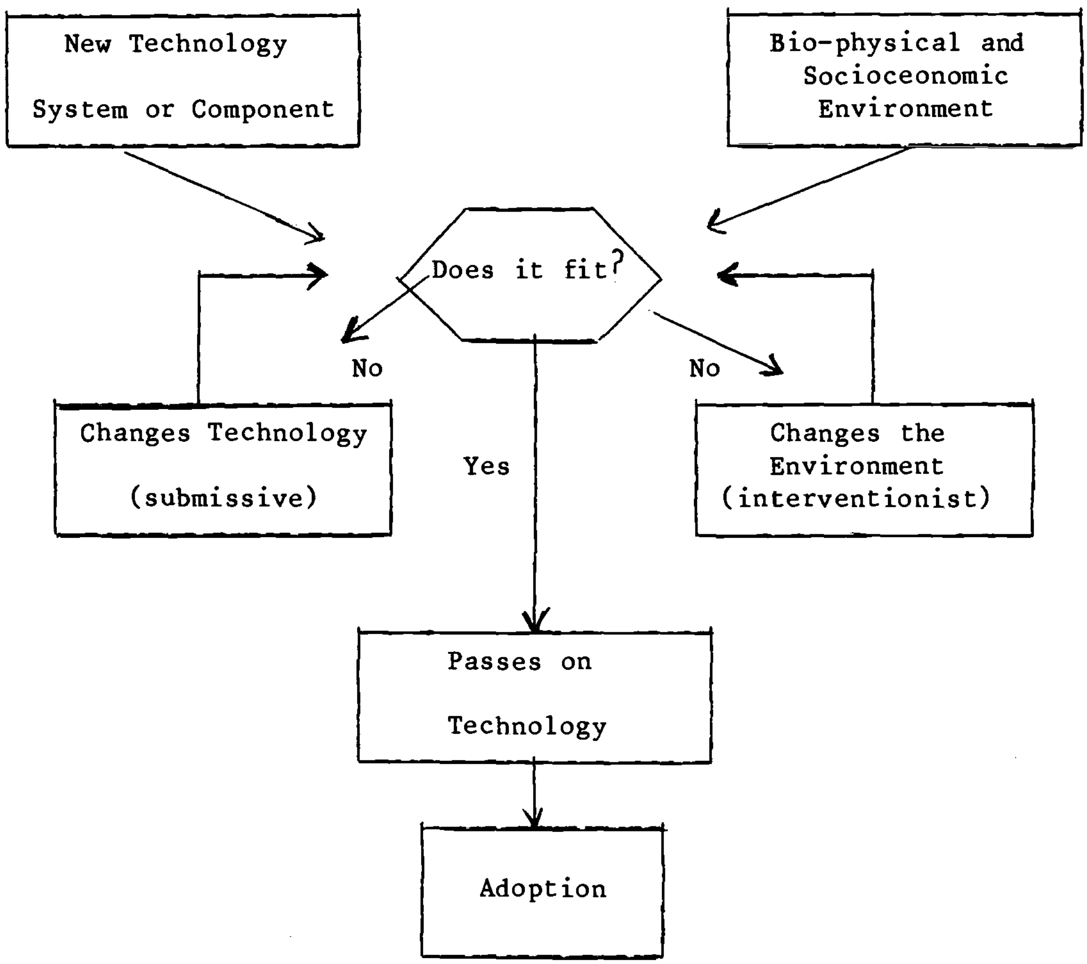

FIGURE 1 Alternatives to Achieve Adoption of new Technology by the Farmer; Technological or Environmental Modification

III. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Diagnosis

a) When defining the data to be included in the diagnosis, their usefulness with respect to the generation of alternatives must be taken into account. This will determine a minimum database.

b) The information included in the diagnosis must cover three levels:

- Regional level;

- Farm level;

- Agroecosystem level (subsystems)

These levels determine how the data are obtained.

- Regional level: Secondary information, meetings with leaders, organizations promoting change, "survey" visits. Multidisciplinary team action. A "tentative" (flexible) model is developed on the basis of this information.

- Farm level: Meeting with the farmer. Action conducted by a team which includes experts in biological and social sciences. Aspects such as resource availability, some production estimates and a description of the existing agroecosystems are covered.

- Agroecosystem level: Meeting with selected farmers. Action conducted by a specialist in biological sciences, and by an economist.

  It covers more detailed aspects with regard to the agroecosystem. There actions are sequential.

c) Static diagnosis at the farm or agroecosystem level must include several visits which are separated by periods when the need for additional data is analyzed and a decision is made.

Evaluation of the Alternative vs. Control on the Same Farm

a) This research is justified, keeping in mind the following objectives:

- To study some characteristics that require the presence of the farmer (an alternative involving farmer interaction) for example: the alternative may imply that the farmers have some spcial ability.

- To test the alternative under conditions which are different from those in existence where basic information was developed.

- To keep the researcher fully aware of the farmers' conditions.

b) The alternative to be tested must be definitely superior to the control. The greater the expected difference, the less necessary the statistical design and analysis of results. However, it is more preferable to have a few observations on several farms than to have many observations on the same farm.

Linkages Between the Generation and Transfer of Technology in Agricultural Research

a) Both research on production systems and development plans are meaningless when taken separately.

b) The researcher working on production systems must determine in which field to adapt the generated recommendations.

c) There is need to establish research projects on transfer of technology which are aimed at determining the most effective transmission methodology(ies).

RECOMMENDATIONS

It is recommended that:

° The participating work teams prepare, for the next meeting, a list of the variables used in the design of a specific alternative. Such lists would be used to make a comparison, between teams, in order to determine the minimum amount of data necessary for the design of alternatives.

° Research institutions intensify their efforts to make planning organisms and development institutions more aware of the fundamental role played by research in development programs.

° Research organizations actively participate in the determination of credit policies, and ensure the availability of inputs and markets necessary for the effective implementation of technologies in specific areas.

° Technology transfer actions of governments and private institutions be restructured in order to formally integrate and coordinate their activities on specific farms.

° The extension worker participate in production systems research, as a member of the team if possible, in order that the results of the research be within reach of the extension worker.

- Researchers participate in the process of planning and evaluating of extension programs.

- Research and extension programs be directed to specific areas and farming systems.

IV. ANNEXES

ANNEX I: List of Participants

Dr. Rolain BOREL	Agrostologist CATIE - Costa Rica
Ing. Teofilo CORDERO	Nutritionist INIPA - Peru
Lic. Manuel DE GRACIA	Nutritionist IDIAP - Panama
Dr. Hank FITZHUGH	Specialist in Animal Production, Program Officer for Latin America and the Caribbean Winrock International, U.S.A.
Ing. Gregorio GARCIA LAGOMBRA	Specialist in Animal Production. Head of the Beef Cattle Experimental Station CENIP - Dominican Republic
Dr. Silos GONZALEZ	IVITA Coordinator in Pucallpa, Peru
Dr. Héctor Hugo LI PUN	Nutritionist Program Officer for Latin America and the Caribbean, IDRC
Mr. Edward LOTTERMAN	Agricultural Economist. Resident in Peru. Winrock International, U.S.A.
Dr. Guillermo MEINI	Specialist in Animal Production Coordinator of the Amazonian Production Systems IVITA - Peru
Ing. Carlos ORTEGA	Agrostologist. Coordinator of the Dairy-Beef Feeding Systems Project IDIAP - Panama
Dr. Paschal OSUJI	Nutritionist. Project Leader, Milk Production Systems Project CARDI- Trinidad
Ing. Danilo PEZO	Nutritionist CATIE - Costa Rica
Ing. Alfredo RIESCO	Agricultural Economist IVITA - Peru
Dr. Santiago RIOS	Specialist in Animal Production Deputy Director General IDIAP - Panama

Dr. Manuel RUIZ	Nutritionist Project Coordinator, Animal Production Systems Project CATIE - Costa Rica
Mr. Arnoldo RUIZ	Animal Scientist CATIE - Costa Rica
Dr. Alberto SATO	Director IVITA - Peru
Dr. Hubert ZANDSTRA	Associate Director, Agriculture, Food and Nutrition Sciences Division, IDRC

ANNEX II: Report of the First Meeting of IDRC-Sponsored Projects in Latin America, Panama, May 22, 1981

PARTICIPANTS:

Instituto de Investigacion Agropecuaria de Panama

Ing. Bolivar Pinzon
Lic. Manuel De Garcia
Ing. Miguel Sarmiento
Dr. Jorge Gomez
Agr. Claudio Samudio
Agr. Juan I. Peralta
Agr. Javier Gonzalez
Agr. Oscar Aponte
Ing. Miguel Avila

Instituto Veterinario de Investigaciones Tropicales y de Altura
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Dr. Guillermo Meini
Ing. Alfredo Riesco
Dr. Silos Gonzalez

Centro Agronomico Tropical de Investigacion y Ensenanza

Dr. Manuel Ruiz
Ing. Danilo Pezo
Ing. Arnoldo Ruiz
Dr. Héctor Li Pun

ORGANIZATION:

During the meeting, acting as:

Moderator: Dr. Héctor H. Li Pun

Secretary: Dr. Jorge Gomez

The first meeting between representatives from IDIAP of Panama; IVITA of Peru; and CATIE of Costa Rica was held in the City of David, Panama, on May 22, 1981, in an attempt to establish closer ties between the different national institutions in several Latin American countries which receive support from the Internatinal Development Research Centre.

Before discussing the proposed Agenda, the characteristics of the projects were briefly analyzed. It was found that, in general, each of them share a common objective of development of improved production systems which are aimed at increasing the socioeconomic status of small- and medium-size farmers. These objectives are to be attained, in each case, using a very similar methodology, whose differences are not very relevant.

Regarding the methodology for a solution to the problems limiting production and productivity on small- and medium-size farms, it was agreed that before taking any other action, it was of vital importance to increase the researchers understanding of the farming systems. The best way to achieve this better understanding is to develop a diagnosis which would make it possible to understand the farmer's real situation and farm management system. This diagnosis can be conducted in two phases: the first being instant identification of the present status, and the second being a monitoring of the prevailing production systems in the areas under study over a reasonable period.

If the above information was available, this diagnosis would not be necessary, and the next phase in the methodology could be taken, i.e. the design of alternatives for the improvement of the present production levels of the target system. It is understood that the design of alternatives is derived from the technology generated under conditions similar to those existing in the region where the alternatives are going to be implemented.

In order to analyse the above points, the participants considered the Agenda suggested by Dr. Hubert Zandstra, which appears below:

1- Role of diagnosis

2- Methods for classification of the systems

3- Identification of limiting components

4- Organization of component research

5- Economic evaluation of component research

6- Design of alternatives

7- *Ex-ante* evaluation of designed alternatives, in biological, economic and operational terms

8- Methods of validating the alternatives on the farms

9- Ways to limit the collection of data on the farms during the validation process

10- Identification of suitability criteria useful for the comparison of systems

11- Measurement problems detected during the process of validation of alternatives on the farms.

Even though all of the above points are considered important, it was agreed that, because of the limited amount of time, the participants at the meeting would select the items which held the greatest degree of interest for them. It was agreed that the items not discussed at this meeting would be brought up at the next meeting. The final Agenda was as follows:

AGENDA

1- Identifications of limiting components

2- Design of alternatives

3- *Ex-ante* evaluation of designed alternatives, in biological, economic and operational terms

4- Methods of validating the alternatives on the farms

5- Ways to limit the collection of data on the farms during the validation process

6- Measurement problems detected during the process of validation of alternatives on the farms

7- Transfer of technology.

Summary of Discussions

The items in the Agenda were discussed at length. After each item, a summary was made of the main ideas expressed and the agreements reached.

Identification of Limiting Components:

It was considered that the main aspects in the identification of limiting factors were: a thorough analysis of the diagnoses made by the multidisciplinary technical team, an analysis of the factors the farmers considered to be important, and the factors which have been identified by the extension workers.

The following conclusions were reached on this subject:

a) The limiting problems identified by the multidisciplinary technical teams must be compared with the farmers' opinion.

b) When taking the farmers' opinion into account, two fundamental points stand out: The first is that although a farmers' views may have some limitations, he has a better understanding of his own problems; and second, when a farmer is made to feel that his opinions are valid, he feels he has an important role in the research work and he thus participates more actively in the activities to be conducted. The farmers' opinions must be thoroughly analyzed in order to determine the degree of importance or priority the farmers themselves give to them.

c) The opinions of the extension workers are also valuable because their constant contact with the farmers makes them aware of the farmers' problems and they can contribute to give those problems the priority they deserve.

d) Once the opinions have been analyzed, any agreements or disagreements regarding the real importance of the problems can be detected. This helps to determine more precisely how important the problems are in order to orient the generation and transfer of technologies needed to deal with them.

Design of Alternatives

It was observed that the design of alternatives for the projects which are partially financed by the IDRC, as well as for other projects conducted by the institutions represented at the meeting, had the following characteristics:

a) A previous solid understanding of the farming systems to be improved and of the targets or the degree of improvement expected from the introduction of the technology.

b) To determine why farms having similar resources display different degrees of efficiency.

c) The design of alternatives must be the collective work of the entire multidisciplinary team, who, in turn, characterize the system on the basis of the diagnosis.

d) When designing the alternatives, the following must be taken into consideration: the recommendations, domains, the scale of production, the availability of resources on the farms, the limited use of inputs which are external to the farm, the simplicity of alternatives, low cost, the farmers' practices and traditions, etc.

e) The design of alternatives must be based not only on the application of technical knowledge, but also on a good deal of "common sense".

f) Considering that the design of alternatives is based, to a certain extent, on subjective criteria, several alternatives or variants thereof must be designed in order that corrections can be introduced along the way, thus increasing the project's changes of success.

Ex-ante Evaluation of Designed Alternatives, in Biological, Economic, and Operational Terms

Once the alternatives have been designed and implemented into the existing production systems, the level of their expected impact must be studied, mainly considering the economic and social benefits of the alternative. This must be based on:

a) A study to determine the economic feasibility of the alternatives.

b) Discussions between farmers and extension workers about the technologies to be implemented, in order to obtain opinions, to determine the degree of operation, and then to make the necessary adjustments before it is introduced.

c) A thorough understanding of the factors that may have an impact on the degree of success of the alternative. Many of these factors cannot be controlled by the researcher, such as: amount of rain, price variations of inputs and outputs, marketing, etc.

d) A probabilistic analysis of the alternatives, provided there are existing facilities.

e) A model of analysis which permits evaluation of the stability of the resulting system, apart from the "normal" variations which may occur over a period of time, and which, logically, are dynamic.

Methods of Validation of Alternatives on the Producer's Farm:

Once those alternatives which have the potential to improve the present production systems had been designed, the participants thoroughly discussed the advantages and disadvantages of verifying the applicability of technologies designed on farms managed by the farmers. It was considered that, among other advantages, this methodology is more conducive to collecting more realistic information because of the interaction with the farmer's management practices and those factors not controlled by the researchers. There would also be a shortcut to transfer of technology. However, variability among farms could be a factor limiting the transfer of results to other farms, since the benefits found on one may be different from those found on others. This would entail duplication on a higher number of farms and would increase the number of efforts necessary to be followed up.

On the other hand, the introduction of alternatives on farms, considering their integration to the system implies, to a certain extent, an analysis of the farm as a whole, which renders analysis more complex.

Discussion was centered on two aspects:

a) Where should research be conducted? On the producers' farms or in experimental stations?

b) Which methods or evaluation criteria must be used?
Regarding the first item, it was agreed that:

- At some time, the alternative must reach the farmers and their immediate application will depend on the complexity of the alternative; the validity, accuracy or predictability of the information; the availability of resources from the institution; and the time available for execution of the projects.

- The evaluation of alternatives on the farms involves some risk and reduced accuracy of the information to be obtained; however, it also saves time and the resources required to be invested are relatively smaller than if testing was done in experimental centres or stations.

- If neither time nor resources were limiting factors in research, the alternative should be tested, in a first stage, under the controlled conditions of the experimental station and with as much statistical rigour as possible under the circumstances. In a second phase, the alternative should be introduced on model farms which are controlled by the institution in the areas where the recommendations will be applied. Thus, once the suitability of the alternatives has been determined, they would be introduced on the farms, which is the final test.

It is evident that there is no clearly defined model for the evaluation methodology.

The present statistical criteria are not applicable to the evaluation of systems as a whole; and due to the great variability to be expected among farms (microclimates, efficiency in the use of resources, differences in the quality of resources, etc.), it is unrealistic to expect a very accurate evaluation; thus, they could not be useful even for the analysis of isolated components.

It was agreed that it is possible to use certain parameters as a frame of reference, such as those used for the ex-ante evaluation. However, one must take into account observations regarding the stability and persistence of the alternative, ease of adoption, sociocultural factors and factors exogenous to the farms which may directly or indirectly affect the alternative being tested.

This subject was considered to be very important and the fact that there is very little knowledge on this subject was recognized. For this reason, it was agreed that this subject should be discussed in a workshop at which top specialists, experienced in this field, would participate, and it was requested that the IDRC promote holding such a conference in the near future in order to broaden the discussion.

Due to the lateness of the hour, it was decided to postpone discussion of items 5 and 6 and go on to item 7.

Transfer of Technology:

Given the present importance of the transfer of technology process generated by research, it was quite clear that there cannot be only one model, but that certain proposed measures could be taken to improve the transfer of technology to farmers. Among these measures are:

a) To involve, from the very beginning, those organizations promoting change (institutions supporting production) in the development of the methodology being followed in the research process.

b) To consider the farmer as an active member of the team extending the generated technologies; also, he should become involved in the research process.

c) To have in each research institution a technical team in charge of coordinating transfer actions with other service institutions supporting production, which would direct the transfer to the farmer.

d) To consider, for all projects, the financial support required for research on transfer of technology.

General Conclusions and Recommendations

The conclusions of this meeting are:

1- The methodology used by the participating institutions, in the different projects discussed, is rather similar and is apparently capable of achieving results that are better applied to production situations on small- and medium-size farms.

2- Since there are few institutions worldwide which are devoted to the use of research methodology on animal production systems and since the subject is rather recent, some of the steps require increased knowledge and some others must be further tested or developed.

3- Among the steps requiring further development may be mentioned: evaluation of *ex-ante* alternatives and validation of alternatives on producers' farms.

The recommendations are:
Any technical meeting, such as the present meeting, are certainly very beneficial for projects which have similar objectives; however, there must be some continuity in this respect, and not merely isolated efforts. Accordingly, it was recommended to the IDRC that additional meetings be held in the near future, at which would be discussed those items still requiring further development. Also, researchers from other institutions who would contribute their valuable experience and knowledge on these subjects would be invited to attend.