ISNAR R9(e)

REPORT TO THE GOVERNMENT OF

THE REPUBLIC OF RWANDA

THE NATIONAL AGRICULTURAL RESEARCH SYSTEM OF RWANDA

February 1983

isnar

International Service for National Agricultural Research
The Hague, Netherlands

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR) on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing and operations. Most of its funds are provided by an informal group of approximately 30 donors: countries, development banks, international organizations and foundations, which make up CGIAR.

ISNAR is the youngest of the 13 centers in the CGIAR network, and it is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff matters, thus complementing the activities of other assistance agencies. Additionally, ISNAR has an active training and communications program which cooperates with national agricultural research programs in developing countries.

ISNAR also plays an active role in assiting these national programs to establish links with both the international agricultural research centers and donors.

Citation:
International Service for National Agricultural Research (ISNAR). 1983. The National Agricultural Research System of Rwanda. Report to the Government of the Republic of Rwanda. Translation from the French original, published in December 1982. The Hague, Netherlands.

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International Service for National Agricultural Research

The National Agricultural Research System of Rwanda

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List of Acronyms

BGM	Bugesera-Gisaka/Migongo Agropastoral Project
CCSA	Consultative Committee for Agricultural Sciences
CEAER	Energy Resources Center of Rwanda, UNR
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CNRST	National Council for Scientific and Technical Research
CRAFOP	Center for Applied and Basic Research and Continuing Education, UNR
CURPHAMETRA	University Research Center for Pharmacology and Traditional Medicine, UNR
DEP	Studies and Projects Division, MINAGRI
DPE	Small Farm Animals Development Project
EDF	European Development Fund
GBK	Gishwati-Butare-Kigali Agroforestry Project
IARCs	International agricultural research centers
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IFCC	French Coffee and Cacao Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
INEAC	National Institute for Agricultural Research of Belgian Congo
INRS	National Institute for Scientific Research
IPN	National Pedagogic Institute (merged with UNR in 1981)
IRRI	International Rice Research Institute
ISAR	Rwandan Institute of Agricultural Science
ISNAR	International Service for National Agricultural Research
MINAGRI	Ministry of Agriculture and Livestock
MINESUPRES	Ministry of Higher Education and Scientific Research
OCIR-Café	Rwandan Industrial Crops Authority, Coffee Authority
OPROVIA	National Authority for the Development and Marketing of Crops and Animal Products
ORSTOM	Overseas Scientific and Technical Research Organization (France)
OVAPAM	National Office for Agricultural and Livestock Work at Mutara
OVIBAR	Office for the Industrial Processing of Bananas in Rwanda
PAK	Kibuye Agricultural Project
PIA	Agricultural Intensification Project, Gikongoro
PNAP	National Program for Potato Improvement
PPF	Forestry Pilot Project
SAVB	Agriculture and Veterinary Section of the Butare School Group
SDM	Mutara Swamp Development Company
SSS	Selected Seed Service
UNR	National University of Rwanda
USAID	United States Agency for International Development

Chapter 1

INTRODUCTION

1.1 Origin of the Mission

On November 13, 1981 the Minister of Agriculture and Livestock of Rwanda informed Dr. William K. Gamble, Director General of ISNAR, of the Rwandan Government's intention to hold a seminar on agricultural research in Rwanda for the following purposes: (1) to define the main orientations for agricultural research for the next decade on the basis of development priorities defined by the government and of producers' needs; (2) to make recommendations on the resources that would be needed to reach the set targets; and (3) to enlist the participation of potential donors in the funding of the research program.

Before holding the seminar, it seemed essential to make an inventory and an analysis of the present state of agricultural research in Rwanda, conducted through ISAR (Institut des Sciences Agronomiques du Rwanda), development projects, foreign aid agencies, and non-governmental organizations. For this purpose, the ISNAR Director General was requested to convene a team of experts to evaluate past research, and to study the existing structures, overall organization, methods to identify priority themes for research, program formulation, training requirements of scientific and technical personnel, as well as to identify constraints in general and seeking appropriate solutions.

Since this type of analysis corresponded well with its mandate, ISNAR decided to entertain this twofold request by sending a mission to Rwanda from June 1 to 20, 1982 and by helping the Rwandan Government prepare a seminar on agricultural research in Rwanda, scheduled to be held in Kigali from February 5 to 12, 1983.

1.2 Terms of Reference

The terms of reference stipulated that:

"The ISNAR mission, in cooperation with Rwandan Government authorities:

"a. will evaluate agricultural research programs in Rwanda to see whether they meet the farmers' felt needs and the government's objectives, and will identify the main fields that have been insufficiently researched.

"b. will analyze the overall organization and the structures of agricultural research in Rwanda, methods used to determine research priorities, research program formulation procedures, personnel recruitment and motivation, job security, training for research officers and technical staff, and lastly, methods for budget planning and financial control. The mission will identify problems and constraints in these areas and suggest appropriate solutions.

"c. will analyze the national agricultural policy as a basis for helping the government formulate an agricultural research policy.

"d. will analyze the present orientation of agricultural research in the light of national development policies and suggest improvements in research policy definition for the next decade with due regard for government development priorities and farmers' needs.

"e. will assist in determining the manpower and other resources needed to carry out a research program corresponding to point d. above."

1.3 Composition of the Team

The mission, which took place in June 1982, was carried out by a team composed of two ISNAR staff members and four consultants:

Dr. Rudolf B. Contant	Senior Research Officer, ISNAR, The Hague (team leader)
Prof. Dr. Kurt Egger	Member of the Steering Committee, Research Bureau for International Development, University of Heidelberg, Germany
Mr. Roberto Egli	East Africa Projects Department, World Bank, Washington, D.C.
Dr. Mustapha Lasram	Director, National Institute for Agricultural Research, Tunis
Dr. Zerubabel M. Nyiira	Senior Research Fellow, ISNAR, The Hague
Dr. Guy Rocheteau	Director of Research, ORSTOM, Paris.

The team, apart from having an international composition, combined knowledge in a large number of disciplines and specializations connected to agricultural research: research organization and management, agricultural education and training, research-development, ecology and agro-ecology, production systems, rural sociology and economics, agronomy, plant breeding and genetics, plant protection, bio-chemistry.

1.4 Work Schedule

The team leader prepared the mission by visiting Rwanda in November 1981 and February 1982. He collected the documentation and, together with the Rwandan authorities responsible for agricultural research, worked out the terms of reference and work schedule for the mission. This information was used at the ISNAR headquarters in The Hague to draw up an outline and guidelines for the study.

From June 1 to 20, 1982 the ISNAR team met with representatives from most of the organizations and institutions directly or indirectly concerned with planning, conducting, applying, and financing agricultural research

in Rwanda, viz.: Presidency of the Republic; Secretary General's Office of the Ministry of Agriculture and Livestock as well as directorates general (Agriculture, Livestock, and Lands), departments and divisions (Extension, Forestry and Water Resources, Studies and Projects) of that ministry; Ministry of Planning; National University of Rwanda and other agricultural teaching establishments; ISAR; parastatal organizations, state agencies and agricultural development projects; district authorities (Communes) and farmers' associations; technical assistance and funding organizations and multilateral cooperation agencies. The full list of organizations visited is presented in Annex 1.

All the team members participated in designing and conducting the study.

1.5 Organization of the Report

The pervasive idea of the report is that agricultural research in Rwanda must be reoriented if the results of research are to contribute to meeting the national agricultural policy objectives and are to satisfy the needs felt by the farmers. Further, to implement this new research policy will require (a) reorganizing the Rwandan Institute of Agricultural Sciences (ISAR) and (b) integrating the national agricultural research system.

With this in mind, the report was prepared in three parts entitled:

a. A new orientation for research.

b. Reorganization of ISAR.

c. Integration of the national agricultural research system.

The conclusions of the report contain specific recommendations for the accomplishment of actions advocated to strengthen the Rwandan national agricultural research system.

1.6 Acknowledgements

On behalf of all the team members, ISNAR would like to thank for their support and cooperation His Excellency Frédéric Nzamurambaho, Minister of Agriculture and Livestock; Mr. Anastase Ntezilyayo, Secretary General of the Ministry of Agriculture and Livestock; Mr. Faustin Iyamuremye, Director General of ISAR; Mr. Jean-Baptiste Ngiruwonsanga, Head of the Public Relations Service, Ministry of Agriculture and Livestock. Special gratitude must be expressed to Mr. Constant De Troyer of the World Bank's Regional Mission for Eastern Africa in Nairobi, and to Mr. Jérôme Chevallier, resident representative of the World Bank in Kigali at the time of the mission.

The team members met more than 130 people in Rwanda, some only for a brief interview, others as working partners for several days. All are to be thanked for the warmth of their welcome and the importance of their contributions.

Certain sections of this report, notably those devoted to research programs for specific crops (see Annex 5), have been corrected on the basis of comments and suggestions gratefully received from the Director General of ISAR and his staff, Messrs. J. Rushemeza, Alain Descombes, Paul Dooms, and Jean Heidebroek of the Studies and Projects Division of the Ministry of Agriculture and Livestock, and Mr. Gilbert Delepierre of the Ministry of Planning.

Chapter 2

A NEW ORIENTATION FOR RESEARCH

2.1 The Crisis in the Rwandan Agrarian System and the Need for Agricultural Research

2.1.1 The Natural Environment and Population Trends

Rwanda may be described in terms of its:

* geographical position: a landlocked country in the center of Africa, 1,800 km from the nearest port (via Uganda to Mombasa on the Indian Ocean);

* physiognomy: a country of high plateaus in the Central Africa Divide with altitudes ranging between 1,000 and 3,000 m;

* climate: moderate rainfall occurring in two rainy seasons with great variation in both intensity and duration. Temperatures are mild but vary considerably, depending on the altitude and relief.

ISAR has identified 12 agricultural regions (Map 1) which, on the bases of altitude and climate-related criteria, can be reduced into three major agro-ecological zones as follows:

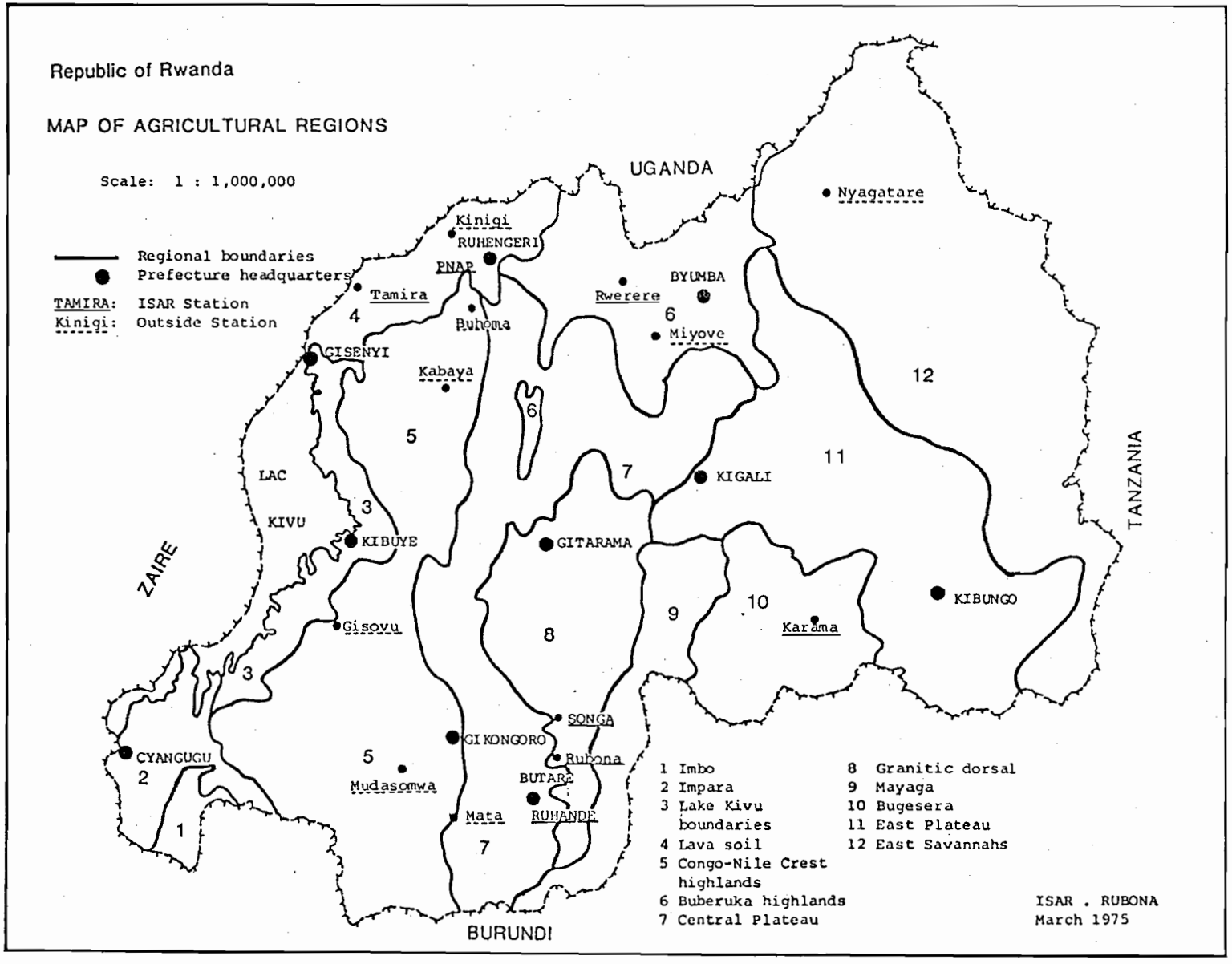
1. The savanna zone located in the east, at an altitude of between 1,000 and 1,500 m. The annual rainfall is between 700 and 1,000 mm; the dry season is long and pronounced. The average annual temperature lies around 20 to 21°C. The relief is rather gentle and the risk of erosion slight. The worst constraint is the excessive irregularity of rainfall. Soils are deep, well structured, and often fertile. The large flood swamps in the southeast, covered with papyrus, have a certain potential for rice cultivation.

2. A zone composed of the central plateau (altitudes 1,500 to 2,000 m) and the western slopes of the Zaïre-Nile watershed. Rainfall reaches some 1,000 to 1,250 mm per year. The average annual temperature is between 17 and 20°C, 22°C along the shores of Lake Kivu. This is the most densely populated area with probably the best agricultural potential in the country, although there is much evidence of erosion and decreasing soil fertility, two major constraints to agricultural production.

3. The mountainous Zaïre-Nile Crest zone at altitudes of 2,000 to 2,500 m or higher. Rainfall reaches between 1,250 and 2,000 mm per year or more, and the average annual temperature is 15 to 17°C or less. The dry season is not pronounced. This is a vast area characterized by a temperate climate and steep slopes; it can be divided into two sub-zones using the following pedological criteria:

   a. highly fertile, volcanic soils in the north;

   b. highly acidic, badly leached soils derived from granites and schists in the south, causing major problems for agricultural development in that region.



Map 1. Agricultural regions of Rwanda

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The population of Rwanda rose from 1.9 million in 1948 to 4.8 million in 1978 and probably reached about 5.5 million in 1982. With over 700 inhabitants per square kilometer in some parts of the country, Rwanda is now one of the most densely populated countries of Africa. The present growth rate is between 3.6 and 3.7% per year, which means that in less than 20 years the population figure will double. This considerable population increase is being accompanied by a fast, massive appropriation of the country's rural areas for agricultural purposes.

2.1.2 The Agro-Ecological Consequences of the Excessive Agrarian Pressure

Originally, about two-thirds of the national territory, i.e., the whole western (mountainous) part, was forestland. The first human settlements were located on the medium-altitude hill tops of the central plateau.

Gradually, in response to agrarian pressure, the valleys and slopes -- traditionally used as pastureland -- were deforested and the swamps were developed into cultivated fields. Nearly all the slopes of a gradient under 50% are now under cultivation.

The tsetse-free parts of the tree savanna in the east of Rwanda was formerly reserved for cattle rearing. Settlements started growing eastward some 30 years ago through spontaneous initiative and encouragement from the public authorities and now have reached the most fragile, unpromising parts of the country's agricultural lands.

Cultivation of lands suited for stockfarming or the most severely constraint-ridden has accelerated the onset of an agro-ecological imbalance which is most difficult to redress. Furthermore, the farmers who are moving into the arable fringes of the good agricultural lands, viz., the high-altitude zone in the west and the semi-arid zone in the east, persist in using the cropping techniques employed on their former lands, techniques which are ill adapted to the agricultural conditions found in the new lands. Inappropriate cropping techniques can be added to the list of phenomena having a spontaneously adverse effect on the environment; migrant-operated farms are experiencing increasing difficulty in developing an ecological equilibrium.

Rwandan agriculture is now caught in a process of continuous degradation: overpopulation goes hand in hand with overcropping of fertile lands, the use of the more fragile fringe areas around arable lands, shrinking of pasturelands, overgrazing, and uncontrolled deforestation. Labor productivity is decreasing. Ill-nourished crops grown on impoverished soils, moreover, become disease-susceptible.

In sum, the country is suffering from deterioration of its plant canopy, which includes decreasing biological and genetic diversity, decreasing soil fertility, and soil losses due to erosion.

2.1.3 The Tightening of Socioeconomic Constraints

The Rwandan rural society presents certain characteristics which until recently, were useful to ensure full, diversified use of rural spaces as an answer to the problem of population increase:

* Land tenure is stable. Rwandan land laws, stemming from old customary law, recognize the principle of inalienable rights to the land. Exceptions are few and are subject to many conditions.

* Traditional inheritance rules dictate distribution of family properties among the sons of each generation. Whenever the original inheritance is impracticably small or a new development needs to be considered by any of the sons, the whole family helps in clearing and preparing the new land. Although migrant children retain their entitlement to family lands, their absence in actual fact relieves the pressure on these lands.

* The production-cum-consumption unit in the rural areas is comprised of the nuclear family (i.e., father, mother, and minor children).

* Especially in certain parts of the north, the dispersal of homesteads and fields within an agricultural unit, with plants grown at various levels, has facilitated agricultural development of new lands and the diversification of agricultural activities within a given production unit.

Similarly, from the economic vantage point, changes observed in the traditional organization of production and the marketing of agricultural produce have efficiently contributed to maintaining the level, diversity, and regularity of supply lines among the peasant population:

* The regional markets have been important in furthering inter-regional trade and the exchange of produce between agricultural communities cultivating lands at different levels.

* There is local trade, with money derived from the sale of traditional food commodities (cassava, beans, and especially banana cider and sorghum beer) circulating within a geographically limited closed circuit, in which farmers sell surplus produce or produce they are temporarily unable to store and intend to repurchase later.

* Without forgetting their basic aim of self-reliance, the traditional farmers, initially, have successfully included industrial crops such as coffee into their multiple food crop production system.

Thus, drawing on its own resources, the traditional rural society has been able to develop and maintain the efficiency of its production system and thus cope with population increases. But the challenges of today are much different from those of yesteryear; it is no longer a matter of moving into new agricultural lands, but rather of intensifying traditional agriculture in areas where virtually no further arable lands are available. It becomes apparent that the institutions of the rural society, which facilitated adaptation in the past, are now playing a role that is anti-productive in present-day agricultural development:

* The law still protects the farmer against expropriation, which means that land tenure is still stable, but there is a growing trend to rent out plots, something little done in the past. An ill-defined class of "tenants" is beginning to take shape -- and their land security depends on their "landlord's" goodwill.

* The inheritance laws are still in force, which means that as a side effect to land shortages there is now a growing economic differentiation as a function of the number of children who inherit a given farm. In some cases, as a result of excessive land fragmentation, a man's plot is too small to sustain a rural family.

* As the lands are increasingly fragmented, the scattering of houses and fields badly hinders agricultural progress. In some cases 10 to 20% of the land is used for housing and infrastructure. Furthermore, in places where there used to be "complete" farm units with access to the various levels of land that have been developed in the rural space, there are now more and more "incomplete" farm units composed of a small number of plots located within a single micro-environment and, hence, without the security obtained from environmental diversity. Last, certain trends indicate that as the land crisis worsens the individualism of the Rwandan farmer will become stronger and thereby weaken the feeling of family solidarity.

Economic organization is also beginning to show signs of imbalance:

* Rural markets are receiving less of their supplies from food crops surpluses and more from sales made by farmers in distress or in debt.

* Since the best lands must be used for food crops, coffee growing is being relegated to the marginal lands that could better be used for grazing or forestry.

* To overcome seasonal food shortages, the farmers circumvent the official coffee trade circuit and barter the "home-stored" part of their harvest in exchange for badly needed foodstuffs, at poor prices.

2.1.4 Needs for Research in Agriculture

This sketchy analysis of the rural situation in Rwanda can be used to draw some preliminary conclusions on the best approach to rural development and the corresponding research requirements:

The need for regionalizing research

Research should define its themes and fashion its actions in terms of the local socioeconomic and agro-ecological conditions. This is where justification can be found for dividing the country into three or four large agro-ecological zones, as was suggested above:

* The arid regions in the east have three possible channels for development, each fraught with specific problems for research: development of swamps, irrigated cropping; mixed farming; and introduction of new production systems adapted to the environmental extremes which agriculture must cope with in the dry regions.

* In the high-altitude regions, priority in research and development must be given to erosion control and soil protection. In the southern high-altitude zone, improving the acidic soils is a precondition to all agricultural development. Any direct intervention in the rural areas should be accompanied by a dynamic policy for the protection of natural resources and for reforestation.

* The situation in the central plateau is very different. The highly effective, traditional production systems cannot cope with the accelerated population increase. The main problem is restoring and then maintaining soil fertility. Research should investigate how agriculture could benefit from chemical fertilizers or crop protection chemicals. This leads to a fundamental scientific problem hitherto virtually unexplored, i.e., how to introduce foreign inputs, that need to be bought on the market, into a complex production system, and into a type of agriculture which is close to subsistence, all the while maintaining an average level of labor productivity that is attractive to the producer. Rwandan agriculture will probably be obliged to continue using mainly resources that are locally available (inexpensive biological inputs). This means that agricultural research services should identify and promote the use of natural resources and agricultural by-products that are available but up to the present have been poorly or insufficiently used by the farmers. The principal research themes here are the introduction of legumes into crop rotations and the introduction of trees into cropping systems (fruit trees, fodder trees) and perhaps the association of crop farming and the rearing of small animals. With this in mind, agronomic research should explore the possibility of using integrated methods for pest control and plant protection.

Overcoming certain socioeconomic constraints

A prerequisite to adopting innovations is a halt to the continued fragmentation of agricultural lands. Such fragmentation is antithetical to intensification of agricultural production. A policy designed to provide non-agricultural employment in the rural areas could help rural development by decreasing, or at least stabilizing, the number of agricultural job seekers. Similarly, the development of commercial agriculture requires the organization of agricultural credit and of a marketing system (prices, transport, storage). Priority should be given to the corresponding economic research.

The need for a modernized concept of agricultural intensification

Considering the present crisis overshadowing the Rwandan agrarian system, isolated or poorly coordinated intensification measures could do more harm than good. Some scientists feel that the introduction of chemical fertilizers or pesticides alone cannot automatically bring about a marked increase in production, and could actually cause accelerated soil degradation (the plant's response to the introduction of fertilizer can be excellent during the first growing season and decline during the second and third).

Agricultural intensification does not mean increasing yields at any cost and under any circumstances. It needs to serve as a compromise between maximum production per hectare -- which needs to be an unwavering priority target in the case of Rwanda -- and several other elements, viz.,: long term stability; diversified production to satisfy a multiplicity of needs; minimizing risks; and maintaining labor productivity at a level that is acceptable to the farmer.

At this juncture, it is important to emphasize that none of the foregoing objectives can be omitted but that probably none of them will be totally achieved. The overall success will depend on the long term stabilization of the production system. The first responsibility of agricultural research in Rwanda is to work together with the extension services and development projects in order to promote more productive, but ecologically stable, agricultural systems.

2.2 Research for Development

2.2.1 Expanded Functions for Research

Agricultural research, in the broadest sense of the term, should be assigned four primary functions which up to now have been inadequately fulfilled in Rwanda:

a. Help government formulate the objectives of national agricultural policy at the time when the development plan is being prepared or revised. The development plan does not clearly describe the constricting factors and the potentials of national and regional agricultural development. The drafters of the plan clearly have not had access to all the scientific information that exists on the rural areas of Rwanda. Bare mention is made of the potential contribution from research to solving agricultural development problems.

b. Through research on agronomic and socioeconomic conditions and potentials of zones scheduled for development, help identify objectives and resource needs for regional agricultural development projects. Many current development projects have a component of applied research, but few of these projects have been planned on the basis of serious scientific study of the environment and, especially, the agrarian systems they are going to change.

c. Contribute to modernizing the contents and methods of agricultural education and training, which at present are to remote from the rural realities prevailing in Rwanda.

d. Provide farmers with better animal and plant material and improved cultural techniques (production, post-harvest, and food technology), which is the foremost function of agricultural research. Emphasis should be placed on production systems and technologies that are adapted to the local conditions and which can be readily assimilated by the farmers.

The foregoing paragraphs demonstrate that research, to fulfill its assigned role, must maintain contact not only with the farming community but also with the development plan, development projects, and industrial and educational services. Agricultural research for development cannot be carried out in isolation.

2.2.2 Diversified International Cooperation

Rwandan research should have easier access to the findings of international scientific research. Cooperation with the developed countries should be maintained, and greater attention should be focussed on innova-

tive research into complicated intermeshed systems and ecology, whose scientific and technical body of knowledge, now being developed, could in the future be extremely useful to agricultural progress in Rwanda. Of first and foremost importance is that Rwanda be in a position to benefit from knowledge and experience acquired in other countries in the intertropical zone whose agricultural conditions are similar to those found in Rwanda, or from international research institutes or centers whose programs are compatible with Rwandan priorities.

2.2.3 An Approach Based on the Study of Production Systems

The main concern should no longer be specialized research on the various crops and animals, aimed at stimulating the modernization of traditional agriculture through the development of varieties with a high genetic potential.

Lessons drawn from past failures should persuade Rwandan agricultural research to study new targets and methods.

First, in the future less work should be done on improving specific commodities by using individual disciplines alone, and more attention should be given to identifying and solving tangible development problems using the multidisciplinary approach.

Second, the responsibility of agricultural research should no longer end with making recommendations for improved techniques for a given rural environment; it should go further to project and monitor the effects of the proposed changes. Straight transfer of even the most appropriate technology should not be the end of the line; the ultimate responsibility should be the development of a given agrarian system in its totality, as concerns both people and products.

This new orientation for research is underpinned by a scientific hypothesis applied to the agricultural milieu called the "systems approach" and by an "integrated approach to development."

The systems approach is characterized by the importance assigned to interactions within a given rural community, since the effects of changing physical, natural, or social components can only be fully assessed if these are linked to the broader agricultural system of which they are an integral part.

In an integrated approach to development, the aims of new development operations are not merely increased crop yields, but also improving economic and social levels, and consolidating the agro-ecological equilibrium within the agrarian system concerned. It also means that in many cases rural development will trigger the simultaneous development of sectors both upstream and downstream, viz., industry, handicrafts, transport, and trade.

Integrated research devoted to agricultural production systems should carry out two duties concurrently: (1) make a scientific analysis of the current production system both before and during the development operation and (2) finalize technical and institutional innovations to be introduced into the production system undergoing change.

For this approach to be successful, adjustment of agricultural research methodology is required in several important respects:

* the multidisciplinary character of research;
* the experimentation processes;
* the relationships between research and extension work;
* the importance given to cultural and socioeconomic factors;
* the selection and training of research scientists and technicians.

Multidisciplinarity

The first stage of research is an analytical phase during which special agricultural disciplines -- e.g., basic disciplines such as soil sciences, agro-climatology, or agricultural chemistry designed to study the environment, or specialized disciplines for the improvement or the protection of individual crops or animals -- must compile and formulate the scientific and technical reference system to be incorporated into the production system to be changed. Mono-disciplinary scientific work obviously needs to be continued; but scientific problem-orientation should be subordinate to the general perspectives and specific priorities for social, political, and economic development, not the opposite.

Up to now, the research workers have mainly worked on developing techniques considered better than the traditional techniques. In the future, new techniques should no longer be developed without permanent contact with the recipient areas. It is not the value or importance of specialized scientific work that is being queried, but rather the implicit or explicit ultimate goal of research that needs to be given fresh thought.

The second step in research, actually a phase of synthesis, relates to the study -- and possible intensification -- of the production systems. Isolated interventions developed on an individual discipline basis must be replaced by multidisciplinary research, carried out by a unified team under a joint scientific direction.

The experimental process

Applying integrated research to production systems is so complex that the related agricultural experimentation must be conducted close to the recipient rural environment; the network of trial stations in Rwanda should be strengthened and diversified. An ideal agricultural experimentation network should include the following:

* Arrangements for local verification and testing under real-life conditions, with farmers selected for their capacity to react quickly and positively to innovations. This system could be improved in certain cases by coupling it with a network of experimental farms outside the <u>paysannat</u>, but where conditions are similar to those prevailing in real farming units in the area of intervention (from the point of view of cropping areas, hired labor, use of various factors of production).

* Experimental fields located in small, homogeneous agro-ecological regions (preferably, but not necessarily, covered by development projects) to serve as back-up units for the regional experiment stations.

* Experiment and testing stations in each of the major agro-ecological zones in the country.

* A central station that houses the joint services, the laboratories, and the heavy equipment.

This network should be completed by a permanent service to study the present production structures and to monitor changes therein, in order: to assist in identifying technologies really suited to rural needs, and to analyze the effects of development actions on the natural and human environment.

Information generated at the various levels of experimentation should move upward (as questions directed to the research services) and then downward (as new technical proposals for the farming community).

Relations between research and extension work

The role of research is to develop technologies that are adapted to local conditions and within the grasp of the local farmers. The role of the extension services is to communicate the results of research to targeted categories of farmers. Research that cannot transmit its findings to the extension services is of no practical value; extension work not sustained by research results is useless, or even detrimental.

These are basic truths that, in practice, are continuously violated. In Rwanda, as in many other places, extension workers for many decades have been passing on improvised technical messages, and research has been working in isolation on building up technical solutions that have been unusable or unused.

Cooperation between research and extension work is especially important because it is mutually beneficial. An extension service can use its knowledge of the field and a multitude of live situations to help research evaluate the validity of its technical proposals. And experiments conducted by research with local groups (progressive farmers, experimental farms) provide the extension services with excellent sites for observing the ways in which technical progress can penetrate rural communities.

Taking into account cultural and socioeconomic factors

If the systems approach is to succeed, the farmers' reactions must be recorded and analyzed. This explains why all integrated research on production systems must include a socioeconomic research component concentrating on an analysis of the conditions in which the small farmers adopt technical innovations and how they do so.

This research must seek:

* to identify the rural line of logic, the farmers' needs (an innovation that does not concur with the producers' objectives will not be adopted), and the division of decision-making within the farming unit;
* to analyze the socioeconomic constraints that dissuade farmers from adopting technical innovations, e.g., unattractive prices, income limitations, labor shortages, difficult access to the market, unavailability of factors of production;

* to analyze economic differentiation within the rural communities and study how various types of agricultural units function;
* to study economic policies and institutional reforms (cooperatives, agrarian reform, etc.) that could alleviate constraints.

Selection and training of research scientists and technicians

Programming and implementing research on production systems requires the participation of research scientists and technicians with special psychological and scientific characteristics: (a) aptitude for field work and human relations; (b) interest in the research-development orientation; (c) team spirit and interest in multidisciplinary work; and (d) training in general agriculture and/or agro-economics, preferably with specialized knowledge of certain of the more sophisticated facets of the required research.

Part of the survey and field work can be efficiently carried out by intermediate-level research workers or technicians who have access to continuing education. The team leaders or program directors must have both the aforementioned qualities and a high level of theoretical knowledge in order to understand the results of international scientific research and adapt them to the local conditions. Furthermore, at least part of the scientific and technical staff should speak the national language.

A research worker or technician properly trained to study production systems can be highly productive. On the other hand, a person who is inadequately trained or psychologically unsuited for this same research will perform poorly.

2.2.4 A Method for Planning Research

It is worthwhile reviewing the main steps in preparing the National Development Plan:

1. The government prepares an initial definition of the major development objectives.

2. This initial set of government proposals is transmitted to the ministers who are responsible for converting general national objectives into practical targets. They make corrections to compensate for constraints that were not properly assessed or information that was not adequately accommodated and, on the other hand, provide information on the manpower and funds required to achieve the plan's objectives.

3. The Commission de Synthèse du Plan, composed of all the technical ministers and chaired by the Minister of Planning, in principle reexamines the original governmental proposals.

4. The draft plan is submitted to the government for approval.

5. The technical ministries are put in charge of plan implementation.

The planning process for scientific research is not fundamentally different from the process used in other technical ministries. But planning

agricultural research of necessity devolves mainly on the Ministry of Agriculture and Livestock because of the ministry's responsibility for rural development.

Agricultural research in Rwanda, therefore, should be planned through two major stages:

1. The services most directly concerned (technical services in the Ministry of Agriculture and Livestock, officers in charge of development projects and parastatal bodies, and agricultural research institutions) must participate in the preparation of the provisional national agricultural research plan, which is based on the main objectives of the development plan originally defined by the government.

2. This draft plan is discussed prior to final approval. The agricultural research plan is implemented under the aegis of the Ministry of Agriculture and Livestock (under whose jurisdiction both the Rwandan Institute of Agricultural Science (ISAR) and agricultural experiment units in development projects operate) in conjunction with the Ministry of Higher Education and Scientific Research (responsible for the university and the National Institute for Scientific Research (INRS)). Resources and responsibilities are divided between the agricultural research institutions.

Preparation of the draft agricultural research plan

ISAR, in 1980, gave a remarkable example of what can and should be done in research planning, notably in the area of forestry. The result was the Technical Note No. 2 of 1980, entitled "Planning Forestry Research in Rwanda." Reference to this example will facilitate this discussion:

Since ISAR felt that research could only be realistically planned if due heed was given to the aspirations and needs of all the groups working in or concerned with the forestry sector, it contacted:

* research workers and leaders, viz., the ISAR Director General, the Department of Crop Production and the Forestry Division of ISAR, the Faculty of Agriculture of the National University of Rwanda (UNR);
* people responsible for implementing the national forestry policy, viz., the Department of Forestry and Water Resources of the Ministry of Agriculture;
* people in charge of development projects involving aspects of forestry: agro-forestry (Nyabisindu Project), rural reforestation (PAK), reforestation by public services (PPF);
* organizations responsible for funding forestry projects, viz., EDF;
* end-users of research results, viz., extension advisers.

The following questions were asked:

* What should be the orientation of forestry research in Rwanda in the medium- and long-term future?

* What should be included in forestry research in the 1980-84 Five Year Plan?

* Considering available resources, how should forestry research be structured?

* In forestry research, what should be the role of extension work on the one hand and of planning and development services on the other?

The results of the study were gathered, classified, and analyzed with the assistance of the research workers most directly concerned. Unanimously, accepted suggestions and the most convincing arguments were adopted for use in an attempt to define the medium- and long-term directions of forestry research.

It is worth noting that the above-mentioned document does not contain the scientific definition of the problems but rather the final objectives set for research: reforestation, natural mountain forests, wood technology, development-management-exploitation.

This method is appropriate, but is incomplete. Well-planned research should be based on choices emanating from the Development Plan, specifying the priority objectives and targets in each case. For instance:

* As concerns reforestation: What is the ultimate goal -- wood production or soil conservation, production of firewood or construction wood, reforestation through plantations, or integration of the tree in the farmer's cropping system?

* As concerns the natural mountain forests: Should they be expanded or merely maintained?

* As concerns wood technology: What types of wood utilization does the plan deem possible or desirable?

The National Plan is not explicit enough on all these points.

These simple examples indicate that research cannot set priorities of its own accord unless the plan has first indicated the government's development objectives and their order of priority. The government alone, after due consideration of all the proposals made by research, is in a position to decide on the best ranking of priorities that should condition the allocation of human and financial resources to the main national sectors of activity and the various ecological and economic regions of the country.

Approving and implementing the national research program

A specialized decision-making body is needed to implement the national research program. It must organize the distribution of the national research operations adopted in the plan to the various research institutions. In respect of agricultural research, the main responsibilities in this decision-making body must clearly lie with the Minister of Agriculture and Livestock and the Minister of Higher Education and Scientific Research.

It is perhaps good to note at this point that, before research can be satisfactorily coordinated, an inventory must be made of current and projected agricultural research along with a clear specification of available human and material resources.

2.3 Parameters to Formulate a National Agricultural Research Program

The following proposals represent an attempt to pinpoint national research priorities as a function of the objectives defined in the document which the Ministry of Agriculture and Livestock drafted in preparation of the Third Development Plan, 1982-1986.

2.3.1 Agrarian and Land Reform

Plan objective: "The primary objective is to draw on all the potential of the cultivable lands according to their soil characteristics and regional climatic conditions." This target implies land development and agricultural settlement of the semi-arid regions in the east of the country and the reclamation of swamps, coupled with a policy designed to regionalize agricultural production on the basis of the agroclimatic potential of the various ecosystems.

For research, the attainment of this objective requires studying the physical -- natural and human -- environment before launching any action, and, further, agro-socioeconomic support research in the newly settled areas. The pedological map of Rwanda needs to be completed at a scale of 1:50,000, and a bona fide map of regional agricultural land use potential should be made, using new parameters connected to factors important in agriculture (soil temperature, slope, degree of erosion, etc.) and to factors determining the possibility of area development (water supply, communications, etc.). A regionalized agricultural production policy will be doomed to failure if it is not accompanied by a program to organize the marketing of the region's special agricultural produce. There is an urgent need for preliminary economic research and studies on markets and the organization of trade and marketing.

Plan objective: Land consolidation operations should be used to remedy the "excessive fragmentation of plots and the dispersion of homesteads which seriously impede efforts deployed to improve agriculture on the one hand and, on the other, the general living conditions in the rural areas."

The plan clearly recommends conducting a scientific study of the land tenure structures. This should be considered as one of the pre-conditions, but not the only one. At present, next to nothing is known about the consequences which reallocating agricultural lands and regrouping homesteads could have on production systems. Any decision in this field must be preceded by a scientific, agronomic, and sociological study of the current links between land tenure structures and farming systems.

2.3.2 Soil Conservation and Protection

Plan objective: "In view of the current pressure on the arable lands, the future cannot be guaranteed unless special attention is given to the problem of soil conservation and protection. The aim is to protect the national patrimony and, if possible, to improve its potential by using techniques that also contribute to erosion control."

The compensatory measures advocated in the plan are difficult to achieve and may not have lasting positive effects. The soil conservation and protection theme, therefore, should become a piority for two-pronged research directed to: (a) using anti-erosion platforms and terraces for agriculture; and (b) improving certain cultural practices under peasant conditions.

In the last resort, erosion could be considered as being the result of parasitic agriculture, i.e., not restoring organic matter, decreasing soil fertility, shortening the fallow period. And this is connected to the farming of marginal lands to parry the problem of increasing population pressure.

Research should be multidisciplinary and should combine the aims of soil conservation and production intensification. It should, with this in mind:

* strive to better comprehend the agronomic side of the environment degradation process and its consequences (scope, reversibility);
* strive to better understand the effectiveness of the traditional land conservation techniques (fertility maintenance, erosion control techniques) and the ancillary sociological, demographic, and economic conditions;
* strive to understand the workings, within a given production system, of the beneficial interaction between environment development, yield improvement, increase in soil fertility, and reduction in erosion;
* seek to revise technical recommendations so as to ensure that innovations incorporated in the environment do not jeopardize traditional soil conservation methods;
* attempt to formulate new, more productive, and ecologically stable cropping systems based on the analysis above.

Any direct action on the farming communities should be accompanied by a dynamic policy to protect the natural resources. High-altitude reforestation should be among the highest priorities for both development and research.

2.3.3 Agricultural Inputs

Plan objectives: "Everything must be done to enable Rwandan farmers to obtain, within the near future: "organic and mineral fertilizers; good quality seed adapted to the different agro-climatic zones; better and more efficient tools of production (adapted technology, mechanization trials); plant protection chemicals (pesticides, insecticides)."

Priority in research should be given to:

* the use of inexpensive biological inputs (compost, manure, green manure, cover plants, legumes, etc.) and all the questions connected to the managed use of organic matter within production systems;
* the use of lime to improve acidic soils;
* the use of mixtures of mineral and organic fertilizers.

None of the basic problems connected with the use of chemical fertilizers in Rwanda can be considered as correctly or completely solved yet. Little or nothing is known about the short term effects of mineral fertilizers on the various production systems and soil types and about the long term effects on soil fertility.

2.3.4 Production Intensification

Food crops

Plan objective: "Since Rwanda has no new arable lands available, agriculture must be intensified to increase food crop yields... Crop regionalization will be one of the main methods to achieve this goal...

"To implement this policy will entail:
* preserving the existing natural resources;
* creating a national industry for producing agricultural inputs;
* strengthening institutions;
* upgrading agricultural pockets of land not yet under cultivation;
* systematic dissemination of improved seed that is well adapted to the local conditions."

The plan seems to underestimate the contribution that research could make to increasing the crop yields. A review of past research and efforts to delineate future research themes indicate the existence of undeniable possibilities, as shown below.

Bananas. Although it is among the most important and most widespread crops, there has been no research on bananas, except for some recent technological studies. ISAR has limited its work to building up a collection of local cultivars that produce edible fruit. It is necessary to expand this collection, develop the systematic selection of local cultivars, measure their productivity, and assess their potential for industrial scale processing.

Beans. Work carried out by ISAR has demonstrated that most exotic varieties were less well adapted to the environment and were more prone to diseases than the mixtures of local varieties used by the farmers. The most promising research themes seem to be the following:
* study of the factors that inhibit symbiotic nitrogen fixation of beans in Rwanda;
* research into methods of intercropping climbing beans (e.g., with maize or sorghum);
* selection of varieties adapted to conditions in the high-altitude regions and in the dry eastern regions;
* selection of varieties resistant to the main diseases (anthracnose, Ascochyta);
* identification of other grain legumes that could replace beans in the marginal zones.

Peas. Peas have traditionally been grown at high-altitudes. Production levels are dropping. The currently cultivated varieties have degenerated, and yields have dropped sharply due to acute sensitivity to diseases and pests, impoverished soils, and the absence of improved varieties. Research, which in the past has neglected the pea crop, in the future should be directed to genetic improvement and cultural methods.

Groundnuts. This plant is well adapted to the semi-arid eastern regions. The varieties available are usually productive and disease-resistant. The future development of the groundnut crop depends more on logistics (seed availability, marketing) than on the improvement of the plant

material. Certain lines of research could provide interesting results, for instance:

* mineral fertilization of depleted soils;
* introduction of drought- and disease-resistant varieties;
* study of early maturity: most foreign varieties, which mature in 90 days in their original environment, require up to 120 days to reach maturity under Rwandan conditions. Early maturity is very important in the Rwandan agricultural system, where lands are scarce and intensive crop rotation prohibits the cultivation of varieties that monopolize arable lands for extended periods of time.

Soybeans. The ISAR soybean program started in the 1970s in conjunction with the International Soybean Program (INTSOY) conducted by the University of Illinois, U.S.A. The main focus on varietal selection has led to the development of varieties that are well adapted to the various ecological regions of Rwanda. Since cropping methods are well known, the main reason for not devoting more land to soybean cultivation is the downstream problem of industrial processing and food technology.

Future research could be directed to:

* food technology (production of oil and cakes, production of soybean milk and powder, etc.);
* genetic improvement with emphasis on the ecological plasticity of the plant;
* study of pod dehiscence at harvest;
* conservation of the seeds' capacity to germinate;
* protecting seed against bird attacks (repellents);
* studying soybeans as a source of soil improvement, especially for fixing nitrogen in the soil.

Sorghum. Sorghum is a very plastic crop found throughout the country at altitudes under 2,000 m. Previous introductions in general have been less productive than local cultivars. The selection program to identify varieties adapted to high-altitudes is proving to be very promising and has already led to the selection of highly productive varieties. In the future, the program should aim at genetic improvement by crossing local varieties rather than merely selecting from among foreign lines. A new genetic improvement program for the dry, low regions has recently been started at Karama. The organoleptic quality must be included as one of the selection criteria.

Maize. Varieties for the high-altitude and the dry eastern regions -- regions of recent expansion in maize cultivation -- are not entirely satisfactory. The present improvement program should be continued, with increased emphasis on the production of synthetic populations adapted to high-altitudes and to drought. The industrial value of maize (for oil, concentrates for livestock) could motivate research on soil fertilization.

Rice. Swamp rice cultivation in Rwanda always has drainage and irrigation problems. It is difficult, furthermore, to select varieties adapted to the ecological conditions that vary so greatly between different swamps. The following themes are worth studying in depth:

* fertilization problems (fertilizers, crop rotation);
* search for new varieties, especially for the higher altitudes.

Triticale. The results registered since 1977, when the crop was first introduced, indicate that triticale is well adapted to the ecological conditions of Rwanda and seems to be rather well liked by the consumers. It could become an important high-altitude cereal. Two research themes should be given priority:

* genetic improvement (fuller kernels, better protection by the glumes);
* inclusion of triticale in the high-altitude farming systems.

Wheat. Wheat is well established in the high-altitude areas and has unquestionable potential. Yield-limiting factors are yellow rust, low sowing rates, lack of weeding, and poor soils. The IDRC-supported ISAR program, together with CIMMYT, has identified two new rust-resistant varieties. Research could focus on:

* continuation of the breeding program to identify disease-resistant varieties;
* study of different crop associations;
* study of optimal fertilization.

Sweet potato and cassava. The farmers have varieties of sweet potato that are adapted to the various regions, but nonetheless must overcome certain phytosanitary problems. Mixing local varieties seems to shield the crop somewhat from diseases, insect attacks, and the vagaries of climate. However, mixing varieties contributes to decreasing yields because the varieties differ in growing cycle and are not ready for harvesting at the same time. It is interesting to observe that there is a growing tendency to grow sorghum in association with sweet potatoes or cassava. The socioeconomic importance of these crops justifies the national program for cassava and sweet potato improvement, which ISAR is to carry out with IITA.

Research objectives suggested by ISAR/IITA for these two crops are as follows:

For sweet potato:

* produce varieties that are resistant or tolerant to viruses, fungi, weevils, drought, dampness, and cold;
* improve cultural practices;
* improve post-harvest technology.

For cassava:

* produce varieties that are resistant or tolerant to mosaic, bacterial disease, green spider mite, and drought;
* improve the nutritive value of the roots and leaves;
* improve cultural practices: planting techniques, soil preparation, spacing, intercropping, and fertilization.

These objectives are justified but need to be rounded out by research into the role of sweet potatoes and cassava in the production systems adopted by the different categories of farmers, especially those having the smallest units.

Potato: As part of the National Potato Improvement Program (PNAP: Programme National pour l'Amélioration de la Pomme de Terre) all aspects of production are being studied:

* introduction and improvement of germplasm;

* selection of disease-resistant varieties (late blight, bacterial wilt);
* plant physiology and agronomy: plant spacing, seed calibration, germination, fertilization, multiplication from true seed;
* seed production;
* storage and processing;
* training and extension work.

The remarkable popularity of potatoes in Rwanda owes a great deal to the work done by PNAP, which proves the importance of studying all angles of problems linked to the development of a given crop. It should be pointed out that potatoes are grown in only a small part of the high-altitude region. Since the demand is nationwide, this crop is being handled through what amounts to the beginning of a large-scale transportation and marketing effort which now encourages farmers to increase their production and more readily adopt innovations coming from research.

Industrial crops

According to the plan, crops are to be ranked in economic terms as follows: coffee, tea, pyrethrum, quinquina, sugar cane, sisal, ramie, tobacco, brewer's barley.

Coffee. Research themes that could have the greatest effect on production are the following:
* research into cover plants as a means of arresting soil degradation: since the best lands are being used increasingly for food crops, the new coffee plantations are often sited on the marginal lands, which have the most need for adequate soil protection;
* plant density: interplanting young coffee trees among existing trees in the older plantations could increase output in the short term;
* phytosanitary protection: chemical treatments against Antestiopsis are expensive, and yield losses are still high -- substitute insecticides need to be studied -- in the long term the best results should be forthcoming from integrated control methods.

Tea. Unlike coffee, nearly all (90%) of the Rwandan tea is grown on large estates. This is a unique situation. The main yield inhibitor is insufficient use of fertilizer, both because of cost and availability. Since tea is grown in varied ecological conditions (high and medium altitudes, valley bottoms, hills), the composition of the fertilizer has to be carefully studied to ensure that it is appropriate for the local conditions in which it is used. With this in mind, priority research themes should include:
* the study of optimal doses of fertilizer mixtures, taking into account the economic factor;
* the study of nitrogen provided by legumes that could be used as cover plants or anti-erosion hedges.

Quinquina. Because of world market trends, Rwanda's competitive position on the quinquina market depends on the installation of the future alcaloid extraction plant at Cyangugu in 1983. Crop cultivation is relatively unproblematic, but the risk that canker of the bark -- detected in certain areas -- will spread is serious enough to justify the introduction of a control program and corresponding research.

Sugar cane. Production drops recorded by the Kabuye sugar factory indicate a need for research on fertilization and for variety trials.

Other industrial crops

The production of pyrethrum, sisal, tobacco, ramie, and brewer's barley in Rwanda depend mainly on economic factors. Research on these crops should not, for the time being, receive high priority.

Research on new plants that might be processed locally and possibly exported is at present lacking.

Animal production

Plan objectives: "The policy on the production of large stock will continue to emphasize the need for a better integration of animal rearing and crop production activities, notably by the development of permanent stall feeding and the cultivation of fodder crops. Further, a wide distribution of heifers of an improved breed throughout the rural areas will be encouraged through the development of agricultural credit..." Concerning goats: "...improving the local breed by crossing it with exotic breeds in order to increase prolificacy and the average weight of the animal." It should also be possible to develop the sheep flocks through "even slight improvements in sheep-rearing conditions, in particular through zero-grazing, considering the sheep's capacity to convert fodder into meat." Work with pigs should focus on reproduction sows, "of which 2,000 (out of a total of 20,000) should (by 1986) be reared in the improved, modern sector which receives feed from agro-industrial by-products." As concerns the small animals, attention should be concentrated on poultry, "notably layer hens which are the most worthwhile and sought by the rural population." Here, again "consideration should be given to the improved, modern sector that will operate alongside the traditional sector."

Livestock production is mainly a matter of development, but there are certain streams of research that seem promising:

* Animal nutrition:
  Cattle nutrition in the future probably will continue to depend on fodder production. If feed concentrates became available for animal consumption, they would be served preferentially to pigs, poultry, and rabbits. Research obviously is needed on fodder crops as a source of food for the large animals. In any case, studies should be continued on the possibility of using farm- and agro-industrial by-products.

* Genetic improvement:
  Cattle: A breeding scheme for the local Ankole cattle was started in 1945. Until 1975 breeding emphasis was on meat production, but in 1976 it was shifted towards milk production. This program should be continued. The improvement program based on crosses between Ankole and exotic breeds started in the 1950s. Results, especially as concerns milk production, were positive. The difficulties encountered in distributing crossbred Ankole x Jersey, Ankole x Sahiwal or hybrids of all three stemmed from inadequate intake facilities in the rural areas (hygiene, nutrition, cattle dips, etc.). If an agricultural

intensification policy is to succeed, good dairy cows raised under zero-grazing conditions are needed as a source of milk and manure. The Ankole should be bred not only to develop its milk potential but also as a component of a crossing program targeted to stabilize a bona fide hybrid breed. Obviously, crossbred animals will be even more demanding than the improved purebred Ankole dairy cows, and both will have great difficulty to adapt to the off-station conditions described above. Hence, improved farm hygiene, nutrition, and health are preconditions to the successful diffusion of crossbred and improved purebred cattle alike.

Sheep and goats: Studies have evidenced a genetic potential in the local breed of sheep and goats that is sufficiently satisfactory to warrant improvement through breeding programs. Considering the economic worth of this small stock, the current program seems to be on too small a scale and should be expanded. The problem of pen-feeding for goats is worth careful study.

* Conservation of foodstuffs of animal origin.

* Integrating livestock into the production system.

Forestry and agroforestry

The plan states that "forestry resources (natural and planted forests) can only meet a small fraction (6%) of the real consumption needs and are therefore under extreme pressure."

In the first instance research should strive to narrow the gap between the production of fuel and construction wood on the one hand and the consumption needs on the other. The proposals in the ISAR Technical Note entitled "Planning Forestry Research in Rwanda," referred to in paragraph 2.2.4 above, focus sharply on this objective.

The note prioritizes the following themes:
* knowledge of tree species;
* forest tree seeds (breeding, creation of seed banks);
* sylvicultural techniques (mainly maintaining planted forests);
* market studies;
* wood technology;
* management of natural forests.

Certain complementary issues can be added:

* There can be no question of neglecting current research on the importance and role of the tree in the agricultural production system in view of a rational association of trees and crops. When introducing new species, due attention must be given to the value of the species to the cropping system (restoring fertility, impact on the water balance, creation of a micro-environment, etc.) and its productive capacity (wood, fruit, fodder, etc.). ISAR's remarkable collection of avocado trees, which includes many genotypes that are adapted to the farmers' needs, can be capitalized through intensified multiplication and distribution, which should be considered as a high priority.

* If research on fodder trees is not planned, livestock may disappear from the Rwandan agricultural scene. There are not enough tree species adapted to the various ecological zones, and there is in Rwanda an undeniable dearth of information on fodder tree species that could be introduced into the country.

* When considering reforestation, emphasis has been placed on Eucalyptus species as a source of wood, but not enough attention has been given to other criteria such as the tree's contribution to restoring soil fertility and the influence of the plant canopy on the water regime.

* High priority should be given to research into alternative sources of energy (sun, biomass, wind, biogas, methane, etc.).

The introduction of new plant species

Time and again the plan refers to programs essential to the genetic improvement of existing crops but never to the possibility of introducing new plant species. Yet, the problem of adapting cultivated plants to extreme cropping conditions, especially in the semi-arid zones, could in many cases be solved more easily by bringing in new plant species than by selecting from among the existing ones.

Improvement of agricultural implements
and post-harvest technology

This issue is vaguely alluded to in the plan and generally overlooked by most authors, yet, should be borne in mind whenever improved equipment can help farmers increase their efficiency, and hence their output, without decreasing the demand for agricultural labor.

2.3.5 Planning of Research

Since financial and human resources available for research are scarce and everything cannot be done at the same time, when priority themes for research are being established, an action plan should be drawn up showing details of both time and space parameters.

In the Rwandan case, whatever be the overall research strategy, it has to fit into a food strategy as follows:

* In the short term (less than 5 years), guarantee the food supply for the whole population.
* In the medium term (5 to 10 years), guarantee maintenance of the prime agroecological equilibrium and conservation of the natural resources.
* In the long term (more than 10 years), at least double the average agricultural output to cope with the population increase.

This explains why, as from 1983, research should be divided into three main streams of approximately equal importance:

1. For short-term results: research and extension work on staple food crops (potatoes, sweet potatoes, cassava) as well as supporting research for development projects, including a major surveying effort

at the national level -- soil map at a scale of 1:50,000 (in progress), general land use map (climatic factors), soil map indicating crop intensification potentials (mineral nutrients, erodibility, drainage/irrigation, water balance). Consideration should be given to watershed management as a prime component of rural development.

2. For medium-term results: research on soil conservation and protection (mainly erosion control and reforestation) and the development of new farming systems (mainly in the marginal zones, i.e., the southern part of the Zaïre-Nile Crest and the semi-arid zones).

3. For long-term results: intensification of food crop and livestock production through combined use of chemical inputs (fertilizers), biological inputs (nitrogen-fixing plants), and better management of the organic matter found in the soils. Peripheral to agricultural research, mention should be made of the importance of botanical research which includes completion of the Flora of Rwanda.

Actions planned must maintain a balance between food and cash crops. It is not possible to modernize agriculture and create non-agricultural jobs in the rural areas without having a certain level of commercial and processing activity for the agricultural produce.

Chapter 3

REORGANIZATION OF THE RWANDA INSTITUTE OF AGRICULTURAL SCIENCES

Up to the present, ISAR's main objectives have been to study soils and climates, a prerequisite for the formulation of development projects; to select and disseminate plant and animal material adapted to Rwandan conditions; and to develop cultural methods adapted to the rural environment and designed to allow the farmers to make best use of selected plant material.

These objectives have not been attained in that the farmers have not accepted the technical innovations that research services have channeled to them via the extension services. The "messages" from research have proved to be out of line with the requirements and constraints of national agricultural development.

This explains the need for a radical reform at ISAR, whose every activity needs to be reviewed: the scientific services and departments, the experimentation system, personnel management for both scientific and technical staff, program evaluation and monitoring, training for research scientists and technicians, research financing, foreign technical assistance, and international scientific cooperation.

3.1 The Organizational Structure and Functions of the Scientific Services and Departments

3.1.1 Present Structure

At present ISAR is organized into four research departments, each having its own divisions and sections (Figure 1).

The Laboratories Department is composed of support services for the institute's work in chemistry, crop protection, and technology. The department has a skeletal scientific staff composed of only one chemist and three plant pathologists (plus two currently being trained abroad). Four sections have no staff at all.

The Environmental Planning Department (Département Aménagement du Milieu), in principle, should work on pedology, climatology, and rural engineering, but has only a one-man staff (an agro-meteorological engineer).

The Plant Production Department is organized into divisions based on groups of crops, plus those of forestry and rural trials. The department employs 14 scientists, more than half of ISAR's contingent, but, up to now, no research scientists have been assigned to the rural trials, horticultural crops, and cash crops divisions (research on pyrethrum is being done by a higher technical staff member).

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* See Annex 2: Supplementary Information on ISAR.

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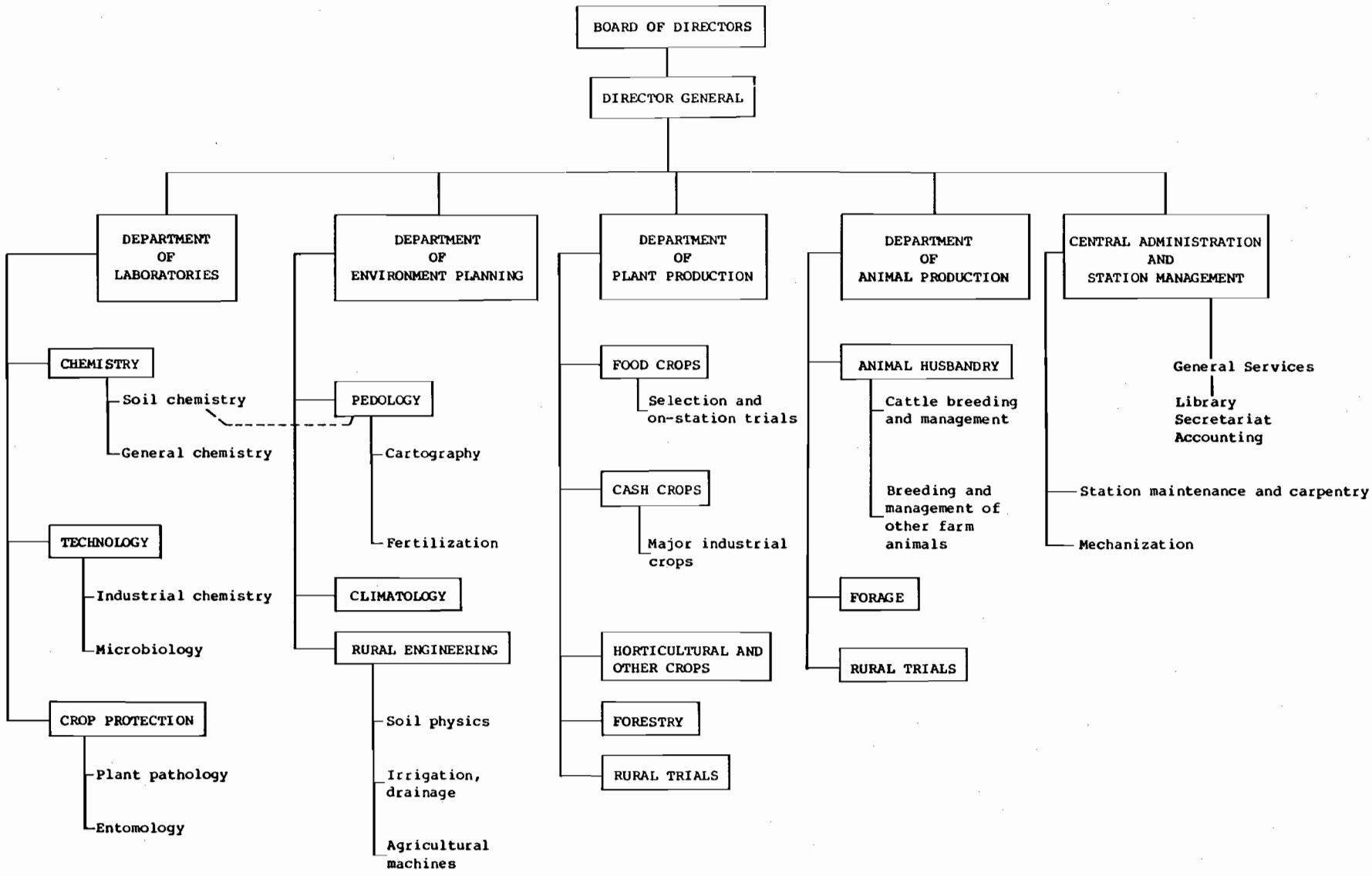


Figure 1. Organization Chart of Rwandan Institute of Agricultural Sciences (ISAR) -- till 1982.

The Animal Production Department has two scientists to handle the animal husbandry, forage crops, and rural trials divisions.

The Central Administration provides all administrative and technical services and runs the library.

This thumbnail sketch of the structure brings out three characteristics:
* there is a large number of scientific sections;
* ISAR programs apparently do not adequately study problems at the farmers' level;
* there is only a small number of research officers, some of whom lack adequate qualifications.

The scientists are very unevenly assigned to the various departments. The situation is worse concerning assignment of staff to the various stations: one scientist in Karama, one in Songa, one in Rwerere, one in Tamira, five in Ruhengeri, five in Ruhande, and seven in Rubona.

There are other shortcomings and deficiencies. For instance, disciplines are not always logically represented in the various departments: rural trials, for instance, are placed under both the Plant Production and the Animal Production departments, although there is no well-defined rural trials program. The Laboratories Department is responsible for crop protection, which is in fact more closely related to the selection and breeding programs. Forestry is given a minor role in the organizational chart; agricultural economics and rural sociology are virtually non-existent.

3.1.2 Structure Recommended

Figure 2 presents an organizational chart that can be recommended for ISAR. The executive and coordination bodies provided for in the law of June 1982 on the reorganization of ISAR are called the Board of Trustees, the Director's Office, and the Research Committee.

In the new scientific structure, ISAR would have seven departments, each headed by a department head, selected for his scientific worth and his ability to direct a research team.

The departments' activities should be organized in part on the basis of the traditional division into scientific disciplines and in part around work themes that can be changed or redesigned to concur with changes in the orientation of agricultural research. The new organization into departments and their respective areas of responsibility might be as follows:

* Department of Laboratories and Technology: pedology, agricultural chemistry, microbiology, agroclimatology, rural engineering, agricultural tools, food technology, and post-harvest technology;

* Department of Plant Production: varietal introduction, selection and breeding, adaptation of new plant species, production of foundation seed, plant protection, cultural methods;

* Department of Forestry: sylviculture, forest tree seeds, reforestation, local tree species, wood technology;

* Department of Animal Production: selection of local breeds, studying exotic breeds and crossbreeding, animal nutrition, animal health;

* Department of Socioeconomics: agricultural economics and rural sociology;

* Department of Research on Agricultural Production Systems: organized around multidisciplinary themes such as erosion control and soil conservation, organic and mineral fertilizers, crop associations and sequences, mixed farming, agroforestry, integrated pest control;

* Department of Scientific and Technical Information: library, documentation on and dissemination of scientific information and the results of research, research data analysis and processing, publications, and liaison between research and extension.

This only leaves the matter of breaking down the departments into divisions. These operate at such a practical level that the views of the scientists themselves should carry much weight in deciding on this subdivision.

The Director's Office should be expanded to include a secretary-general who would relieve the director of most strictly administrative responsibilities.

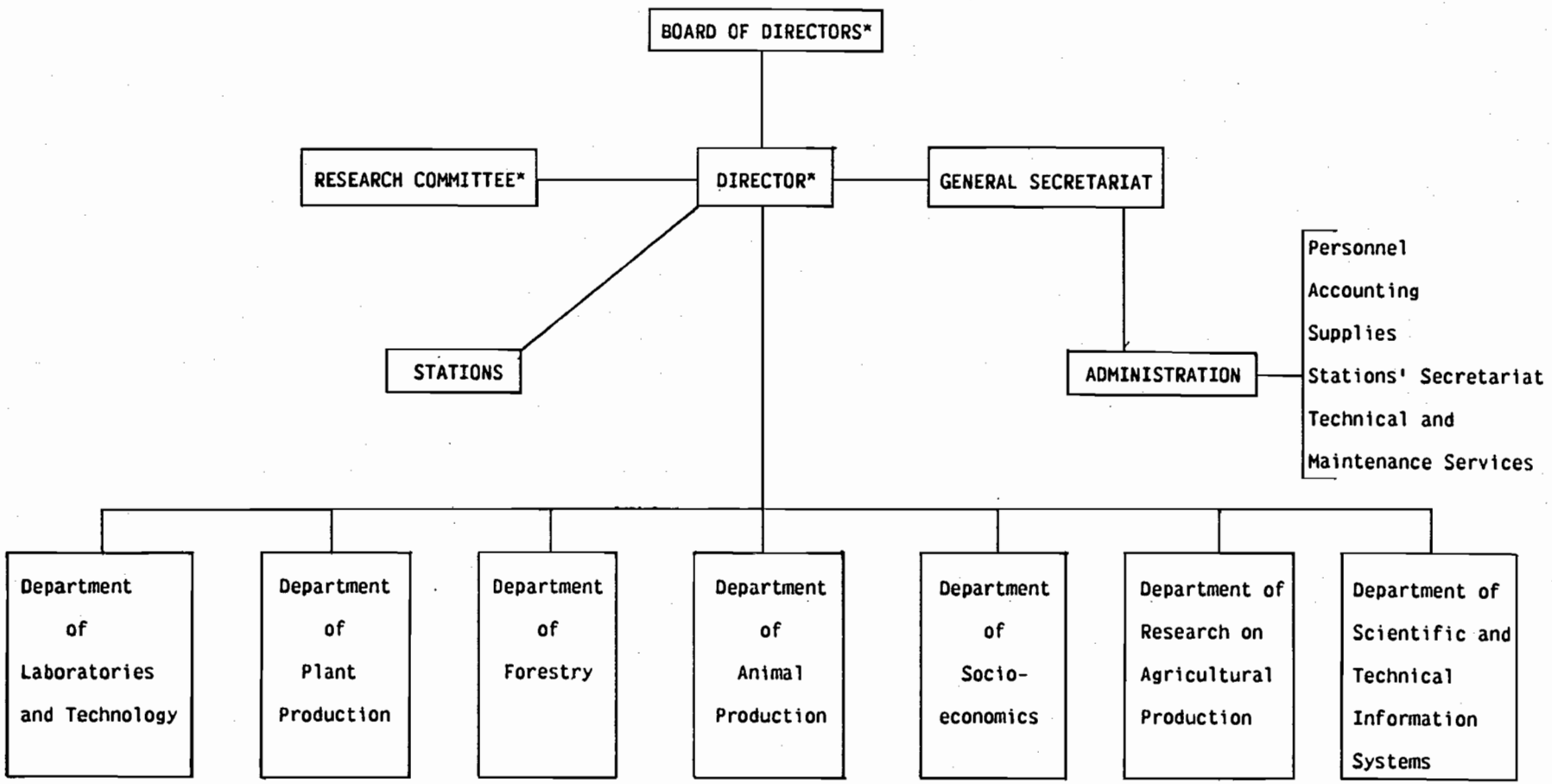
The experiment stations should be run by station heads, under the direct authority of the ISAR Director. To the extent that the station heads are personally involved in research, they should be attached, as all other scientists, to the scientific department of ISAR most directly connected to their discipline.

3.2 Experimental Facilities

ISAR now has seven experiment stations or centers:
* the agricultural research station of Rubona, which is the main station;
* the cattle breeding center of Songa;
* the Ruhande arboretum (run by ISAR on behalf of the Ministry of Agriculture and Livestock);
* the Karama experiment station;
* the Rwerere experiment center;
* the pyrethrum selection station of Tamira;
* the PNAP (National Potato Improvement Program) station at Ruhengeri and its multiplication center at Kinigi.

3.2.1. Equipment

Detailed information on these stations appears in Annex 3. The size of the stations varies considerably, and their location and infrastructure do not always correspond, according to objective criteria, with what is needed to implement the stations' programs.



* Provided for in the June, 1982 Law on the Reorganization of ISAR.

Figure 2. Proposal for a new organizational chart of ISAR.

At Rubona, all the laboratories, offices, and the central ISAR library, are accommodated in one building. It is too small to take in the new personnel scheduled to be recruited, and will accommodate the much-needed expansion of the library and the administration. The station has 15 houses for senior staff and 40 lodgings for technicians and other support staff, but no field facilities (hangars, stores, workrooms) nor any greenhouses. Construction designs have not progressed beyond the planning stage.

Except for the soil chemistry laboratory, which has some modern operational equipment, none of the laboratories in Rubona have significant laboratory or field equipment. Biometry, the soil physics laboratory, and the plant protection laboratory seem to suffer most here. The other stations have no laboratory equipment and very little agricultural equipment. There are only two tractors in running condition for the Rubona, Songa, and Karama stations all together. Much of the agricultural equipment is grounded because of lack of spare parts.

ISAR is also suffering from inadequate means of transportation; all told, there are only 12 vehicles in operating condition for all the stations.

Efforts to strengthen ISAR will have to include a substantial improvement of its infrastructure. This applies to laboratories, administration buildings, the library, and various types of equipment.

3.2.2. The Experimentation Network

The geographical map showing the location of the ISAR experiment stations in Rwanda (Map 1, page 6) indicates that the present stations provide rather good coverage of the main agro-ecological regions.

Multilocation trials are conducted regularly, although the sites are not well defined and vary from one year to the next. More experimental agricultural research is needed in the southern part of the high-altitude zone of the Zaïre-Nile Crest, in the southwest where the soils are heavy and derived from base-rich rock (Cyangugu), and in the savanna region in the east.

To close these gaps, ISAR intends to create a new unit at Cyangugu and a station at Gitarama for the National Improvement Program for Sweet Potatoes and Cassava now in the planning stage. Another small station, financed by EDF and managed by France, is to be sited near Gisovu on the Zaïre-Nile Crest. Nothing is being planned yet for the eastern and southeastern regions. Care must be taken to avoid duplication between ISAR stations and the experimental fields established as part of development projects.

Sites for variety trials must be selected with due reference to agro-pedoclimatic conditions and, whenever possible, in places where development projects or seed multiplication services (SSS and cooperatives) are already at work. Simple trials should also be sited in the farmers' fields, e.g., trials to compare a new variety with a variety traditional to the zone or a comparison of a new technique and the farmer's traditional method.

3.3 Management of Scientific and Technical Staff

A national agricultural research system should seek to provide conditions that guarantee: (a) recruitment of adequate numbers of qualified staff and (b) job security, staff stability, and research program continuity. To achieve this goal, the system must have an efficient recruitment procedure and offer sufficiently attractive financial and working conditions.

3.3.1 Recruitment

The research scientists now employed by ISAR have not chosen research as a profession; they were assigned to the Ministry of Agriculture and Livestock and then seconded to the agricultural research service by the Ministry of Public Service. More and more young scientists are graduating from the national university and often do not know what is expected of them. They receive their job description when they first assume their duties. The technicians and the assistants recruited on a permanent basis have had the same experience.

Research work requires special psychological and intellectual qualities that in some cases are different than those required for most administrative jobs. A research scientist must be recruited not only for his theoretical knowledge but also because of his openmindedness, creativity, interest in scientific work, capacity and inclination for experimental research, field research or laboratory work depending on the case, and lastly, his degree of commitment to serving national agricultural development.

The 1982 law to reorganize ISAR involves an overhaul of procedures to meet these objectives. Henceforth, the ISAR Board of Directors will be responsible for recruiting personnel, on the basis of recommendations made by the ISAR Research Committee. Ideally, applications would be invited and the selection of candidates should be made by a scientific jury, in this case composed of members of the ISAR Research Committee. This same jury could also process applications for refresher courses and continuing education to be offered to resident scientists and technicians.

3.3.2 A Special Statute for Research Scientists: Salary Scales and Career Opportunities

The scientific and technical staff does not seem satisfied with the working conditions at ISAR. The main grievances seem to be the low salaries, very limited incremental changes, and the absence of a promotion system based on the scientist's individual merits.

The salary scale is spread across a small number of tightly partitioned categories. Up to now, the Ministry of Public Service has been the only authority empowered to grant promotions to higher categories. There has been no grade scale to guarantee the promotion of efficient, worthy officers. A scientist could only be promoted by being appointed to the post of station head or department head.

Agricultural graduates (Ingénieurs agronomes), like all civil servants, sign a five-year contract to serve in the public service. During that period, the Ministry of Public Service must approve all reassignments to other institutions in Rwanda. The fact that a large number of Rwandan scientists join the administration or development organizations has caused a certain instability among the scientific staff.

These factors, taken together, have seriously affected the quality of research at ISAR. A statute for research personnel is now being prepared, in application of the law on the reorganization of ISAR. It is vital to the success of any action to strengthen the Rwandan agricultural research system.

The statute must be based mainly on the following principles: average salaries that attract scientists to the Rwandan public service, possibilities for incremental and grade advancement resulting from seniority (i.e., experience) and individual performance. It is unfortunate that the law does not entitle scientists who agree to continue their education for lengthy periods abroad to promotions or other career benefits after they have obtained the appropriate paper qualification. In any event, the best scientists and technicians should be encouraged, without, however, discouraging the less brilliant but no less dedicated employees.

The relationship between the conditions described in a statute for research staff and the effectiveness of research is very complicated. In the case of ISAR, a more thorough study will be needed before detailed recommendations can be made.

3.3.3 Scientific Supervision for Research Workers

At present, scientific supervision and backstopping of research workers in ISAR is not organized. The primary scientific responsibility devolves on the director, who is also responsible for all financial and personnel matters. The station heads and department heads seldom participate in making decisions and receive limited responsibilities. The result is that the director has little time for planning, monitoring, and coordinating research programs.

This situation could be corrected by three possible changes:

a. Free more time of the Director to be devoted to providing scientific supervision for the research staff. For this to happen, a secretary general should be hired to handle all administrative matters and accounts. Further, program management should be decentralized down to the level of the department heads and the team leaders.

b. Provide the Director with support of a scientific advisory board. The new Research Committee, composed of heads of department and station heads, could fulfill this role.

c. Attach the less experienced research scientists to a scientific adviser, possibly from outside ISAR, who would provide guidance and check their scientific work. Each adviser would, further, be responsible for submitting an annual report to the ISAR Research Committee on the quality of the research carried out by the scientists in his counsel.

3.4 Monitoring and Evaluating Programs

A clear distinction needs to be made between individual research programs and research operations:

* An individual research program is composed of all the activities a scientist is expected to carry out within a given period of time.

* A research operation brings together a certain number of scientists who either work on themes of shared interest or on specific development actions, orchestrated by a coordinator. A research operation can be carried out by one scientist alone or a group of scientists.

3.4.1 Current Situation

In the past, ISAR's attempts to introduce a monitoring and evaluation system for its activities have not come to fruition. Research can only be checked and assessed if it has been carefully planned (objectives, duration, resources, etc.). Up to now, the individual research programs have been the result of annual proposals made by individual researchers and department heads, as approved by the Director General; program descriptions have not been detailed enough, which has made it difficult to design a valid evaluation procedure for any research activities. In 1977, the Director General suggested setting up a program committee that would include development project officials, but it was not provided.

To date, ISAR has concentrated mainly on varietal selection aimed at offering improved varieties to the farming communities. No efforts have been made to evaluate the impact of the new varieties, although relevant surveys in the field could easily have been made in cooperation with the development projects and the Ministry of Agriculture's extension services. These remarks do not apply to the PNAP (potato) research-development project which is an integral part of ISAR.

PNAP constantly monitors its work in the rural areas. It evaluates and then ranks factors inhibiting yields or holding back broad dissemination of the crop, tries out the introduction of new techniques to the farmers, evaluates the adoption of innovations at the level of individual smallholdings and at the regional level, and compares the speed of assimilation between regions and groups of farmers.

One may reasonably expect that the new organizational plan for ISAR, which provides for a research committee (see 4.4.3), will improve the program monitoring and evaluation process.

3.4.2 Proposals for Internal Evaluation

In-house programming and evaluation should occur at the two levels described above, namely, for research operations and for individual research programs.

After approval by the various levels of authority, all research operations and individual programs should be described on project description cards.

The cards for the research operations should show:
* the title of the research program;
* the names of the coordinator and the participating staff;
* the duration;
* the objectives and expected results;
* the methodology;
* the work schedule;
* the present state of progress (updated at least once a year);
* resources required.

Individual program cards should indicate the names of all the research operations in which the scientist is working and a description of the nature of his contribution.

The ISAR Director General, with the help of the research committee, should be responsible for the preparation of the project description cards for the research operations, while the individual program cards should be prepared by the individual scientists, under the supervision of the department head.

Using this procedure, research planning and programming authorities can at all times see what progress has been made in ongoing research, pinpoint weak spots, and have a good perception of the possibility of setting up new operations. This procedure would also facilitate monitoring and evaluating the performance of the individual scientists.

Annual reports, with details of the progress made, could be appended to the research operation cards and the individual scientists' program cards.

These annual reports, which should include for each research operation a critical evaluation of the methods used and of target attainment, would be examined by the department heads and the program coordinators at a yearly meeting on programs and operations for the following financial year. The use of resources allocated previously should be studied with a view to working out the exact resources needed for the following year.

The research committee, of course, must consider remarks and criticisms from partners outside of ISAR who have been brought together in ISAR "work groups" (see 4.4.3). In general, closer contact between ISAR and the development projects and research conventions on "associate programs" (described in 4.4.3) would contribute to ensuring that research be evaluated by those who conduct it (a type of self-evaluation) and that lessons learned from problems of the past contribute to refashioning programs in the future.

3.4.3 External Evaluation

It is not enough to have an in-house evaluation at ISAR. Every three or four years research operations should be evaluated from without. The ISAR Board of Directors could invite Rwandan and foreign scientists and technical experts as consultants to make this evaluation, which should be extremely useful for the National Scientific and Technical Research Council and for the Ministry of Planning.

3.5 Training for Research Scientists and Technicians

Paramount importance must be given to raising the educational level of the ISAR scientists and technicians, which includes refresher training for resident personnel. ISAR needs a 10-year training and recruitment plan for its scientific staff. Investing in people is the most important investment for agricultural research.

3.5.1 Training Scientific Personnel

Most of ISAR's scientists, especially those who have not had much research experience, need additional training in a specialized area of research. They should prepare a M.Sc. or a Ph.D. in the United States or in Canada, or receive equivalent training in Europe or in Africa. The essential point is to ensure that scientists receive high quality specialized instruction through courses and a piece of research work carried out under proper scientific guidance.

Such specialized training is justified in all the basic disciplines and in all new fields of activity (farming systems, optimal use of research results, socioeconomics) recommended for a reoriented ISAR research program (see 2.2).

Any newly recruited scientist who does not yet have one of the above specialized diplomas should agree to continue his education abroad to the M.Sc. or Ph.D. level. The research committee, taking into account the priority research programs and after studying the applicants' files, should decide on the subjects of specialization and dates of absence.

Theoretical courses at the Ph.D. level are offered abroad only. Education at the M.Sc. level could be received abroad or in Rwanda through joint programs with foreign universities. Whatever be the case, the thesis should focus, whenever possible, on subjects directly related to the development of Rwanda.

Some M.Sc. candidates could enroll in a "third cycle" program of the National University of Rwanda, obtain additional credits in their major field abroad and then return to Rwanda for research work (at ISAR or UNR) under the guidance of UNR professors, ISAR scientists, or visiting professors who come to Rwanda for short tours. This system has been successfully adopted in many developing countries. UNR has a considerable capacity that should be used for specialized training in agronomy, chemistry, biology, geography, and socioeconomics.

Besides this higher education, ISAR scientists should take greater advantage of short courses organized by international agricultural research centers and some specialized schools and universities outside the country.

Some ISAR staff (station heads, administrators, etc.) should be given the opportunity to attend organization and management courses or accountancy courses, as the need may be.

All ISAR scientists should be required to speak English, a language needed for reading the international scientific literature and for making better use of training opportunities, especially short training courses. English courses are offered at the University Faculty of Economics, Social Sciences and Management at Butare and at the Faculty of Arts at Ruhengeri. Plans should be made to hold an intensive English course at Butare for scientists from Rubona, Songa, Karama, and Ruhande and a course at Ruhengeri for scientists from stations in the north of the country.

Table 1 and Diagram 1 suggest a 10-year recruitment and training plan to strengthen the ISAR staff. By the end of 1993 the national agricultural research institution would have 15 Rwandan Ph.D.-level scientists[1], 28 at the M.Sc. level, and 3 agricultural graduates having an ingénieur agronome diploma.

This plan may seem ambitious at first, since it implies an average annual increase in the number of national researchers of about 10%, but it is the only way to strengthen the research capability and establish an efficient national agricultural research system.

To make up for the shortage while nationals are being trained, expatriates averaging about 10 in number should be engaged for the next 10 years. This means that there would be approximately 30 active scientists working between now and 1986, with the total number climbing gradually to reach 46 by 1992-93.

Special attention must be given to rather special cases such as those of staff members who have been trained at a technical level only but who at present are responsible for research work. Thought should be given to encouraging the most effective ones to pursue their studies at university level on the premise that they will be promoted to a research grade upon obtaining the Ingénieur agronome diploma or equivalent.

3.5.2 Training for Technicians

The Agriculture and Veterinary Section of the Butare School Group (SAVB) and the Nyagahanga Girls School train field technicians to the A2 level (secondary school graduation level: baccalauréat), most of whom work as district extension officers or are hired by development projects. With proper supervision they could become first-rate field technicians for agricultural research. At present, training for laboratory technicians is nonexistent in Rwanda.

To become fully qualified laboratory technicians, Rwandan students must go abroad -- to Europe or elsewhere in Africa, e.g., Kenya or Nigeria. International agricultural research centers offer good refresher training through apprenticeships and short courses for technicians. All these organizations offer scholarships. Certain development projects also offer scholarships to attend courses overseas and refresher training locally. ISAR should better exploit these various possibilities.

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[1] Eleven trained under the 1983-93 plan, four already at the Ph.D. level or presently studying.

Table 1. Suggested Recruitment and Training Plan for ISAR Scientists***.

	1982	83	84	85	86	87	88	89	90	91	92	93
National scientists:												
At beginning of year	20*	26	28	30	33	36	39	41	43	45	45	45
Newly recruited	6	2	2	3	3	3	2	2	2	0	0	1
Total	26	28	30	33	36	39	41	43	45	45	45	46
Of whom:												
Leaving for M.Sc.	-	4	4	3	3	4	3	3	4	0	0	0
Returning with M.Sc.**	-	-	-	-	4	4	3	3	4	3	3	4
Leaving for Ph.D.	-	2	2	2	2	2	1	-	-	-	-	-
Returning with Ph.D.**	-	-	-	-	-	2	2	2	2	2	1	-
Attending M.Sc. studies	-	4	8	11	10	10	10	10	10	7	4	0
Attending Ph.D. studies	-	2	4	6	8	8	7	5	3	1	0	0
Total	-	6	12	17	18	18	17	15	13	8	4	0
Nationals on the job:	26	22	18	16	18	21	24	28	32	37	41	46
Foreign experts:	4	8	10	12	12	12	12	10	10	5	5	0
Total scientists actually on the job:	30	30	28	28	30	33	36	38	42	42	46	46
Short courses and training visits (1-6 months)		4	4	5	5	5	4	4	3	..	..	..

* Including three working towards their M.Sc. or Ph.D. abroad (expected to return in 1983).

** These figures do not include the return of three research students who left to attend universities abroad prior to 1982.

*** The table does not cover attrition. A 5% attrition rate, which is a fair estimate, would in this case mean a loss of about 15 scientists over a 10-year period.

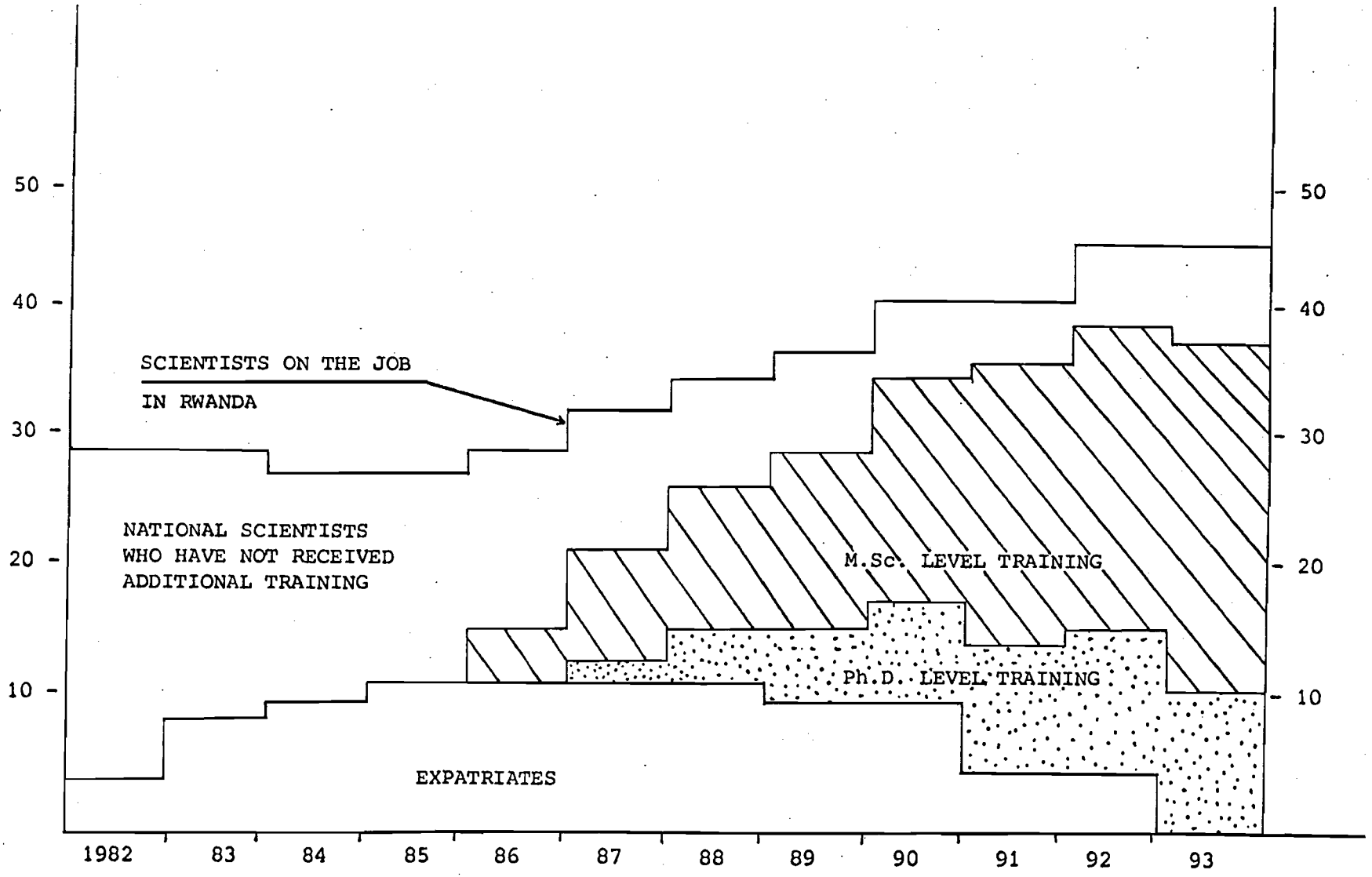

Diagram 1. Changes in Staff Numbers and Training for ISAR Scientists.

Advanced or refresher training for technicians can be obtained at three levels: (1) refresher courses abroad, (2) on-the-job training for laboratory and field technicians, and (3) advanced training for repair works (laboratory equipment, electricity, agricultural machines) abroad or in Rwanda, with possible assistance from the Faculty of Applied Sciences and other institutions.

The ISAR scientific staff, together with UNR teachers, could easily organize refresher courses for the technical staff working in their two institutions. Two types of training courses could be organized, one for laboratory technicians (chemistry, pathology, equipment handling, statistics), and another for field technicians (experimental design, establishment and management of trials, data recording, statistical methods).

Training technicians in repairing simple laboratory equipment and agricultural tools is vital for maintenance purposes, especially in view of the high cost of sending equipment to be repaired abroad or bringing in repair men from abroad.

3.6 Management of Infrastructure and Equipment

Research requires large quantities of (scarce) funds to pay for essential facilities such as offices, laboratories, experiment stations, laboratory and field equipment, transportation, and staff housing as well as social amenities.

When the infrastructure and scientific equipment are not properly managed, this almost always has repercussions on the quality and quantity of the research.

Managerial problems can occur at three levels: (1) choice of investments, (2) preparing investments and selection of equipment, and (3) use and maintenance of equipment and infrastructure.

Choice of investments

Allocating available resources involves some very fundamental choices. Should priority be given to building staff accommodation or to improving the laboratories? Should staff expenditure be given priority over outlay for equipment? Should investments be centralized, or should efforts focus on the creation of regional stations? There is no single answer to these questions. It is the responsibility of the board of directors of any research institution to make choices on the basis of the set targets and giving due consideration to prevailing limitations.

Preparing investments and selection of equipment

Choices related to the construction of buildings and the acquisition of heavy equipment lie with the national administration or the administrative services of the technical assistance agencies when foreign financing is involved. Research institute directors and scientific staff should be consulted about the characteristicts and technical specifications of the material to be purchased. There is less risk involved in choosing equipment when all parties concerned discuss the matter beforehand. When funds

have been made available, reasons must be given for the choice of equipment. Whenever possible, only those types and makes of equipment should be selected for which after-sales service is available within the country. This should also apply to equipment provided through foreign assistance. If need be, the choice could be expanded to include brands that are represented in neighboring countries. In any case the final decision on the equipment to be purchased should not be taken before the future users have been consulted, especially if the supplier cannot meet all the technical specifications called for by the scientists. Independent consultants can be invited to help identify the right equipment.

There are two important points that need to be emphasized:

1. It would be advisable for the various Rwandan institutions with similar needs for equipment to consult each other in order (a) to standardize their equipment and, hence, facilitate maintenance and (b) to coordinate purchases and thereby avoid under-utilization and duplicated orders for costly equipment.

2. Steps should be taken to ensure that the institutions of learning and research will be better informed of the variety of models commercially available.

As regards point 1, a few years ago a joint ISAR-UNR committee was set up to rationalize the purchasing procedure, but because of changes in membership the committee never became operational. The initiative should be renewed.

Concerning point 2, documentation on equipment (e.g., catalogs from different firms) should be stored and kept up to date at the university or elsewhere for the reference of teachers and scientists.

Utilization and maintenance of infrastructure and equipment

Of greatest importance is the know-how of those operating and maintaining the research equipment, on the one hand, and the quality of the supervision provided by scientists and the director of the research institution, on the other.

This revives the problem of training for technicians. It will always be difficult to overcome the problem of finding spare parts and qualified technicians locally. Certain pieces of equipment unquestionably will have to be sent abroad for repairs in the future as in the past.

The user organizations must cooperate, not only at the purchasing stage but also when it comes to maintaining the equipment. It is suggested that UNR and ISAR establish and finance a joint maintenance service that could be manned partly by the university (maintenance of laboratory equipment) and partly by ISAR (maintenance of field equipment and vehicles). A system of cost-sharing and burden-sharing could be worked out.

3.7 Financing Research

3.7.1 Finding Funds

Until 1977 the whole agricultural research system of Rwanda was paid for from foreign -- nearly all Belgian -- funds. After that date, the Rwandan Government started financing part of ISAR's costs. In 1982 when Belgium withdrew the totality of its technical and financial assistance to ISAR, the Rwandan Government, despite continued support from Switzerland and Canada (IDRC), was obliged to allocate to ISAR a budget of 90 million RwF (approximately $1,000,000) to meet its operating costs. Notwithstanding this sizable budget, ISAR found it difficult to make ends meet throughout 1982. Out of the 90 million RwF, 76 million were used to pay the salaries of the national staff, leaving only 14 million for operating expenses proper, which actually required 55 million RwF.

The Rwandan Government, moreover, was never able to provide ISAR with money to meet capital expenditure. Belgium totally stopped its capital aid in 1981. Thus, except for the Swiss aid to the Forestry Division, ISAR did not receive any funds for capital outlay in 1981 and 1982.

As a result of the above situation, new sources of funding will have to be found. To redress the situation, two additional requirements must be met:

1. On the one hand, the government should use objective criteria to calculate resources to be earmarked for research. In 1982 with an ISAR budget of close to 120 million RwF (including Swiss and Canadian aid), the funds allocated to agricultural research amounted to a mere 0.27% of the agricultural GNP (assessed at 45 billion RwF). In Sub-Saharan Africa, the average for 12 countries in 1980 was 0.64%. Using this as a norm, the percentage in Rwanda should be somewhere between 0.5 and 1%. The Rwandan Government thus should double or triple its contribution to agricultural research. Such a financial effort is justified, since returns on investments in agricultural research, in the medium or long term, are among the highest.

2. On the other hand, the various agencies providing funds for agricultural research, both national and foreign, should arrive at a better coordination, since their aims and methods are seldom the same, sometimes even incompatible. Not only the underlying philosophies, but also the financing and accounting procedures, vary with the origin of the funds. It is essential that donors' rules on the administration of project funds be standardized: an institute such as ISAR is not equipped to operate several accounting systems simultaneously.

3.7.2 Financial Management of ISAR

Current situation

ISAR is a financially independent public establishment. Its budget is administered according to the public accounting rules in force in Rwanda.

The ISAR draft budget for the following year is submitted to the Ministry of Finance in the month of August. The first step in budget preparation is to have the scientific departments and the technical-administrative services express their needs and submit program projections. The Director General's office compiles the proposals in the form of a budget document accompanied by a work program for onward transmission to the Ministry of Agriculture. The Minister is free to amend the draft budget before sending it on to the Ministry of Finance. This ministry or the Conseil du Gouvernement then determines the actual budget subvention. To complete the process, the ISAR Director General earmarks the funds to various budgetary heads and, in principle, provides each department with its own annual budget.

The system seems to fault at the disbursement stage. On the one hand, the departments are not always informed of readjustments made during the budgetary year, and, on the other, the analytical accounting procedure is applied to the budgetary categories after the end of each quarter, which means that the department heads cannot obtain a running account of the state of their budget and expenditure. Accounts for labor costs are the only accounts booked individually per department. As a result of this situation, it happens that certain departments do not, in fact, receive all of the funds allocated to them at the beginning of the year.

The management of the experiment stations also seems too highly centralized. Labor costs are paid from an imprest fund, but other recurrent expenses are decided upon by the Director General at Rubona.

The 1982 law on reorganizing ISAR

The new law to reorganize ISAR considerably improves the financial management system. A board of directors is to be created for ISAR, with responsibility for preparing a draft budget and adopting research programs submitted by a research committee. It will be also expected to prepare written regulations for ISAR.

A government commissioner appointed by the President of the Republic is to control ISAR management, and two statutory auditors, appointed by the Minister of Finance, are to check the ISAR accounts. The law also stipulates that the Director of ISAR shall submit a quarterly financial statement to the Minister of Agriculture and the Minister of Finance.

Additional recommendations

ISAR's new regulations, promulgated by the Board of Directors, should explain the budget preparation procedure and managerial practices and the degree of participation expected from the department heads and the station heads. Funds from the national budget that are allocated to ISAR are to be assigned on a per-department and per-station basis to allow department heads and station heads to have precise up-to-date information on their budgetary assets. In their budget application, the department heads should distinguish between general department expenses and expenses per research operation (which should be further broken down into budgetary heads). It must be clearly noted that when a research operation involves several departments, each participating department should include in its

budget application only the funds needed to cover its particular share of the research. The common expenditure for a research operation should be covered by the budget of that department to which the coordinator of that operation belongs.

The station heads should receive an imprest fund for all the common expenditure incurred by their station (and not only for personnel costs) in order to simplify formalities and shorten the time needed to receive funds from the Central Administration.

Financial disputes between departments should be settled by the research committee, of which all department heads and station heads are members.

To apply this new procedure will require more, and more highly qualified, staff in the ISAR accounting services.

3.8 Foreign Technical Assistance and International Scientific Cooperation

Since 1976, ISAR has been able to obtain assistance from non-Belgian sources, namely IDRC (high altitude cereals), Switzerland (forestry), several IARCs such as CIP (potato), IITA (cassava, sweet potato), ICRISAT (sorghum), CIAT (grain legumes), and CIMMYT (maize, wheat). Negotiations are under way for more external support for ISAR programs.

In addition to the recommendations set out above concerning a new concept for international scientific cooperation (see paragraph 2.2.2), it would seem advisable:

* for ISAR to strengthen its contacts with international agricultural research centers and draw more heavily on their technical assistance;
* to diversify the sources of foreign technical assistance, which ISAR has enjoyed by virtue of bilateral and multilateral scientific cooperation agreements, opening more doors in its relations with both developed and developing countries.

Further, on a less important matter, foreign experts sent to Rwanda should be assigned for a period of time that is calculated to meet the needs of the program that they are to carry out, rather than for an indefinite period, as has been the case in the past.

In certain disciplines, part of the research requirements could be efficiently met through short- or medium-duration support missions.

Chapter 4

INTEGRATION OF THE NATIONAL AGRICULTURAL RESEARCH SYSTEM

4.1 The Link between Training and Research and the Contribution of the National University of Rwanda to National Agricultural Research

At the National University of Rwanda (UNR), the Faculty of Agriculture and the Geography Department in the Faculty of Arts, as well as the Energy Resources Center of Rwanda (CEAER), the Center for Applied and Basic Research and Continuing Education (CRAFOP), and the Faculty of Economics, Social Sciences and Management have all recently developed research programs that are directly or indirectly connected to agriculture. The agricultural research capability is substantial but partly latent because of lack of resources and coordination at the national level.

The Faculty of Agriculture is conducting research on animal husbandry, fertilization, and inter-cropping and plans to study problems related to biological inputs, fisheries, forestry, and agroforestry. The Geography Department contributes extensively to building up knowledge on the human and natural environment in Rwanda. The Faculty of Economics, Social Sciences and Management gives courses and conducts research on rural sociology and economics. CEAER carries out research on sources of energy such as biogas. One of the CRAFOP projects is related to agriculture and aims at collecting and evaluating latex-producing plants in Rwanda. These UNR research and teaching units are more fully described in Annex 4.

The role and position of UNR in the national research system can be defined using the following three parameters:

1. UNR's contribution to training national research scientists.

2. The contribution of research to agricultural instruction in the university.

3. The contribution of university research to solving Rwandan agricultural production problems.

UNR's contribution to training national research scientists

Several questions could be asked:

* what type of education can best meet the needs of agricultural research in Rwanda?
* does UNR offer such education?
* what is missing from the educational program, and how could it be improved?
* what role could UNR play in providing refresher training and continued instruction for national research workers?

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Agricultural research workers in Rwanda must have a solid general education in natural sciences and in statistics, and a sound background in a large number of agricultural sciences,such as agronomy, zoology, botany, agroclimatology, pedology, rural engineering (post-harvest technology, equipment, rural habitat), agricultural economics, and rural sociology. They must also know where to position these elements in the agricultural production systems, and understand their connection with the physical, natural, and human environment. This knowledge is needed to accurately record and analyze experiments and the factors that condition agricultural production, all preliminary to preparing valid development-related proposals.

The education offered at the Faculty of Agriculture meets only part of the aforementioned requirements:

* Crop and animal production, pedology, soil fertilization, and soil chemistry are subjects that are well covered. There also seems to be a good balance between basic and applied agricultural sciences. On the other hand, agroeconomic and socioeconomic subjects are covered superficially in the "first cycle" (years 1-3) and receive only 12% of the students' time during the "second cycle" (years 4-6), although the subject matter is judiciously broken down to include agricultural planning and management, agricultural extension, inter-regional and international trade, and the place of agriculture in economic development. Very little time is spent on forestry and none on agroforestry or the study of production systems. The reform planned for university training in agriculutre would give the Faculty of Agriculture responsibility for the first two years of the "first cycle" (hitherto under the Faculty of Sciences) and would also introduce specialized options into the university curriculum, thus offering more thorough preparation in certain basic disciplines. The training of research workers should be improved, thanks to these measures, although high-level specialization will still have to be acquired abroad. On the other hand, these changes may impair the opportunities for an integrative, synthesizing training in farming systems, and this would be a handicap for future field agronomists and extension staff.

* More than 40% of the second cycle (780 hours out of 1,860) is devoted to practical exercises and field or laboratory visits. Further, the second cycle thesis consists of a survey or a study which is important as part of the students' training, especially for students going into research. But both the effectiveness and the quality of this practical instruction have been held back by lack of equipment and funds.

UNR, as an institute of learning, could provide more refresher training for research scientists. UNR resident and visiting professors, for instance, could give special training on research methods, and draw attention to certain scientific and technical documentation and other sources of information. UNR, after strengthening and diversifying its relations with the international university community -- which are already very good -- could use this relationship to identify short and longer training opportunities abroad and could serve as a liaison between national research teams and specialists abroad. Last, the most senior scientific personnel at UNR, individually or as a group, could provide scientific supervision for field work being carried out by junior Rwandan scientists and for thesis preparation by doctoral students enrolled at UNR, or even

in foreign universities. This presupposes the existence of formal inter-institutional cooperation as well as the necessary human and financial resources.

The contribution of research to agricultural instruction in the university

Research and training are complementary activities that reinforce each other within any university.

UNR's involvement in research can contribute to national efforts to develop agriculture and also to enrich and improve the quality and contents of education. Research actually improves course contents by helping teachers relate more closely with live problems and remain abreast of progress made in their discipline. For the more advanced students, research helps sharpen their capacity to observe and their ability to critically analyze situations. Participating in development-related research makes them more keenly aware of the importance of research for development than academic instruction could ever do. All students can benefit from research work, but it is especially important for those who intend to become professional research scientists.

Most university research is carried out by students preparing their final thesis. At present, professors have neither the time nor the money to do research themselves. The close connection between the teaching staff and the senior students is the product of need, but has proven to be a remarkable educational tool that should continue to be used, even if professors receive the resources needed to carry out advanced research themselves.

ISAR senior scientists could be invited more often to give courses, tutor practical work, or supervise graduation theses. As ISAR scientists gain experience, their teaching responsibilities could be increased correspondingly.

The contribution of university research to solving Rwandan agricultural production problems

University research should be considered important, not only as a means of consolidating the academic reputation of the institute and its staff, but also because of the role the university can play in furthering development by contributing to the identification and solution of national problems -- including agricultural development problems. In this respect, UNR has some advantages over other Rwandan research institutions.

For instance:

* UNR has the largest number of senior level diploma holders from a great variety of disciplines, ranging from general basic subjects to applied sciences. Its scientific strength could be put to good use in various ways, including through joint programs with ISAR or other organizations.

* Because students are mobile and physically relatively undemanding, using them in research work could give UNR a comparative advantage for certain types of field activities and studies such as agro- and

socioeconomic surveys, monographs, analysis of operating methods of agricultural plants or companies, technical guidance for farmers, and experimentation in the more remote areas.

* Last, UNR has certain equipment not found in an institution (such as ISAR) which does not have an educational responsibility especially for some of the more basic disciplines.

The university's commitment to research has certain limitations:
* because of their heavy scientific and teaching load, professors have little time for personal research;
* funds for research are very sparse, and essential equipment is sometimes not available;
* there are restrictions in choosing lines of research because the university must respect its fundamental obligation, i.e., teaching;
* the university is seen as an academic institution rather than as a source of service for national agricultural development;
* care must be taken not to duplicate work done by other research institutions.

One remedial measure would be to strengthen relations between ISAR and UNR. In particular, ISAR and the Faculty of Agriculture could work more closely together if they:
* cooperated in defining a multi-year joint program as well as an annual program, stipulating component resources;
* organized information exchanges on ongoing and future programs;
* jointly financed programs and procured adequate resources (funds would come from the Ministry of Agriculture and Livestock, ISAR, and other sources, including outside donors);
* assured joint supervision of students by ISAR scientists and teachers from the Faculty of Agriculture;
* systematically circulated student theses via the ISAR documentation service.

This type of cooperation intended to link ISAR and the Faculty of Agriculture should also be organized with other educational and research services, such as the Geography Department of the Faculty of Arts and the Faculty of Economics, Social Sciences and Management.

4.2 The Role of Development Projects and Parastatal Organizations in National Research

Several development projects and some parastatal organizations, like the national research and education institutions, have included research and experimentation in their activities whenever this was deemed necessary for project implementation or as a public service (see list in Table 2).

Rarely was -- or is -- this research carried out with participation from national research institutions or in consultation with other development projects. It cannot be said that relations between ISAR and the projects are nonexistent -- project staff visit ISAR whenever necessary, usually to

obtain scientific data or to consult with ISAR scientists on specific problems arising out of project activities. But these contacts have never been regularly scheduled, which means that project staff do not fully benefit from the scientific and technical knowledge of national research institutions and, vice versa, national research does not derive full benefit from the results of experiments carried out as part of the development projects, although most of the subjects of experimentation have bearing well beyond the confines of these projects.

Most project-related research is support research designed in terms of predetermined development targets. In general the physical, natural, and human environment are not studied thoroughly enough before launching the development operation although, such study should generate information needed for an accurate assessment of the potential for developing agriculture in the region.

At present at the national level, development project selection and preparation is handled by the Studies and Projects Division (DEP) of the Ministry of Agriculture and Livestock, which is manned by five Rwandan agronomists who formulate and monitor projects, and one economist to supervise the accounts. Although the DEP is free to call in outside consultants and its staff has great technical and scientific know-how, it is not equipped to carry out the necessary pre-project and impact studies. Backing and assistance should be sought from other national bodies such as the statistical data services and the research institutions.

Concerning the latter point, the future looks promising for the agricultural statistics and survey project carried out under the aegis of the Statistics Bureau of the Ministry of Agriculture with the assistance of USAID for the purpose of providing reliable data needed for planning and creating a permanent statistics observation unit to monitor agro-socio-economic change in the rural areas. On the other hand, there are virtually no plans for pre-project studies and research. Similarly, monitoring studies on development projects should be expanded to include impact studies that will indicate whether the objectives or the methods of these projects need to be revised.

There is no doubt that part of the research connected to in-depth feasibility and impact studies for development projects could be handled by the university, namely, by students and teachers of agriculture, geography, economics, and sociology, if adequate resources were made available.

In sum, the following recommendations seem appropriate:

1. Even if, in the name of efficiency, project research teams need to continue working independently and taking initiatives in defining and running their programs, they should not continue to work totally outside the national agricultural research system. Their home organization should be encouraged to conclude research conventions with ISAR along the lines suggested in the summary of recommendations (section 5.3 g).

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Table 2. Research in Progress or Planned in Agricultural Development Projects.

Name of project	Objective	Research target of the research	Organization or country in charge
Kibuye Agricultural Project (PAK)	Agricultural extension	Extension work methods	Swiss technical assistance
Lake Kivu Food Crop and Coffee Development Project	Production of coffee and food crops	Coffee farming, cropping systems, erosion control	IFCC/ISAR (3 scientist scheduled)
Forestry Pilot Project (PPF)	Protection of the Nyungwe forest by planting strips of trees, reforestation, exploitation	Study of tree and shrub flora, behavior of local and imported species	Swiss technical assistance
Nyabisindu Agro-Pastoral Project	Intensification of the traditional farming systems using ecological agricultural concepts	Development of farming systems; agro-forestry	German technical assistance (3 expatriate scientists)
Development Project for the Central Zone of the Zaïre-Nile Crest	Agricultural development of the central area of the Crest (high-altitude acidic soils)	Restoring soil fertility new production systems	French technical assistance
East Kigali Project	Intensification of food crops; mixed farming (cattle)	Integration of stock- and crop-farming, organic fertilizers	French technical assistance
Bugesera-Gisaka/Migongo Agropastoral Project (BGM II)	Harnessing new lands for agriculture, paysannats	Agriculture in the semiarid regions of the plateaus	IITA/ICRISAT/ISAR (2 IITA scientists)
Chinese Rice Production Project	Swamp preparation for rice production	Agro-pedology, varietal selection	Chinese technical assistance (PRC)
Mutara Development Agency (SDM)	Preparation of Kagitumba-Muvumba swamps for rice production and food crops	Agro-pedology, varietal selection	CIDA (Canada)
Agricultural Intensification Project in Gikongoro Prefecture (PIA)	Agricultural development in high-altitude zones, erosion control, reforestation	Erosion control, reforestation, extension work in hilly regions through pilot projects	UNDP/FAO
Small Stock Development Project	Pigs, rabbits, poultry: "complete service"	Feed derived from local produce	UNDP/FAO
OPROVIA Phase II	Marketing, food storage	Bean storage	USAID/OPROVIA (3-4 foreign experts and Rwandan senior staff); ISAR
OVIBAR	Industrial processing of bananas into wine, bread, biscuits, flour, alcoholic drinks	Varietal tests, maturation studies, selection of yeasts, utilization on by-products, etc.	OVIBAR (2 Rwandan researchers, 2 more to be assigned)
Agricultural Statistics and Survey Project	Statistics for planning, permanent unit for data collection	Pilot Survey, questionnaires, sampling, etc.	USAID/MINAGRI (Rwandan senior staff and foreign consultants)

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In sum, the following recommendations seem appropriate:

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2. The support research carried out in development projects should be continued, but much greater encouragement should be given to evaluation studies by agronomists and socioeconomists before, during, and after the development operation.

3. The research units in the development projects should heartily welcome university research, especially when conducted by students in agriculture completing their studies at UNR, and by scientists carrying out field research for ISAR (multi-location trials, rural farm tests, etc.).

4. The problem of structuring experiments within development projects should be studied to decide, inter alia, who should be responsible for multi-location trials (should the research services, i.e., ISAR, supervise and the projects execute the experiments?), and whether ISAR personnel should be seconded to the projects.

5. ISAR should work more closely with the Studies and Projects Division of the Ministry of Agriculture and Livestock whenever a project agreement includes a research component.

4.3 Creation of a National Service for Agricultural Information

The function of "scientific and technical information related to agriculture" is threefold:

* to provide national research teams and leaders of national agricultural development with access to scientific and technical documentation that contains information on the most recent international research;
* to disseminate the results of national research to the scientific community;
* to ensure liaison between research and extension services which together must formulate technical messages for the rural communities.

4.3.1 Access to Scientific and Technical Information

The only two libraries in Rwanda offering reading matter on agriculture and agricultural research are located at ISAR and UNR. Since both have problems, the first relevant recommendation is that an expert documentalist should be sent to evaluate Rwanda's needs for scientific and technical information.

The ISAR library at Rubona

The ISAR library at Rubona is the bigger. It has 2,500 publications and over 90 subscriptions to periodicals. This is the only place where many of the INEAC publications can be found. The library has a rather good selection of subscriptions to journals and reviews in the biological sciences, but is lacking in other disciplines such as economics, rural sociology, rural development, appropriate technologies. There are next to no journals or reports from African countries, publications from international agricultural research centers, scientific and technical bodies operating under multi-lateral and bilateral assistance, and from foreign universities. There is a flow of documentation between ISAR and certain international centers such as IITA, ICRISAT, CIMMYT, CIP, and CIAT, but more needs to be done. Exchanges with foreign universities are limited almost exclusively to universities in Belgium. From within the country, ISAR regularly receives reports from the following development projects: BGM, GBK, OVAPAM, PPF, PAK. Other projects and organizations irregularly, -- or never -- share their reports with ISAR.

Journal subscriptions were suspended between 1981 and June 1982 because of lack of funds. This problem has been temporarily solved, although no permanent source of financing has as yet been secured.

The library premises are very small and a large part of the documentation is stored in an inaccessible attic. The library is run by a secondary school-level librarian who has not been trained as a documentalist.

Despite all these shortcomings, the library serves the Rubona scientists rather well. On the other hand, services to stations outside Rubona are highly inadequate or nonexistent.

As stations grow and hire more scientists, the library will undoubtedly be solicited for more services. Increased demands can also be expected from governmental services, parastatal organizations, and development projects. Under the present circumstances, such greater demands could not be satisfied.

As a first step, the library could send all the stations a monthly information bulletin containing a photocopy of the tables of contents of the periodicals received. After seeing the titles, the researchers could ask for photocopies of the articles in which they are interested or consult the periodicals at Rubona.

As a second step, certain reference books and specialized reviews could be transferred to branch libraries in the stations, provided there is adequate assurance that the stations maintain a good, properly equipped system for indexing, reproduction, storage, and circulation of documents and for communications between the stations.

These objectives could only be achieved if the library were given better facilities. This should include:

* constructing premises suitable for an active library;
* assuring a guaranteed regular budget for the documentation service;
* training personnel and hiring a qualified bilingual (English-French) librarian;
* equipping the documentation service with a photocopying machine, a camera, a slide projector, and an overhead projector;
* ensuring uninterrupted subscription to periodicals and completing incomplete series;
* improving document indexing and the cataloguing system.

The UNR library

The UNR library at Butare has a few thousand publications and several journals in the agricultural sciences; the library at Ruhengeri has substantial documentation in the social sciences. Each department in UNR has a small collection for its teaching staff, which can also be consulted by scientists from ISAR and other institutions.

4.3.2 The Presentation and Diffusion of the Results of National Agricultural Research

Adapting the word of research to the farmers' needs is one thing, ensuring that this message reaches the end-users is quite something different. More and stronger channels of communication are needed to convey the scientific information and, even more so, the technical message.

Written information

ISAR research is presented through technical notes and scientific papers. In 1982 ISAR prepared technical notes encompassing its scientific work on each major food crop in the country for the last 20 years. Further, since

1978 ISAR has been holding regular study days devoted to carefully defined themes to stimulate contacts between scientists and development officers. Reports of these meetings have been published.

The system presently used to present and distribute the scientists' published works could be improved:

* Considering the high cost of printing and distributing documents, the mailing list for ISAR publications should be narrowed down to ensure that publications are only sent to people who use the information, but, at the same time, should be expanded to include certain university libraries, research organizations elsewhere in Africa and overseas, and also all regional extension leaders in Rwanda, including the prefectural (provincial) agronomists and veterinarians.

* The contents of these documents (especially the annual reports) would be more useful and palatable for the development and extension officials if they were more analytical and less descriptive and contained more practical recommendations. ISAR recently set up an editorial committee, which should improve the quality of the publications. Another possibility would be to produce only a few copies of the annual reports and technical notes in their present form for the record, and to publish instead an annual, condensed, technical, synthesizing document highlighting practical results that could be of direct use to the development and extension officers.

* The Bulletin Agricole du Rwanda should receive more support from the national scientists.

* Extension pamphlets should be better adapted to user needs than the ISAR "fiches techniques" have been in the past. They should be written by the scientists and the extension workers together, with outside assistance from communications specialists.

Oral and audio-visual communications

ISAR has to develop this activity from scratch. It might be done as follows:

* Farmers' visits to ISAR stations. A "visitors' day" might be organized once a year in each ISAR station. Through direct contacts between scientists and farmers, the former can transmit their knowledge to the latter and at the same time through feedback obtain a better understanding of the rural environment.

* Radio broadcasts. The Ministry of Agriculture and Livestock broadcasts a half-hour program on agriculture twice a week in the national language, Kinyarwanda. It would be very desirable for ISAR and certain development projects to participate.

* Illustrative billboards and audio-visual projections, as are already being used in certain projects (PAK) to train extension workers.

extension personnel (agronomes de commune) in June 1982. This was an excellent initiative that should be pursued and attract support. The crucial issue to be resolved relates to the course content, which should be such as to provide extension workers with information that can be passed on to the farmers. It would be useful for senior staff of development projects to participate as teachers in these courses.

4.3.3 Creation of a National Agricultural Information Service located at ISAR

In the context of the reorganization described earlier, ISAR's role of providing agriculture-related scientific and technical information should be expanded and turned into a special national agricultural information service, located in the new Department of Scientific and Technical Information. This service should serve two new major functions:

* National archives for agriculture: The service should become the legal depository for all publications in the field of agriculture in Rwanda. This means gathering all publications relating to agriculture and rural development in Rwanda, in particular by asking MINAGRI, the university, agricultural development organizations, and projects to send a copy of their reports and other publications to the central library at Rubona.

* Exploiting research results, which means:
  * disseminating the results of research to the national and even international scientific community;
  * improving contacts and consultations between research teams of different origin;
  * improving relations between research and extension.

4.4 Institutionalizing the National Process for Scientific Planning and Coordination

Agricultural development is a long-term process requiring uninterrupted nationwide research. Since human, material, and financial resources are limited, it is vital to avoid any duplication. Going further, development is a matter of such urgency that weak points in the attendant research must be quickly and clearly identified. Agricultural research carried out in Rwanda, therefore, must not be a mere amalgamation of uncoordinated initiatives, and, similarly, research coordination must be entrusted permanently to national institutions. The final target should be to integrate and unify the national agricultural research system.

4.4.1 Present Situation

Relations between institutions in the field of agricultural research and the research-development interface in Rwanda are very limited.

Up to now ISAR has not been involved in most of the activities related to national agricultural development. It has not participated in taking decisions on agricultural policy nor in defining production targets or agricultural plans. With a few exceptions -- Forestry Pilot Project; Lake Kivu Coffee and Food Crop Development Project; and PNAP, which is an integral part of ISAR -- ISAR does not participate in research activities orchestrated by development projects or parastatal organizations and, further, does not take part in extension work.

Furthermore, the cooperation between ISAR and the university is too irregular. ISAR and the Faculty of Agriculture once joined forces in a multipartite study on intercropping, but for the rest cooperation has been limited to ISAR taking in agriculture students preparing their graduate thesis.

Lastly, survey and advisory services of the various Government ministries rarely invite ISAR scientists to participate in studies or even to give their opinion or provide information.

No one party is responsible for this state of affairs. One wonders whether the various parties have really strived to come together to identify and develop conditions conducive to better cooperation. Technical assistance and funding agencies have sometimes aggravated the situation by increasing rather than reducing the barriers between the different research activities.

Whatever be the case, up to now there has never been a plan to coordinate agricultural research on a nationwide basis, nor has a service been created to define a national research policy.

4.4.2 The Legal Reform of the National Research System

It is the task of the Ministry of Higher Education and Scientific Research, created in 1981 to redress the aforementioned shortcomings. At present it is preparing regulations to ensure research coordination at the national level. These regulations provide for the establishment of a National Council for Scientific and Technical Research (CNRST), which will serve as an adviser to the Government and will be responsible for defining general policy and priority orientations for Rwandan research.

The CNRST is to receive assistance from specialized commissions, such as the Consultative Commission for Agricultural Sciences (CCSA). The composition of the CNRST and the specialized commissions has not yet been decided.

Along the same lines, the new law on restructuring ISAR provides for the introduction of a Research Committee to propose programs and to coordinate research at ISAR.

These new institutions (CNRST, CCSA, and the ISAR Research Committee) together with the Commission de Synthèse pour la Préparation du Plan, should be able to coordinate and plan the nation's agricultural research in the future.

Nonetheless, certain questions are still outstanding and certain comments and recommendations still need to be made concerning the conditions in which these new institutions will be run.

4.4.3 The Functioning of the New Institutional Framework: Comments and Recommendations

The reorganization recommended for agricultural research in Rwanda is outlined in Figure 3.

Five action levels are envisaged:
* definition of general policy;
* identification and description of research needs;
* coordinated planning and programming of research amongst the major research institutions;
* research implementation;
* application of research results and dissemination of innovations throughout the rural areas.

The following three bodies would be responsible for ensuring two-way communications between the above-mentioned levels:
* National Council for Scientific and Technical Research (CNRST);
* Consultative Commission for Agricultural Sciences (CCSA), an offspring of the CNRST;
* Research Committee of ISAR, supported by work groups.

The CNRST should bring together senior officials from the ministries of Higher Education and Scientific Research, Agriculture and Livestock, Planning and Finance, as well as the directors of research institutions and the deans of the Faculty of Science, the Faculty of Agriculture, and the Faculty of Economics, Social Sciences and Management. The chairman of the CNRST could come from the Ministry of Higher Education and Scientific Research, but it is suggested that the Ministry of Planning should assure the permanent secretariat to ensure that broad guidelines for top-priority research be communicated directly by that ministry. This would guarantee a close linkage between the objectives of the development plan, priority research programs, and program financing. If necessary, the CNRST could invite outside consultants to help define the orientations of research.

The Consultative Commission for Agricultural Sciences (CCSA) should be composed of senior representatives of agricultural research institutions, institutions for higher education in the fields of agriculture and socio-economics, technical services of the Ministry of Agriculture and Livestock, development projects, and agriculture-related parastatals. The chairmanship must be given to the Ministry of Agriculture and Livestock, which is responsible for ISAR and speaks on behalf of the Government in all matters related to agricultural research conducted in development projects. It is in the CCSA that the needs for agricultural research and the major program orientations are identified. The Commission could also play an important role in coordinating the use of research facilities and equipment. The CNRST and its specialized commissions could also serve to coordinate agricultural research at the national level and provide the formal liaison between UNR and ISAR on all matters related to training and research.

Research programs are defined, developed, and carried out by the various research organizations within the general guidelines set out by CNRST and in the plan.

The Research Committee provided for in the new law to restructure ISAR is an advisory body to the ISAR Board of Directors and, according to the law, has the following duties:

* submit program plans to the Board of Directors;
* coordinate research in the institute;
* recommend the creation of new centers and stations;
* authorize the publication and dissemination of research findings;
* recommend candidates for scientific posts;
* give opinions on all major issues related to research and extension.

Two remarks could be made:

First, a clear distinction must be made between three types of programs at ISAR:

1. ISAR programs proper -- designed and implemented wholly by ISAR scientists;
2. "joint programs" in which ISAR scientists work directly with agricultural extension services or with scientists from other national research institutions (UNR, INRS);
3. "associate programs" implemented by virtue of research agreements concluded between ISAR and development projects that include a research component.

Second, the Research Committee should set up work groups which are the formal meeting points between ISAR scientists and non-ISAR research workers and development officers who work with the former on joint or associate programs. The work groups could be set up on a per-theme or per-region basis, or could devote themselves to a specific crop or a production system. They should serve as the forum for a broad exchange of ideas, not only between ISAR scientists and the teams working on the joint or associate programs, but between all parties concerned with the development of agriculture and the dissemination of technical innovations to the farming community. Care should be taken not to exclude the end-users of research, i.e., development officers, extension workers, farmers.

If these work groups are run efficiently, it will not be necessary to change the membership of the ISAR Research Committee which, according to the law now in force, is limited to institute employees.

UNR and INRS should remain completely independent of ISAR as concerns their scientific programming, but the importance of increasing the number of ISAR/UNR/INRS joint programs on research/training/development cannot be overemphasized.

Building up a national system for research planning and programming in Rwanda implies reorientating agricultural research (Chapter 2) which in turn necessitates the reorganization of ISAR (Chapter 3).

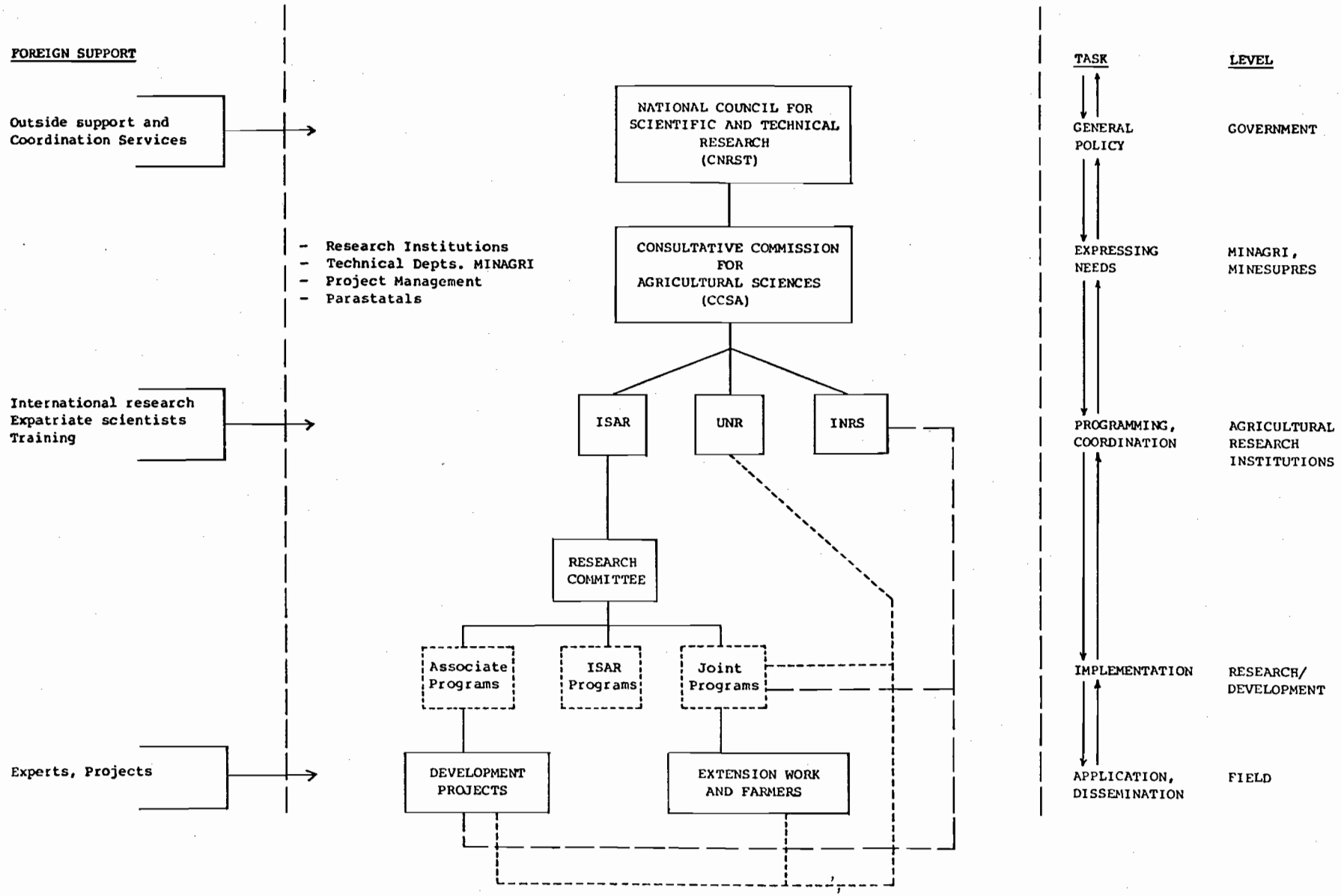

Figure 3. Coordination of Agricultural Research in Rwanda.

Chapter 5

CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

The following recommendations form a long-term plan to strengthen the national agricultural research system of Rwanda.

5.1 Present Situation

a. Agricultural research organizations in Rwanda are experiencing serious difficulties in their daily operations:

   * The Rwandan Institute of Agricultural Sciences (ISAR) has been losing research staff and has no guaranteed budget.

   * The National University of Rwanda (UNR) has relatively large teams of teachers-researchers and senior students available for agricultural research but seriously lacks resources.

   * Research carried out within the purview of development projects is growing, but there has been no solution found to the problem of incorporating this research into the national research system.

   The national research effort is split up among teams and institutions whose activities are not coordinated. In most cases, be it at the national or at the individual institution level, research priorities are mainly set as a result of unconnected individual initiatives.

b. The link between research and development is nonproductive. The technical innovations recommended by the extension services are not adopted in the traditional production systems. The fault lies less with the extension system than in the fact that the message emitted by research does not answer the needs of or fit in with the socioeconomic situation facing the farmers.

c. Since academic courses on agriculture in Rwanda cannot draw on the results of national scientific research within the country, they continue to rely on information from sources focusing on classical types of tropical agriculture, which are based on technical methods to stimulate the intensification of agriculture in developing countries where land is available, where industrialization is developing rapidly, and where the agricultural context (a declining agricultural labor force and a potentially capitalistic system of production) is totally different from the Rwandan situation.

The problems brought to the fore have financial, economic, and institutional implications that cannot be solved by ISAR alone. Considering the vital role that research should play in agricultural development in Rwanda, the team recommends strengthening the whole national system of agricultural research in Rwanda.

5.2 Recommended Action

Action to be recommended should stimulate the integration, work towards the unification and ensure the continuity of the national agricultural research effort, in the framework of a long term project designed to restructure the system.

a. Reorientation of agricultural research

The team recommends that national agricultural research, without foresaking classical approaches to agriculture and related disciplines, should give preference to the study of agricultural production systems and an integrated approach to rural development. In the past, the importance of the socioeconomic sciences to development has been underestimated; in the future it should be considered of foremost importance. This production-systems approach should seek to work out agricultural techniques that are well adapted to rural conditions and can be readily assimilated by the farmers.

b. Reorganization of national agricultural research

The team recommends as follows:

1. Using every possibility to improve the coordination, in time and in space, between the agricultural programs conducted by the different research institutions in Rwanda (ISAR, UNR, INRS). The Consultative Commission for Agricultural Sciences (CCSA), chaired by the Minister of Agriculture and Livestock, should be responsible for this coordination. Certain programs could be organized into joint programs supervised by one of the participating research institutes.

2. Reorganizing ISAR so that it can live up to the requirements for the aforementioned reorientation recommended for agricultural research and to meet its increased responsibilities in national research planning and coordination.

3. Converting the research activities in the development projects into associate programs with ISAR as the other partner. These programs should be covered by research agreements concluded between the organizations responsible for the scientific work in these projects and ISAR. The convention format is described in paragraph 5.3 g.

c. Establishing a national system for science planning and programming

The team considers it unnecessary to complicate the institutional organization by adding new specialized decision-making bodies and suggests that the responsibility for national science planning and programming in agriculture be shared by:

* the Ministry of Planning;
* the Consultative Commission for Agricultural Sciences (CCSA), an outgrowth of the National Council for Scientific and Technical Research (CNRST);
* the Research Committee of ISAR.

d. Implementation of a 10-year recruitment and training scheme at ISAR

ISAR needs a 10-year recruitment and training scheme for scientific and technical personnel to meet the following goals:

* qualify Rwandan nationals for filling the scientific and research management posts;
* identify and prepare personnel with skills and aptitudes to match the new needs of development-oriented research in Rwanda;
* provide higher or complementary training for scientists and technicians already at post.

e. Optimizing research

To optimize research will require:

* statistical and computerized processing of scientific data and information generated by experiments;
* archiving research findings and disseminating them to the national, and even international, scientific community;
* more opportunities for research teams of different origins to share their experiences and views and to consult each other;
* ensuring closer liaison between research and extension.

The team recommends creating a department of scientific and technical information at ISAR to handle these four functions.

f. Strengthening relations between research and extension

Research-extension relations were not directly broached during the mission but clearly require further study.

5.3 Specific Measures

Achieving the objectives described above will require some special measures, described below.

a. Reorganization of the scientific services of ISAR

The team suggests the following:

The Department of Plant Production -- comprising divisions for food crops, cash crops, horticultural crops, forestry, and rural trials -- should be reorganized into three departments:

* a Department of Plant Production for activities concerned with plant introduction, production of foundation seed, varietal research, plant breeding, adaptation of new plant species, crop protection;
* a Department of Forestry for activities in the areas of sylviculture, forest tree seeds, local tree species, reforestation, wood technology;
* a Department of Socioeconomics for agricultural economics and rural sociology.

The Department of Animal Production should expand its present work on cattle, goats, and sheep to include other small animals (pigs, poultry, rabbits), beekeeping, and fish-farming.

The Environment Planning Department (Département Aménagement du Milieu) and the Laboratories Department should be merged into a Laboratories and Technology Department for pedology, agricultural chemistry, microbiology, agroclimatology, rural engineering and agricultural implements, food technology, and post-harvest technology.

A new Department for Research on Agricultural Production Systems should be created to embrace multidisciplinary research on certain target themes, such as erosion control, soil conservation, organic and mineral fertilizers, crop sequences and associations, mixed farming, agroforestry, and integrated pest control.

b. Reevaluation of the terms of service and working conditions for ISAR staff

The team feels that publication of new terms of service and staff regulations for the ISAR staff is cardinal to the success of current efforts to strengthen the research system.

c. Recruitment and training of research scientists and technicians

* ISAR's scientific staff should be increased from the present 30 scientists (including 26 nationals) to 46 Rwandan scientists by 1993. Taking into account likely staff losses over time, on the average three new research scientists should be recruited every year for 10 years.

* To satisfy the need for further training for resident scientists and the extra qualifications that will be required of new personnel without interrupting the research program, and to enable Rwanda to make immediate use of the results of international agricultural research, ISAR will temporarily need a certain number of foreign scientists: 10-12 between 1984 and 1990, a figure that may drop to 5 in 1991 and 1992.

* ISAR scientists should be given the opportunity as soon as possible to acquire further training, e.g., doctorat or Ph.D., maîtrise or M.Sc. This should be done either abroad or in Rwanda, or through a combined system set out in agreements between UNR and foreign institutes or universities.

* ISAR technicians, especially those working in the laboratory, should be given further training in specialized schools.

* The extent of the maintenance and repair problems for scientific and laboratory equipment at both ISAR and UNR justifies hiring a specialized, highly skilled technician.

* ISAR administrative staff should be further trained in managerial skills.

* ISAR needs a qualified documentalist.

d. Strengthening and diversifying international scientific cooperation and technical assistance

The team recommends as follows:

* Sources of foreign technical assistance which ISAR has received by virtue of bilaterial scientific assistance agreements should be diversified.

* Existing contacts with the international agricultural research centers (IARCs) should be strengthened and greater use made of the technical assistance they are able to offer.

* Foreign technical assistants should be assigned to ISAR only for the period of time required to complete the program under their responsibility; part of the research required in certain subjects might be assigned to short- or medium-duration support missions.

* ISAR scientists and technicians should be given opportunities to attend refresher courses or supplementary training programs--in IARCs or other places of higher learning.

e. A national role for ISAR in collecting and disseminating agricultural research results

The team recommends creating at ISAR a Department of Scientific and Technical Information which (in addition to being responsible for the library, ISAR publications and processing of research data) would handle two major nationwide functions: (1) national archives in the field of agriculture; (2) dissemination of research results.

f. Reinforcing the agricultural research capability of the National University of Rwanda (UNR)

Teachers-researchers from the Faculty of Agriculture and senior students under their supervision should have access to better laboratory, documentation, and computer facilities, possibly at ISAR. Students in agriculture, geography, and rural sociology at UNR should receive subsidies to pay for the preparation and distribution of their graduate theses.

g. Establishing research agreements between ISAR and the research units of development projects

Research in the field of agriculture or agroeconomics conducted under development projects should be covered by research agreements signed by the organization in charge of the project's scientific program and ISAR. The agreement between the two partners should cover:

1. The title of the research program.
2. The organization or laboratory responsible for the scientific facets of the program.
3. The organization or service responsible for program finances and accounts.
4. The organizations and laboratories participating in the program.

5. The scientific and technical staff involved in the program.
6. Research objectives and expected results.
7. Procedures for monitoring and evaluating the program and for drawing up annual work plans.
8. A detailed work schedule.
9. A schedule of expenditure.
10. The publication, dissemination, and utilization of results.
11. Research training for Rwandan scientific and technical staff.

h. Setting up a national system for science planning and programming

Responsibilities could be assigned as follows:

The Ministry of Planning should lay down priority orientations for research, in keeping with the objectives of the development plan.

The Consultative Commission for Agricultural Sciences (CCSA) should coordinate agricultural research at the national level and serve as liaison between UNR and ISAR for matters relating to training-cum-research.

The ISAR Board of Directors, represented by the ISAR Director, should be authorized to prepare and conclude research agreements for "associate programs carried out in development projects.

The ISAR Research Committee -- which, according to the law on restructuring ISAR, has two main duties ("submit draft programs to the ISAR Board of Directors" and "coordinate research work within the Institute") -- should also be formally charged with helping the Director of ISAR in the preparation of research agreements between ISAR and the associate programs located in development projects.

5.4 Essential Investments

a. Urgent investments for ISAR infrastructure and equipment

Rubona:

* Construction of an administration building to improve ISAR's administrative capability and make it possible to turn over to research the rooms now being used for administration.

* Building and equipping premises for the new Department of Scientific and Technical Information and purchase of reproduction and printing equipment and materials.

* Construction or remodeling of a warehouse to store selected seed.

* Improvement of the laboratory equipment, which must satisfy not only the needs of ISAR, but also certain demands from related departments of the University and, in some cases, research in development projects.

Regional stations:

* Establishment of new experimental units on the Zaïre-Nile Crest, at Gitarama, at Cyangugu, and in the southeast.

* Renovation of existing stations.

b. Measures concerning the scientific staff of ISAR

* Recruitment of 25 new Rwandan scientists in the coming 10 years.

* Recruitment of a chief accountant and a qualified documentalist.

* Opportunities for additional training for research scientists (M.Sc. or Ph.D.): 128 man-years in the next 10 years.

* Provision of refresher training through short courses for both scientists and technicians (1 to 6 months every 5 to 7 years).

* Intake of foreign scientists: 96 man-years over a 10-year period.

* Provision of further training in managerial skills for senior administrators (1 month every 5 to 7 years).

c. Measures concerning the UNR

* Financing 30 theses per annum (15 in agriculture, 5 in rural sociology, 5 in agricultural economics, and 5 in geography) by providing funds for:
  * lodgings for trainees in the field;
  * execution of surveys (interviewers, transportation);
  * statistical processing of data;
  * laboratory analyses;
  * publication and distribution of final reports;
  * scientific supervision of students.

* Building and equipping support bases to help improve the quality of the above research and the utilization of research results: offices, premises for storing samples, herbaria, and equipment to record and reproduce survey data.

Annex 1

LIST OF GOVERNMENT SERVICES AND ORGANIZATIONS CONTACTED DURING THE MISSION

Presidency of the Republic
Ministry of Agriculture and Livestock
Ministry of Higher Education and Scientific Research
Ministry of Planning
National Census Bureau

Rwandan Institute of Agricultural Sciences (ISAR)
National Program for Potato Improvement (PNAP)

National University of Rwanda (UNR)
Agriculture and Veterinary Section of the Butare School Group (SAVB)
African and Mauritian Institute of Statistics and Applied Economics (IAMSEA)

Rwandan Industrial Crops Authority, Coffee Authority (OCIR-Café)
National Authority for the Development and Marketing of Food Crops and Animal Products (OPROVIA)
Rwandan Pyrethrum Authority (OPYRWA)
Office for the Industrial Processing of Bananas in Rwanda (OVIBAR)
National Office for Agricultural and Livestock Extension in the Mutara Region (OVAPAM)
Rwandan Rice Production Organization (Rwamagana, Nyabugogo)
Rwandan Sugar Scheme
Small Farm Animals Project and the National Center for the Production of Small Farm Animals
Legume Cooperative of Rwanda
Seed Multiplication Service (SSS)

Agricultural Statistics and Surveys Project MINAGRI/USAID
Bugesera-Gisaka/Migongo Agro-pastoral Project (BGM)
Project for the Development of Coffee and Food Crops in the Lake Kivu Area
FAO Fertilizer Project
Gishwati-Butare-Kigali Agroforestry Project (GBK)
Mutara Swamp Development Project (SDM)
Nyabisindu Agro-pastoral Project
Kibuye Agricultural Project (PAK)
Fishery Development Project at Lake Kivu
Agricultural Intensification Project, Gikongoro (PIA)
Forestry Pilot Project (PPF)

INADES Rwanda
International Association for Rural Development (AIDR)
Action for Integrated Rural Development (ADRI)

Kanombe Commune (Kigali)
Mabanza Commune (Kibuye)

World Bank
European Development Fund (EDF)
Central Fund for Economic Cooperation, France (CCCE)

United Nations Development Programme (UNDP)
Belgian Technical Assistance Mission (CTB)
Canadian International Development Agency (CIDA)
French Aid and Cooperation Mission (FAC)
German Technical Assistance Mission
USAID Bureau

Annex 2

SUPPLEMENTARY INFORMATION ON THE RWANDAN INSTITUTE OF AGRICULTURAL SCIENCES (ISAR)

1. Historical background

The Rubona Agricultural Center was created by Belgium in 1930 to produce and distribute seed to the farmers who had depleted their seed stock after the 1923 and 1929 famines.

In 1935 the National Institute for Agricultural Studies in Belgian Congo (INEAC -- Institut National pour l'Etude Agronomique du Congo Belge), created in 1933, was made responsible for program supervision.

In 1950 the Rubona Agricultural Center was converted into a research station under the administrative and technical supervision of INEAC. It had an annex at Songa for cattle breeding, which was initially created as a state farm in 1935.

In 1955 an experimental station was created at Rwerere to study the adaptation of certain crops to conditions in high-altitude areas. Another trial station was set up at Karama in the Bugesera in 1959 to free the southeastern region of the tse-tse fly.

After independence, the Rwandan Institute of Agricultural Sciences (ISAR -- Institut des Sciences Agronomiques du Rwanda) was established by Legal Order No. R/118/52 of June 22, 1962.

A convention signed by Belgium and Rwanda in 1965 charged Belgium with the scientific, technical, and administrative management of ISAR. In 1969 the convention was revised to give supervision of ISAR's scientific and technical activities to the Faculty of Agricultural Sciences of Gembloux (Belgium).

In 1972 a new ISAR station was created at Tamira to study pyrethrum.

In 1975 the convention was amended to turn over administrative authority for ISAR to a Rwandan national.

In 1977 Belgium informed the Rwandan Government of its wish to concentrate its work on a limited number of programs without, however, decreasing the total sum of its financial assistance.

Since 1980, cooperation between Belgium and Rwanda in the field of agricultural research has been moving through tight straits, and by 1981 the Belgian program was cut down to cover only legumes, livestock, and horticulture; more program cuts were made thereafter. Belgium decided to withdraw its technical assistance staff on June 16, 1982.

2. ISAR's partners

Until 1976 the Belgian research contingent was ISAR's only partner. After that time, ISAR succeeded in obtaining assistance from IDRC (high-altitude

cereals), Switzerland (forestry), CIP (potato regional program), ICRISAT (sorghum), IITA (cassava, sweet potato), and CIAT (grain legumes).

A protocol agreement with IDRC was signed in 1977 and renewed in 1981 for three years to provide support for the cereal sector through a program fully staffed by Rwandans. IDRC-supported research focuses on sorghum, maize, wheat, triticale, sunflower, and includes a training component. The financial support granted ISAR for a four-year period amounts to $185,000, which is used to pay the salaries of technicians and drivers, operating expenses, publications, and the purchase of equipment. An additional budget of $80,000, managed directly by IDRC, finances consultants' missions and overseas training courses.

As the result of an agreement concluded with ISAR in 1979 Switzerland is now financing a program designed mainly to strenghthen the ISAR Forestry Division and develop a nationwide forestry research program. In 1980 and 1981, Switzerland seconded two forestry engineers and provided 140,000 Swiss francs to run the Tree Seeds Exchange (Centrale de graines) and a research program, and an additional 280,000 Swiss francs for operating expenses of the Forestry Division and for purchasing sundry equipment.

An agreement on scientific and technical assistance was signed in 1978 by the Ministry of Agriculture and Livestock and the International Potato Center (CIP) to provide support for the National Potato Improvement Program (PNAP). CIP assigned two experts and financed the operating costs of the research program. Considerable attention is devoted to training extension workers at various levels. The program, which operates under the aegis of ISAR, has received 12 million RwF in 1982.

A long-term protocol of cooperation, prepared in 1980, has been signed by Rwanda and the International Institute of Tropical Agriculture (IITA). The main activity is to be the National Cassava and Sweet Potato Improvement Program (Programme National d'Amélioration du Manioc et de la Patate Douce), but funding has not yet been secured.

Last, the prospects of diversifying international assistance should improve in the near future, thanks to increased assistance from internanal agricultural research centers (such as IITA and ICRISAT for research in the semi-arid zones). Greater financial/technical support through bilateral channels (the main project here is the creation of a high-altitude station on the Zaïre-Nile Crest, financed by EDF and run by France) and multilateral agencies (the most important confirmed project being the World Bank-financed research program in the semi-arid areas, mentioned above).

3. Personnel changes at ISAR from 1975 to 1982

In 1975 ISAR had 12 Belgian technical assistants, 1 Rwandan agronomist, and 13 Rwandan technicians. By the end of 1981, there were 12 expatriate scientists (including 8 Belgians) and 13 Rwandan graduates (Ingénieurs agronomes). The number of A2-level technicians doubled between 1975 and 1981.

By June 1982 when all the Belgians had left, the resident staff comprised:

* seventeen Rwandan scientists (1 Ph.D. in agricultural science, 13 Ingénieurs agronomes, 1 B.Sc.-level chemist, 1 B.Sc.-level biologist, 1 veterinarian);
* four foreign experts (two seconded to PNAP/CIP and two to the Swiss Support Project for the Forestry Division);
* three senior technicians (Ingénieurs techniciens) responsible for research programs.

There are also three Rwandan scientists completing their studies abroad.

Thus at present, ISAR has few resident scientists. Several divisions and sections have no scientists at all; some sections do not even have technicians. Furthermore, most ISAR scientists have little experience. Out of 23 Rwandan research staff (including those abroad), 17 have less than five years experience. Only one scientist has a doctorate.

Annex 3

REVIEW OF THE ISAR STATIONS

1. Agricultural Research Station of Rubona

Butare prefecture.

Created in 1930 (Agricultural Center), 1950 (INEAC Station), 1962 (ISAR).

Longitude E. 029.46; Latitude S. 02.29; Altitude 1,650 m; Rainfall 1,171 mm; Average temperature 19°C (66°F).

Dry seasons: 3 months (June to August); 2 months (January and February).

Soils: derived from granite and schist basement rock.

Area: 675 ha including 600 ha of natural grazing. The rest is used for annual rainfed crops, plantations, planted tree groves and nurseries.

Library: 2,500 publications; approximatively 90 periodicals received irregularly.

Publications: annual reports, technical notes, reports of study days, technical brochures for extension services, various reports.

Fields of activity:
* plant production (food crops, fruit, cash crops);
* forestry;
* study of the environment (pedology, climatology, cartography);
* laboratories (chemistry, crop protection, microbiology)

(Scientists of the Department of Animal Production work at the Songa Station and are only housed at Rubona).

Personnel: 7 scientists actually at post, about 20 technicians, 350 full-time laborers. In 1981 there were eight Belgian technical assistants, all of whom had left by June 1982.

Infrastructure and equipment: The station is composed of a main building comprising the laboratories, library, offices, a small conference hall, a repair shop, storerooms, and a shed in the trial fields. The station has 15 houses for senior staff and about 30 for junior staff. Except for the soil chemistry laboratory, which is well equipped (but, paradoxically, not optimally used), all the laboratories suffer from lack of space and equipment. The soil physics laboratory is dilapidated and located in a basement where the humidity is high. The Crop Protection Division has one laboratory and one office -- which is not sufficient to accommodate three scientists and two technicians. The Food Crops Division has two small, unequipped rooms and a dilapidated greenhouse.

There are two small offices with some calculating equipment supposedly to be used for rural trials and biometrics, and there is the Director's office and a large room accommodating the administration. The central storehouse has no temperature or humidity control, but yet stores, inter alia, foundation seed for the national seed multiplication service (SSS).

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Budget in RwF (1980):

Salaries (excluding Belgian technical assistance)	28,000,000
Construction and equipment	13,000,000

General remarks:

* Inadequate basic infrastructure, ill-equipped laboratories, not very functional library.
* The station is located 15 km from Butare, which has community services such as a hospital, a club, and a cultural center. Social life at Rubona is pleasant.

2. The Ruhande Arboretum

Butare prefecture.

Arboretum belonging to the Ministry of Agriculture but run by ISAR. It is attached to the Rubona station. The ISAR Forestry Division is located here.

Longitude E. 029.44; Latitude S. 02.37; Altitude 1,750 m; Rainfall 1,190 mm; Average temperature 18°C (64.4°F).

Dry seasons: 3 months (June to August); 2 months (January and February).

Area: 180 ha of planted tree groves and natural forests.

Field of activity: forestry.

Personnel	Dec. 31, 1981	June 30, 1982
Rwandan scientists	2	3
Expatriate scientists	2	2
Technicians	2	4
Laborers	57	57

Budget in RwF (1980):

Salaries	1,900,000
Construction and equipment	1,600,000

3. Cattle Breeding Center of Songa

Butare prefecture.

Created in 1935 (state farm), 1945 (INEAC center), 1962 (ISAR).

Longitude E. 029.47; Latitude S. 02.24; Altitude 1,600 m; Rainfall 1,050 mm; Average temperature 20°C (68°F).

Dry seasons: 3 months (June to August); 2 months (January and February).

Soils: Mayaga zone, soils derived from schist and granite rock, some hills with red soil.

Area: 775 ha including 700 ha of natural grazing and 15 ha of forage crops.

Fields of activity:
* cattle and sheep farming;
* breeding and distributing of local Ankole dairy cattle;
* cross-breeding (Jersey x Sahiwal and Jersey x Ankole);
* study of pasture species and forage crops.

Personnel	Dec. 31, 1981	June 30, 1982
National scientists	2	2
Expatriate scientists	1	0
Technicians	1	1
Laborers	120	120

Herd size: 800 cattle (including calves), 150 reproducing ewes.

Budget in RwF (1980):

Salaries	6,500,000
Equipment	840,000
Income (produce sales)	+ 7,000,000

General remarks:
* Infrastructure is inadequate: milking sheds can only hold 300 cows, no laboratory, only rudimentary agricultural equipment.
* The center is about 30 km from Butare.

4. The Karama Experiment Station

Kigali prefecture.

Created in 1959.

Longitude E. 030.16; Latitude S. 02.17; Altitude 1403 m; Rainfall 853 mm; Average temperature 20.8°C (69.4°F).

Dry seasons: 4 to 4.5 months (June to mid-October); 2.5 months (January to mid-March).

Soils: dry red soils (xeroferrisols) of the nearly level uplands mainly suited for grazing.

Area: 2,800 ha including 2,600 ha of natural rangeland.

Fields of activity:
* animal husbandry;
* low altitude food crops;
* irrigated crops.

Personnel	Dec. 31, 1981	June 30, 1982
National scientists	2	2
Expatriate scientists	2	0
Technicians	3	3
Laborers	200	200

Herd size: 850 cattle (150 purebred Ankole, the rest crosses Ankole x Sahiwal), 200 goats.

Budget in RwF (1980):

Salaries	10,500,000
Equipment and construction	3,500,000

General remarks:

* The number of scientists and technicians is not proportionate to the amount of research and experimentation expected from the station. Efforts should be concentrated on the priority programs (cassava, sweet potato, sorghum) and on keeping the herd size down to the strict minimum needed for good research work.
* Infrastructure and equipment are unsatisfactory.
* The station can provide irrigation through pumping.
* The station is very isolated, but it has a dispensary with three medical assistants.

5. Rwerere Experiment Center

Ruhengeri prefecture.

Created in 1957 to study the high-altitude zones. Experiments are only carried out in the lower areas adjoining the Rugezi swamps.

Longitude E. 029.53; Latitude S. 01.32; Altitude 2,300 m; Rainfall 1,166 mm; Average temperature 15.6°C (60°F).

Dry seasons: 2.5 months (mid-June to August); 1 month (January).

Soils: ferrisoils along the swamps.

Area: 65 ha including 30 ha cropped and 35 ha of pastures and forest.

Fields of activity:

* high-altitude crops (legumes, cereals, potato, sweet potato, oilseed crops);
* fruits (avocado tree orchard);
* animal husbandry (goat improvement).

Personnel	1981	1982
National scientists	5	1
Technicians	3	3
Laborers	80	80

Infrastructure: offices, six houses, drying shed, storehouses; no laboratory, no library, no equipment.

Budget in RwF (1980):

Salaries	5,500,000
Equipment	0

General remarks:

* This station could be used to test new temperate-zone fruit crops.
* The station is the most isolated of all the ISAR stations. It has its own dispensary. The Sub-Prefecture expects to build a hospital and a secondary school.

6. Pyrethrum Selection Station of Tamira

Gisenyi prefecture.

Created in 1972 for pyrethrum selection.

Longitude E 029.21; Latitude S. 01.34; Altitude 2,300 m; Rainfall 1,450 mm; Average temperature 15°C (59°F).

Dry season: 2 months (July and August).

Area: 60 ha of which 15 ha for pyrethrum, 5 ha for food and garden crops, and 6 ha of woodlots.

Activities:
* pyrethrum selection;
* selection of wheat, triticale, and maize;
* oilseed crops (sunflower);
* potato seed multiplication.

Personnel	1981	1982
Rwandan scientists	1	1
Expatriate scientists	1	0
Technicians	3	2
Laborers	68	68

Infrastructure: one administration office, four houses for senior staff, accommodation for laborers; no laboratory, no pyrethrum drier.

Budget in RwF (1980):

Salaries	3,500,000
Equipment	50,000

General remarks:
* The station has been poorly maintained because of lack of funds.
* It is rather isolated; the closest primary school is 3 km away and the closest dispensary 8 km away.

7. National Potato Improvement Program (PNAP)

Ruhengeri prefecture.

Created in 1979 to improve potato production in Rwanda.

Research station at Ruhengeri: Longitude E. 029.38; Latitude S. 01.31; Altitude 1,850 m; Rainfall 1,250 mm; Average temperature 15.6°C (60°F).

Seed multiplication farm at Kinigi: Longitude E. 029.35; Latitude S. 01.27; Altitude 2,300 m; Rainfall 1,500 mm; Average temperature 15°C (59°F).

Dry season: 2 months (July and August).

Soils: volcanic.

Area: at Ruhengeri: 4.5 ha of which 3 ha cultivable (mainly potatoes); at Kinigi: 47 ha of which 45 ha cultivable (potatoes in rotation mainly with cereals and legumes).

Fields of activity:
* selection of new potato varieties from introduced germplasm;
* agronomic, pathology, and post-harvest studies on potatoes;
* basic seed production;
* training and extension in potato cultivation within local farming systems; on-farm trials and demonstration.

Personnel:	1981	1982
Rwandan scientists	3	3
CIP scientists	2	2
Technicians	2	2
Support staff	8	8
Laborers	90	90

Infrastructure: an administrative building including offices, a laboratory, and a garage; 6 staff houses; 2 sheds (total capacity 125 t); 2 semi-permanent glasshouses; 10 bamboo store rooms (total capacity 30 t); a 80-HP tractor, a tractor-mounted sprayer and a 3.5-t trailer.

Budget in RwF (1982):	
Salaries	5,000,000
Equipment	3,500,000
Investments	3,900,000
Mission costs	500,000
	12,900,000
Receipts (from sales)	2,100,000

General Remarks:
* Within the framework of PRAPAC (Regional Program for the Improvement of Potato Production in Central Africa), Rwanda is responsible, among other things, for the training of research staff and technicians of the CEPGL countries. At present, funds are being sought for construction of a training center;
* Both the PNAP station and the multiplication farm are well equipped for their task;
* The station is suitably located in the prefectural capital of Ruhengeri; Kinigi is only 15 km from Ruhengeri.

Annex 4

NATIONAL UNIVERSITY OF RWANDA

The National University of Rwanda (UNR) was created in 1963 after independence. At first it had three sections (Faculty of Social Sciences, Faculty of Medicine, and Teachers' Training School), with 16 teachers and 51 students. By 1981 the numbers had risen to 161 teachers and 903 students. On December 3, 1981 UNR merged with the National Institute of Pedagogics (IPN -- Institut Pédagogique National) and now has a campus at Butare and another one at Ruhengeri.

This annex is devoted solely to the faculties, departments, and institutes working in the field of agriculture, namely:

* at Butare: Faculty of Agriculture, Faculty of Economics, Social Sciences and Management, and the Energy Resources Center (CEAER -- Centre d'Etudes et d'Applications de l'Energie au Rwanda);

* at Ruhengeri: Faculty of Science, Geography Department of the Faculty of Arts, the Center for Applied and Basic Research and Continuing Education (CRAFOP -- Centre de Recherche Appliquée, Fondamentale et de Formation Permanente). (In 1981/82 the Faculty of Science was still using buildings on the Butare Campus, and at present CRAFOP is still housed in the premises vacated by the IPN at Butare).

As a contribution to national science, all teachers at the university are obliged to carry out research and publish the results. A distinction needs to be made, however, between individual course-related research on the one hand and research carried out in autonomous research centers on the other.

1. Faculty of Agriculture

Agricultural science was first taught in Rwanda in 1958, when the Faculty of Agriculture and Animal Husbandry was created at the Université Officielle du Ruanda-Urundi at Astrida, now called Butare. In 1960 this section was transferred to Bujumbura (Burundi) leaving Rwanda without facilities for higher training in agricultural science until 1974, when a Department of Agriculture was created in the Faculty of Science. In 1979 the department was turned into a faculty. Thus, between 1960 and 1974, all university-level agriculturists had to be trained abroad, i.e., in Canada, Belgium, the USSR, the Federal Republic of Germany, France, and Zaïre.

The Faculty of Agriculture was given three main assignments: "(1) to produce versatile agricultural professionals (Ingénieurs agronomes polyvalents), able to cope with the agricultural situation of the country; (2) to provide the scientific and professional training that students need in preparation for specialized advanced studies; (3) to make an immediate or potential contribution to identifying and solving certain of Rwanda's agricultural problems."

At present, the full-time teaching staff is composed of 5 Rwandans (including 1 Ph.D.) and 5 Canadians, with 2 additional Rwandan teachers finishing their doctorates in Canada. The subjects taught are crop production and plant pathology, pedology, animal husbandry, rural economics, and agricultural engineering. The Faculty of Agriculture benefits from a cooperation agreement with Canada which, inter alia, provides postgraduate scholarships.

The program of study consists of two 3-year "cycles." The first cycle is open to students who have completed their secondary schooling at advanced level (Humanités scientifiques) and the second to students holding the university first-cycle diploma (Baccalauréat) in general agriculture. Students indicate their choice, i.e., agriculture, at the start of their university studies.

The first two years of the first (Baccalauréat) cycle, are given in the Faculty of Science, and constitute a common core devoted to basic sciences for students in agriculture and biology-chemistry. The third year of the first cycle is wholly directed by the Faculty of Agriculture but makes use of service teaching by staff of the Faculty of Science and the Faculty of Economics, Social Sciences and Management. This year is spent on general agricultural science courses, such as microbiology, genetics, plant taxonomy, physiology, animal husbandry, ecology, sociology, etc., prerequisites for the second-cycle program.

The second cycle (leading to the diploma of Ingénieur agronome), given entirely at the Faculty of Agriculture, includes several general courses, as well as advanced courses in plant pathology and crop production subjects (559 hours), animal sciences (405 hours), agricultural engineering (270 hours), pedology (180 hours), and economics (165 hours). There are no electives.

The second-cycle program includes a short thesis or graduation paper (mémoire de fin d'études) defined as "an orderly presentation of the results of an individual study (survey, compilation, or experiment) that can be used as an immediate or potential contribution to identifying or solving a problem, preferably one found in Rwanda." The students choose a subject for their thesis from a list of subjects prepared by the faculty and, to the extent possible, concurrent with training opportunities offered by development projects or laboratories outside the university. The average cost of a thesis with field work is approximately 100,000 RwF (US$1,100). This means that the choice of a subject and the location of the field work for a thesis are often determined by material considerations, despite the research subsidy paid for these theses by UNR and the Ministry of Higher Education and Scientific Research. Out of the 17 students in the 1982 graduating class, 4 prepared their thesis at ISAR, 11 at the Faculty of Agriculture, and 2 in development projects.

Upon completion of their second-cycle studies, students receive an Ingénieur agronome diploma and are hired by the administration as senior government officials, AO level.

A plan to reform the agricultural science studies at UNR includes four proposed measures:

* decreasing the number of years of study from six to five;
* placing all first-cycle studies under the Faculty of Agriculture;

* increasing class sizes, which should produce graduating classes of at least 25, but ideally 40 to 50 Ingénieurs agronomes per annum;
* introducing a certain degree of specialization in order to meet the diverse needs of Rwandan agriculture, in rural economics, agricultural chemistry, forestry, etc.

Some 10 to 12 agricultural graduates are trained abroad each year.

Advanced training for positions in university teaching and research (M.Sc., Ph.D., or equivalent) means studying in foreign universities. Because of the specialized nature of all their M.Sc. programs as a prerequisite for Ph.D. studies, Canadian universities do not admit Ingénieurs agronomes from UNR directly to Ph.D. programs, but oblige Rwandan students to enter in the first-year M.Sc. courses, irrespective of whether they have completed the first or the second cycle at the UNR Faculty of Agriculture. There are a few universities in Europe that admit the (unspecialized) Ingénieurs agronomes from the UNR directly to their doctoral program.

So that it could serve both education and research needs, the Faculty was given land at three sites:

a. the animal husbandry experiment station located in a swampy area at Gihindamuyaga, 6 km from Butare.
b. a 3-ha horticulture and vegetable demonstration plot on the faculty grounds proper; and
c. an experimental field at Karubanda, 2 km from Butare, for food crops and fertilizer studies.

But it does not have a single laboratory for plant sciences, animal sciences, or pedology. Plans are in the offing to create a general multipurpose laboratory for students and a research laboratory.

Research work (carried out almost entirely by students preparing their second-cycle thesis under the direction of the teaching staff) is mainly devoted to animal husbandry, fertilizers, and mixed cropping. Animal production research centers on poultry rearing for meat and eggs, sheep and pig nutrition, and genetic improvement of New Zealand rabbits through cross-breeding and selection. Agro-pedological research up to the present has concentrated on fertilization: trials of different N and P fertilizer formulations on maize, inoculation of soybeans and climbing beans with Rhizobium, study of the effects of phosphorus on potatoes and sweet potato, fertilization of mixed crops. In plant pathology, research is currently underway on bacterial wilt of potatoes. In the field of rural economics, a study has been made from 1980 to 1982 of the quantities of agricultural produce appearing on the Gikongoro market.

Between 1979 and 1981, the Faculty of Agriculture, the Agricultural and Veterinary Section of the Butare School Group (SAVB), ISAR and the Nyabisindu Agro-pastoral Project conducted a joint research program on mixed cropping with maize, soybeans, and sweet potatoes. Each partner financed its own share of the program, and ISAR was responsible for compiling and analyzing the results. This is one of the rare examples of agricultural research being carried out through a joint program sponsored by a group of institutions.

Programs being planned for the coming years focus on biological fertilizers, goat rearing, fish-farming and lake-fisheries, forestry and agroforestry.

2. Faculty of Economics, Social Sciences and Management

Until 1971, this faculty offered first-cycle courses only; thereafter it opened a second-cycle curriculum leading to a Licence en gestion (M.A. in management). The faculty now offers new first-cycle students the possibility of choosing between four majors (economics, social sciences, accounting, management) which they will pursue through the third year of the Baccalauréat (B.A. level). The second-cycle has not undergone any change for the time being, but the faculty in the future may offer the four majors above through the second cycle, if adequate personnel and funds can be obtained.

The faculty has five departments and 19 teachers (of varying qualification). Research is carried out through second cycle theses and graduation papers, based on original research pertinent to Rwanda.

3. Energy Resources Center of Rwanda (CEAER)

This center was originally a department of the Faculty of Science, but in 1977, three years after its creation, it became autonomous and was assigned to study, inter alia, the contribution of energy to rural development. Activities of the Biomass Department have included the setting up of two experimental units to produce biogas from cow manure and the testing of a wood-saving stove. The Meteorology Department makes daily recordings of weather information at Ruhande and processes the data into a reference bank. The center has a scientific staff composed of seven full-time teachers-researchers, of whom two belong to the Biomass Department and one to the Meteorology Department.

4. Faculty of Science

The Faculty of Science was born as an outgrowth of the Teachers' Training School in 1964. It offered first-cycle instruction until 1972, at which time it had an enrollment of 116 students. Starting in 1974 it introduced a curriculum of studies in agriculture up to Ingénieur agronome level, which led to the creation of the Faculty of Agriculture in 1979. When the UNR and the IPN (Institut Pédagogique National) merged in 1981 the responsibility for training secondary school teachers in scientific disciplines was turned over to the Faculty of Science which, to meet this obligation, created three majors: biology, chemistry, mathematics-physics.

At present, the faculty has 42 full-time teachers and 320 students, of whom 180 are enrolled in a first cycle that feeds into other faculties (agriculture, medicine, applied sciences). Teachers at the Faculty of Science carry out research in its own four research laboratories or at other -- autonomous -- research centers (CEAER, CURPHAMETRA, CRAFOP). The research topics are either theoretical or oriented towards solving development problems, or they are aimed at promoting the diffusion of scientific and technical findings.

5. Geography Department of the Faculty of Arts

The Geography Department has concluded an inter-university agreement with Bordeaux III University. The department has six teachers, all at third-cycle doctorate level. The curriculum consists of two 3-year cycles leading respectively to a Baccalauréat-ès-Lettres (B.A. level) and to a Licence (Master's level). The Geography Department has made remarkable contributions in physical, economic, and human geography that are well worth pursuing. The main publications produced by the department have been a geography book on Rwanda and the Atlas of Rwanda.

Students working for their Licence prepare a thesis which, in most cases, is based on a field geographic survey. The department has a well-equipped cartography laboratory.

The department's teachers-researchers, together with the students, conduct a considerable amount of research relevant to agriculture, drawing heavily on field surveys. Doctoral dissertations now under preparation deal with the traditional agrarian structures in Rwanda or specific themes such as soil erosion and soil conservation practices.

6. Center for Applied and Basic Research and Continuing Education (CRAFOP)

CRAFOP was born in 1979-80. By January 1981, it included 11 dynamic projects, of which 8 were in the field of chemical, physical, and biological sciences, and 1 in geography. The most important research project centers on the natural products of Rwanda, with special emphasis on the latex-producing plants. Several teachers are pursuing their doctoral research as part of this project while obtaining their theoretical instruction in Rwanda from international consultants.

Annex 5

PERSPECTIVES FOR AGRICULTURAL RESEARCH IN RWANDA

This annex discusses past results and future prospects for agricultural research related to individual crops in Rwanda. Most of this research was conducted by ISAR and its predecessor, INEAC. Emphasis has always been placed on plant production, especially on the genetic improvement of the main crops. Relatively few trials have been devoted to cropping techniques per se, and insufficient attention has been given to the cropping methods used in the farmers' fields. Nevertheless, since 1978 for certain crops, ISAR has compared traditional cropping techniques to those advocated by research and extension services. This was done, inter alia, through the Associated Crops Program, which involved studying the value of combining two or three crops such as maize, sweet potatoes, soybeans, potatoes, beans, groundnuts, and cassava. Separate studies have been conducted on traditional sowing methods (broadcasting) and row-sowing since 1979, in particular for sorghum, maize, and beans.

Because of the need to double yields in less than 20 years, in order to cope with population increases in the absence of more cultivatable land, very high priority should be given to research on the possibilities of using biological and chemical inputs.

Note should be taken from the outset of the fact that the results of past research and proposed research themes on individual commodities, dealt with here, need to be supplemented by interdisciplinary, theme-specific research. This annex should in no case be considered as a ranked list of subjects for agricultural research. Priorities must be established in keeping with the objectives of the National Development Plan and also with the resources that can be mobilized.

1. Plant Production

Food crops

Table 4 presents the main food crops in terms of the areas cultivated, their production levels and their average yields for the years 1970 and 1980, as well as forecasts for 1986 as spelled out in the Third Five-Year Plan.

Bananas

With production of two million tons each year, bananas are by far the most important crop in Rwanda. The crop occupies 22% of the land devoted to the ten leading food crops. During the last decade, land areas reserved for bananas have been increased by 63% and production has risen 24%, although average yields have dropped 23%, from 12 t/ha in 1970 to 9.2 t/ha in 1980. This yield decline is due partly to the fact that bananas are now being grown on lands which, in respect of soil fertility, rainfall, or altitude, are not the most suitable, and partly because of the development of intercropping, which requires wider spacing between the banana plants.

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Table 4. Statistics of Food Crop Production.

	1970			1980			Difference (+ or -) between 1970 and 1980 (%)			Projection in the Plan for 1986			Difference (+ or -) between 1980 and 1986 (%)		
	Area* '000 ha	Production '000 t	Yield t/ha	Area* '000 ha	Production '000 t	Yield t/ha	Area (%)	Production (%)	Yield (%)	Area* '000 ha	Production '000 t	Yield t/ha	Area (%)	Production (%)	Yield (%)
Bananas	137	1644	12.0	224	2060	9.2	+ 63	+ 25	- 23	230	2300	10.0	+ 3	+ 11	+ 8
Beans	161	145	0.9	257	180	0.7	+ 59	+ 24	- 22	286	214	0.75	+ 11	+ 18	+ 7
Peas	76	64	0.84	51	35.7	0.7	- 33	- 45	- 17	50	37.5	0.75	- 2	+ 5	+ 7
Soybeans	-	-	-	5.2	3.9	0.75	-	-	-	7	6.3	0.9	+ 35	+ 62	+ 20
Groundnuts	16	15	0.94	17	16	0.95	+ 6	+ 6	0	25	25	1.0	+ 47	+ 54	+ 5
Sorghum	141	141	1.0	162	178	1.1	+ 15	+ 26	+ 10	162	194	1.2	0	+ 9	+ 9
Maize	50	50	1.0	71	78	1.1	+ 42	+ 56	+ 10	88	106	1.2	+ 24	+ 35	+ 9
Sweet Potato	73	379	5.2	114	866	7.6	+ 56	+128	+ 46	127	1270	10.0	+ 11	+ 46	+ 32
Cassava	28	336	12.0	49	637	13.0	+ 75	+ 89	+ 8	50	650	13.0	+ 2	+ 2	0
Potato	21	136	6.5	32	217	6.8	+ 52	+ 60	+ 5	37	370	10.0	+ 16	+ 71	+ 47

*Areas: total areas cultivated during the two cropping seasons.

Source: Ministry of Agriculture and Livestock (November 1982) and Ministry of Planning (1982).
These figures are indicative estimates calculated to show trends in food crop production.

The Rwandan farmer's attraction to banana cropping has many intricate sociological and agronomic explanations.

Three types of banana are grown; more often than not, they are grown together: the wine banana (also known as the beer or cider banana), the plantain (cooking banana), and the dessert banana. The so-called beer banana, which is not edible, accounts for 80 to 90% of total banana production. In the banana growing regions with good market outlets, the plantain is becoming increasingly popular, e.g., Kibungo which supplies Kigali, and Bugoyi which serves Gisenyi and the Zaïrean town of Goma. Long before the development of the plantain market in the big towns, the popularity of banana "beer" ensured farmers of a ready market for their beer bananas.

Although certain varieties of bananas are resistant to many crop pests and diseases, Rwandan bananas do suffer from anthracnose, a very serious disease. Banana production is also held back by certain cropping techniques, such as insufficient thinning and late replacement of old banana plants. The dessert bananas, which consist of foreign cultivars, are much more sensitive to nematodes.

Despite the great economic importance of the banana, research has been limited to building up a collection of local edible cultivars. Propagating material has been distributed, but not widely.

Because of the importance of beer bananas and the attendant problem of using large areas of arable land to grow them, research may be required on growing different banana types together and on intercropping bananas with other food crops.

Beans

About 25% of the lands used for food crops are devoted to beans, which makes this the leading food crop. During the last decade, bean growing areas have increased by some 60% and production by 25%, but average yields have fallen from 0.9 t/ha to 0.7 t/ha, largely because of reduced soil fertility and extension onto marginal lands, i.e., the dry regions in the east and the high-altitude regions in the west.

Depending on the region and the local customs, farmers prefer growing dwarf beans or climbing beans. Under similar farming conditions, the latter produce far higher yields than the former.

In certain parts of the Ruhengeri and Gisenyi regions beans are grown as a monocrop, but farmers in the rest of the country cultivate varietal mixtures of either dwarf or climbing beans (often of different colors), usually associated with other food crops. Whether he grows dwarf beans or climbing beans, the farmer constantly selects among those varieties which, according to his experience, have proven to be adapted to the special conditions prevailing in his micro-environment and which are disease-resistant. The dwarf and semi-climbing beans more often than not are grown with maize or some other crop. For instance, except where bananas are grown in pure stands, beans have always been grown as intercrops in the banana groves (e.g., in the central part of the country), and this type of association is spreading rapidly.

One of the main obstacles to increasing yields is poor soil fertility, especially in the high-altitude regions of the south where beans grow poorly above an altitude of 2,000 m, more, apparently, because of the high acidity of the soil than because of the altitude.

Most bean varieties have nodules, but apparently not the nitrogen-fixing types. Hence the need to identify efficient strains of Rhizobium and bean varieties that respond best to inoculation. Other problems concern post-harvest losses caused by weevils and reduction in cooking quality caused by storage under ordinary conditions after just a few months.

ISAR, in collaboration with CIAT, has carried out many studies on beans, especially the selection of local and introduced varieties. Varieties have been identified that yield between 1.5 and 2 t/ha under research station conditions.

No single foreign variety has proven sufficiently superior to the local varietal mixtures for farmers to be willing to accept it. In any case, the problem is not to replace the farmers' present varietal mixtures by pure varieties, but to introduce into these mixtures high-yielding genotypes that increase productivity without jeopardizing plasticity.

Considering the above, research themes should include:

* research on cultural methods that facilitate the integration of climbing beans into crop associations (intercropping with maize — or sorghum? -- the stalks of which serve as live props for the climbing beans);
* crossing of local varieties in the hope of achieving substantial yield improvements;
* selection of varieties adapted to high-altitude regions and the dry regions in the east;
* research on grain legumes that could profitably replace beans in the areas marginally suitable for this crop: Phaseolus lunatus, Phaseolus coccineus, Dolichos lablab, Cajanus cajan;
* research on post-harvest technology (conservation, storage).

Peas

Peas are generally grown as a monocrop in the high-altitude regions, but in the center and in the east they are intercropped, often with beans. It is the only traditional crop whose land allocation has decreased during the last decade. Production figures have dropped 50% and average yields have declined from 0.84 to 0.7 t/ha.

The decline in production has been caused in part by the deterioration of the high-altitude lands of the southern part of the Zaïre-Nile Crest (invasion by Eragrostis, extreme acidity, aluminum toxicity, acute phosphorus deficiency, and reduced fallow time). Traditionally, peas are extensively grown as an untended fallow crop, but increased pressure on the land now makes this impossible. Furthermore, although peas are second only to beans as a food legume, no work has been done on genetic maintenance and improvement, and varieties have degenerated over the last few years.

Traditionally, farmers have cultivated peas as a monocrop with minimum land preparation. This cropping practice encourages semi-spontaneous fallow, and hence a good soil cover as well as a certain nitrogen input,

because peas, like soybeans, fix nitrogen symbiotically. Because of this ease of cropping, peas are the only grain legume which farmers will use for soil conservation; other legumes require much more care and maintenance, and in some cases do not even yield a directly edible product.

Trials carried out at the Rwerere station indicated that weeding does not improve yields. Furthermore, they showed that there was no justification for staking pea plants grown after a fallow period or after a sorghum or maize crop. However, the interpretation of these experimental findings is questioned by some scientists who feel that, quite the contrary, peas are probably the only crop whose yield can be spectacularly increased, even doubled, by modified cultural practices, i.e., shifting from extensive to intensive cropping (denser sowing, using sticks as props, weeding).

In ISAR trials, climbing pea varieties gave higher yields than dwarf varieties. In the areas where this crop is grown, there are no major crop pests or storage problems.

Especially in the high-altitude regions, yields suffer most from impoverished soils and the absence of specially bred varieties.

Groundnuts

Groundnuts were first introduced in the 1920s and have developed progressively. For the last 10 years, however, the crop has been cultivated on about 15,000 ha, with yields remaining around 0.9 t/ha. The total output is consumed raw; groundnut oil is not produced in the country.

The main yield depressants are virus diseases (rosette), Cercospora, and low soil fertility. But the principal obstacles to expansion of groundnut cultivation are the difficulty of keeping seed from one season to the next and the high sowing rate (150-180 kg/ha of unshelled seed) compared to the low yields.

There apparently is a problem of seed availability. Groundnuts are so well liked that a large part of the production is consumed by the producer's family or is sold for consumption at the market place.

The first introductions came from Zaïre; the variety Gandajika A65 has proved to be well adapted to Rwandan conditions. During the 1950s, 25 varieties were imported from Brazil; the Fatui variety has been disseminated among the farmers. Since 1962, many other varieties have been imported from elsewhere in Africa, from South America, and from Israel. Multilocation trials have been carried out to test varietal aptitudes, disease resistance and tolerance, response to fertilizers and irrigation, and the effects of plant spacing.

Three Zaïrean varieties (HN-G18, HN-G17, HAD-30) have demonstrated an ability to produce higher yields and have a better resistance or tolerance to rosette and Cercospora than Fatui. No decisive conclusions can be drawn from manure and fertilizer trials.

At present, the varieties available are satisfactory, both as concerns their yield potential and their tolerance of the main diseases. The future development of the groundnut crop will depend more heavily on logistics (availability of seed, marketing) than on the improvement of the plant material.

The following research themes are to be recommended:
* varietal selection to develop drought tolerance;
* protecting seed against insects;
* the response of groundnuts to mineral fertilizers applied to poor soils.

Soybeans

Soybeans were first introduced in the 1940s but it was not until the 1970s that the crop became widely accepted. Areas planted rose from 550 ha in 1970 to 4,000 ha in 1980. Average yields are about 750 kg/ha. The slow beginnings, followed by the rapid expansion in the 1970s, was more the result of sudden acceptance by the farmers than of progress in research. In the last few years, soybeans have been increasingly grown on certain swamplands. They adapt better to certain marginal and/or acidic soils and are more drought tolerant than beans.

Palmetto (first planted in Zaïre in 1940 and one of the first varieties grown in Rwanda) has proven to be the best and is still being cultivated. ISAR started working on soybeans in the 1970s in conjunction with the International Soybean Program (INTSOY) run by the University of Illinois, U.S.A. Some 500 varieties imported from the U.S.A., Nigeria (IITA), and Asia were tested at Rubona and Karama. On-station trials of the 10 best varieties gave yields of between 1,600 and 2,700 kg/ha. At the Rubona station, the Davis and Bossier varieties produce the highest yields. On the other hand at Karama, in a drier region, Palmetto is still among the best. Multilocation trials have been carried out since 1981. Results seem to indicate the availability of varieties superior to Palmetto for all the ecological regions.

Soybeans, which in the past were not subject to diseases or pests, are now showing signs of diseases such as Sclerotinia. Low seed germination capacity and storage difficulties are less of a problem in Rwanda than in other countries.

The soybean seems to be destined to become a major food crop in Rwanda. Satisfactory planting material and cropping techniques are available. Inadequate knowledge of food preparation techniques seems to be the foremost obstacle to the expansion of the crop. The one, and only, small oil mill, located at Nyabisindu, produces ground soya cake and oil, which it sells successfully to the local population. This is a fair indication of promise for the future. Thanks to this oil mill, the region around Nyabisindu has become the country's leading soybean producer. Nutrition centers will have an important role to play in popularizing soybeans.

Trials have shown that soybeans respond very favorably to inoculation with Rhizobium and that artificial inoculation is required when introducing this crop into a new region. Suitable Rhizobium strains are available, and the methods of inoculum conservation are known. Hence, if production and distribution facilities were made available, large-scale distribution of inoculum into the rural areas would be possible.

The following themes for research on soybeans are to be recommended:
* continued work with INTSOY and IITA on genetic improvement, with emphasis on ecological plasticity;

* research into maintaining the germination capacity of the seed;
* study of pod dehiscence of different varieties at harvest;
* use of soybean as part of the human diet: small oil mills to produce oil and cake, soybean milk production, soybean powder as a nutritional drink for children.

Sorghum

Sorghum is the traditional cereal crop of Rwanda. During the last decade the area devoted to this crop has been increased by about 10% and production has risen by 26%. Average yields have increased from 1 to 1.1 t/ha. This increase is the result of the crop being planted in regions recently occupied by farmers (Bugesera and Mutara). Sorghum is one of the few cereals adapted to conditions in these semi-arid regions.

Sorghum is cultivated at altitudes of between 1,400 and over 2,000 m, i.e., at altitudes exceptionally high for this crop. Many hardy varieties exist, selected for their organoleptic qualities. Sorghum is grown on such a large scale that bird attacks, percentage-wise, do negligible damage except to the very late- and the very early-maturing varieties.

During the last 20 years, ISAR has been working intensively on improving sorghum through mass selection and the development of pure lines from local varieties. Many introductions are the result of joint efforts with ICRISAT, IDRC, CIMMYT, and the Ford Foundation in Lebanon. Results clearly indicate that varieties of Rwandan origin give good yields and that most of the imported material had to be rejected because it was poorly adapted to local conditions. Selections from local varieties have a yield potential of up to 6 t/ha, a satisfactory height, a good-quality panicle and a good level of disease resistance, especially in the high-altitude areas.

Considering the great potential of the genetic material developed these last few years, any supplementary research efforts related to the genetic improvement of sorghum should give pride of place to varieties for the low dry regions. ICRISAT, IITA, and ISAR, as part of the Agropastoral Project (BGM) project, have signed an agreement on a program for the genetic adaptation of sorghum to semi-arid conditions. This program will be carried out at the Karama experiment station. For the high-altitude areas, genetic improvement should focus on the crossing of local varieties.

It should be pointed out that selection is not intended merely to increase yields, but must also consider organoleptic characteristics (consumers' tastes vary from region to region), and farmers' preferences as to plant size and growing cycle. The farmers, for instance, may not choose late-maturing, long-stemmed varieties even though they give the highest yields in the stations. Farmers often find that yields are increased by fertilizer application, although on-station trials have shown no such response.

Research could give priority to:
* genetic improvement by crossing local cultivars for adaptation to high-altitude regions, and introduction and selection of varieties adapted to the low areas of the southeast, with due regard to organoleptic characteristics;

* cropping methods and fertilization;
* conservation of sorghum beer;
* intercropping experiments with climbing beans, propped by sorghum stalks; (however, since sorghum stems are not very resistant as props, strong, medium height (1.5 to 2 m) varieties would be needed, and another problem is that often sorghum and beans are not grown during the same cropping season).

Maize

Maize has not become very popular in the traditional agricultural regions of the central plateau, nor around Lake Kivu. On the other hand, it is becoming increasingly important in the high-altitude regions (above 1,900 m) and in the lower regions (below 1,500 m). Except for a few paysannats (Mutara) which produce and sell a surplus, maize is still grown as a subsistence crop. During the last 10 years, the maize-growing area has been increased by 40% and the production has risen by 56%. The average yields have improved slightly to reach a level of about 1.1 t/ha.

Maize production is not especially problematic in the plateau zone. The variety Bambu cultivated in this region displays good resistance to streak and helminthosporium. On the other hand, there is no variety that has proven suitable for the very high and for the low-altitude regions.

Among the varieties first introduced from Zaïre, Bambu displayed the greatest adaptability and soon predominated. At a later time, lines from Katumani (Kenya) were introduced, especially in the low-altitude regions.

Since 1968, varieties have been introduced in a more systematic manner, partly with assistance from FAO and CIMMYT. Mass selection has been carried out using the local Nyirakagoli population. Since 1980, the CIMMYT introductions have been used to correct certain specific short-comings in the four best varieties: Bambu, Nyirakagoli, Golden Corn and Katumani. Maize cultivation could well expand significantly in the high-altitude regions, and also in the semi-arid eastern and south-eastern parts of the country. In the latter areas, e.g., Karama, maize performs well under irrigation.

In the Ruhengeri prefecture, a project is now taking shape which could have substantial impact, because in this high-altitude region it may become necessary to find a replacement crop for pyrethrum. The project seeks to produce maize as a cash crop for human and animal consumption.

In light of the above, the following research themes are to be recommended:
* continuation of the current improvement program and intensification of the search for synthetic populations specially adapted to the high-altitude regions and the low, dry southeastern region;
* testing the responses of new varieties to mineral fertilizers, especially in preparation of an industrial production scheme;
* research into a farming system designed to intercrop climbing beans and maize in order to stimulate maize production in the high plateau zone and around Lake Kivu.

Rice

Rice is rather new in Rwanda. It started spontaneously in the Bugarama region, located on the Ruzizi plain at an altitude of 900 m, following cultivation methods applied by Burundi and Zaïre on their side of this same plain. In the 1960s, swamplands were reclaimed to cultivate rice. Today, Rwanda devotes about 1,500 ha to rice production.

Rice can only be produced in swamplands if certain requirements related to drainage, irrigation, soil, and climate have been met. Each swamp area is different and requires special study and experimentation. The main problem is selecting the right variety, since the ecological conditions vary greatly from one swamp to the next. Up to now, varieties derived from Chinese-Malagasy crosses have been used most widely. A new Chinese variety (Keng Diao 3) has recently been introduced and is being tested in all the projects. Rice pests and diseases are not a problem yet. Treating seeds with organic-mercury compounds provides satisfactory protection. Yields are declining in all swamp-rice fields, but this is due to the absence of fertilizers and crop rotation.

The farmers have prepared nearly all the small valley bottoms for agriculture. But this preparation is limited to building mounds and ridges and does not include a water control system. Many of these valley bottoms are flooded during the rainy season and, therefore, can only be cultivated during the dry season. The possibility of growing irrigated rice on these valley bottoms in the rainy season should be explored.

Besides research on this latter problem, priority should be given to the following research themes:

* use of fertilizers and introduction of crop rotation for maintaining the fertility of the rice production areas;
* research to identify new varieties of irrigated (and rainfed?) rice for the high-altitude areas.

Triticale

Triticale was first introduced by IDRC (Canada) in 1977 and then by CIMMYT in 1979. It is too early to draw any conclusions from the trials now under way, but first results seem to indicate that triticale is better adapted than wheat to Rwanda's ecological conditions. It gives higher yields, is more disease-resistant and less subject to bird attacks. Furthermore, the Rwandan consumers seem to like it. It might become an important crop in the high-altitude regions. Research should continue to focus on genetic improvement, especially a better filling of the seed and better protection by the glumes. The proper integration of this crop into the farming systems of the high-altitude regions should also be studied.

Wheat

Wheat research must be continued alongside research on triticale. Wheat is well established in the high-altitude areas and has unquestionable potential. Yield-limiting factors are mainly diseases, (especially yellow rust), low sowing rates, lack of weeding, and poor soils. Workers in the IDRC-supported ISAR program, with CIMMYT, have identified two new rust-resistant varieties. Expansion of this monocrop will depend on the distribution of adequate quantities of seed to the farmers.

Research could focus on:

* continuation of the breeding program to identify disease-resistant varieties;
* study of different crop associations;
* study of optimal fertilization.

Sunflower

Sunflower could be important in the high-altitude regions as a source of vegetable oil. IDRC is supporting ISAR in its research on this crop. The variety Odryfele has shown promise in tests carried out at the Rwerere and Tamira stations. Production is impeded by fungal diseases, bird attacks, and -- for tall varieties -- lodging.

Sweet potato

The sweet potato has developed magnificently during the last decade and can now be found in nearly all the regions of Rwanda. The area cropped has been increased by 81%, production has risen by 130%, and yields have gone up from 5.2 to 7.6 t/ha.

The farmers now have varieties that are well adapted to the different agro-ecological conditions of Rwanda. The varieties produced at the stations are barely superior to the local varietal mixtures used by the farmers.

Nonetheless, mixing varieties can sometimes create problems: clones combined in a mixture may have different growing cycles; early-maturing varieties are harvested at the same time as -- unripe -- late-maturing varieties. Yet, mixing varieties is one type of guarantee against the vagaries of climate and disease.

Although the practice of growing local varietal mixtures seems to reduce crop damage, further research is needed on certain diseases (viruses, anthracnose) and pests (weevils, *Cylas* spp. and the *Acraea acerata* caterpillar) which are still far from being under control.

Research on this crop is worth continuing and even strengthening (see last paragraph under Cassava, below).

Cassava

Cassava came from Zaïre in the 1940s and spontaneously spread throughout the country, especially on the poor and semi-arid soils. During the last decade, the area devoted to cassava and the production figures have both nearly doubled. Average yields are about 13 t/ha.

As with the sweet potato, the number one problem is plant health, the main diseases being mosaic, *Xanthomonas manihoti*, and *Cercospora*. The worst pest is the green mite *Mononychellus tanajoa*. The first task to be undertaken should probably be to produce virus-free cassava propagating material and organize its large-scale distribution.

Current research conducted jointly by ISAR and IITA is mainly designed to develop cultivars adapted to the various ecological conditions, with special attention to plant health problems. As yet, the bitter Eala 07 variety, introduced from Zaïre in 1937, is still the best.

ISAR, together with IITA, has prepared a comprehensive national sweet potato and cassava improvement program that covers all relevant research and development questions.

Potatoes

Potatoes were first introduced some 60 years ago, but have been slow in making inroads. In 1970, some 136,000 tons were produced on 20,000 ha. Since that time the area planted has been increased to 32,000 ha, and the output has nearly doubled. The main inhibitors to production are plant diseases, Pseudomonas solanacearum (bacterial wilt) and Phytophtora infestans (late blight), and virus diseases. Another important problem is producing and storing healthy seed.

The National Potato Improvement Program (PNAP -- Programme National pour l'Amélioration de la Pomme de Terre) was set up in 1979 with the assistance of CIP, to tackle the manifold aspects of potato production:

* introduction and evaluation of germplasm: since 1979 over 7,000 different genotypes have been tested;
* agronomy and physiology: trials on plant spacing, seed calibration, germination, fertilization; vanguard research seeks to replace potato tubers by true seed in plant multiplication (on the station, yields with tubers and seed have been comparable);
* pathology: study of disease-tolerant varieties and fungicides (trials have shown that mildew can be controlled at a reasonable cost in the rural areas);
* seed production: over 500 tons of seed, mainly of the Sangema and Montsama varieties have been produced; 260 t have been sold to the seed multiplication service (SSS) and to development projects; new Rwandan varieties will be multiplied and distributed starting in 1983.
* storage and processing;
* training and extension work: PNAP has trained over 150 people and laid out and harvested more than 100 demonstration plots in about 10 different Communes.

Throughout these multifaceted operations, emphasis has been placed on the use of new varieties, compost, fungicides, and good storage. The program has produced satisfactory results; the secret has been, to tackle all the production problems, not only the problem of genetic improvement.

Since potatoes are grown only in a small part of the high-altitude region but are consumed throughout the country, a unique large-scale transportation and marketing effort has developed and now encourages farmers to increase their production and adopt innovations coming from research more readily. There is a great need for a study on potato marketing.

Industrial crops

Coffee

Arabica coffee is grown on small estates in almost all the regions of Rwanda below an altitude of 1,800 m. Approximately half the Rwandan farmers produce coffee; the average per farm is 150 coffee trees, covering an area of 0.08 ha. Between 1960 and 1980, the area of land devoted to coffee production rose from 15,000 to 32,000 ha, but the average yield per tree dropped from 520 to 400 g of parchment coffee.

The Coffee Authority ("OCIR-Café") considers that these yield drops have been caused mainly by the following factors:

* Insufficient mulching. Mulch is recommended as a soil cover. The heavy population pressure on land resources has led to a decrease of land in fallow and substantial reclamation of swamplands, thus causing hay and straw production for mulch to drop sharply. No alternative system has been developed to protect the soil. As a result, the soils in the coffee-growing areas, often sloped, have deteriorated.
* Poor cultural practices, especially in pruning and harvesting.
* Losses from Antestiopsis. Effective control measures do exist but are not well applied by the farmers; further, there is the possibility that the insect has become resistant to the insecticide now being used (Sumithion).

ISAR has a collection of coffee varieties at Rubona. It has bred new varieties, some of which have been distributed for many years in certain regions where they proved to be more productive (Jackson and Bourbon Mayaguez 71 and 139). The superiority of these lines over Mibirizi, the first variety to be imported into Rwanda, has been demonstrated at Rubona, but some scientists feel that multilocation trials are needed in the other regions for full confirmation. Planting density trials have not yet produced conclusive results.

As part of the coffee and food crops project (Projet de Développement de la Caféiculture et de la Production Vivrière) in the area around Lake Kivu, a research agreement has been negotiated between OCIR-Café and ISAR as one partner and IFCC as the other.

The OCIR experience suggests that the following research themes could affect production the most rapidly:

* the development of cover crops to stop soil deterioration;
* increased planting density: interplanting with young coffee shrubs in the existing coffee plots has been suggested as an effective way to increase yields;
* plant protection: research is needed to identify an insecticide that could replace Sumithion to control Antestiopsis; it would also be advisable to study an appropriate integrated or biological control method.

Maximum use should be made of the results obtained from selection and from research on the use of manure and mineral fertilization in both Rwanda and Burundi during the last 20 years.

Tea

Tea grows in a multitude of ecological conditions (swamps, hillsides) and at altitudes of up to 2,300 m. There are about 9,000 ha of tea in Rwanda. All the tea plantations have been developed through special projects that received sound technical assistance during the introductory phase. About 90% of the tea is grown on large estates, the rest by small farmers. Total production is about 7,000 tons, the average yield 700 kg/ha. Rwanda imports high-quality genetic material from Burundi, where tea research is fairly well advanced.

Because of supply and cost problems, little fertilizer is used, which explains the current low yields. Increased tea yields are important because most tea factories are under-utilized, and land is at a premium.

Consequently, priority research themes for tea should be:

* the study of nutrient absorption through fertilizer application in each of the regions naturally suited for tea production;
* the study of nitrogen obtained from legumes used as cover plants, shade, or anti-erosion hedges.

Cinchona

Rwanda has about 2,000 ha of cinchona (1,400 ha on large plantations and 600 ha on small farms) as a result of a promotion program conducted by OCIR since 1976.

During the last five years the world market for cinchona bark derivatives has narrowed considerably, which has forced OCIR, the organization responsible for marketing, to stop all purchases of cinchona since it became impossible to pay profitable prices to the producers. When the alcaloid extraction plant begins turning (in 1983) Rwanda may become competitive again on the world market .

The cinchona program suffered most when the seedbeds were destroyed by fungal diseases (damping off), but this problem has nearly been overcome. There is a potential risk of canker of the bark (Phythophtora sp.), but as yet no major damage has occurred.

Research should give priority attention to incorporating cinchona into farming systems on small holdings, especially by intercropping food crops or soil-improvement plants in young cinchona plantations.

Sugar cane

Rwanda has only one sugar cane plantation. It is located at Kabuye near Kigali at an altitude of 1,600 m, in a valley bottom, and covers close to 600 ha. It produces 2,300 to 2,400 tons of refined sugar per year. The cane takes two years to mature, and the yield is 100 t/ha of cane, i.e., an average of 50 t/ha per year, with a sugar content of 9.5%. The plantation and refinery were established through foreign technical assistance, which stopped in 1972. Varieties introduced prior to that date got mixed and now need to be purified.

Five varieties have just been imported from Tanzania and are at present under observation. During the last five years, yields have dropped from 130 to 100 t/ha, probably because of loss of soil fertility.

Besides variety trials, any research on sugar cane should be devoted to soil fertility.

Other industrial crops

In Rwanda, the production of pyrethrum, sisal, tobacco, ramie, and brewer's barley is governed mainly by economic considerations. For the time being, high priority should not being given to research on these crops.

The Rwerere station, however, should remain informed of progress in ramie production, which is growing rapidly in the north and is being studied by the Ministry of Agriculture in the Rugezi swamp.

Forestry

Natural forests are now found only in the high-altitude zones (Nyungwe, Gishwati, volcano chain in the north) and some savanna areas, especially in the Bugesera. The high-altitude forests are rather well protected, but in the savanna, the tree population was nearly wiped out during the last 10 years. Deforestation of the savanna has been caused by the growing demand for charcoal, mainly in Kigali, and by crop encroachment. There is a severe nationwide shortage of both construction timber and firewood. In fact, the shortage of firewood is so serious that many farmers use agricultural waste for fuel, which further depletes the soil. Some 60,000 ha of forest have already been planted in an effort to overcome this shortage, and the figure is to rise to 100,000 ha by 1986.

Research should first and foremost be directed to reducing the huge gap between production (of timber and firewood) and consumption. This objective has been well covered in the ISAR Technical Note entitled, Planning Forestry Research in Rwanda (No. 2, 1980), which emphasizes the importance of:

* knowledge of tree species;
* forest tree seed (selection of mother trees and creation of seed plots);
* sylvicultural techniques (mainly upkeep of plantations);
* market surveys;
* wood technology;
* management of natural forests;
* research on diseases and insects harmful to fruit trees, especially exotic species.

Certain complementary subjects could be added:

* Research on the importance and role of the tree in agricultural production systems must be included in order to associate trees and crops rationally. New species must be introduced, bearing in mind both their potential importance in the cropping system (restoring fertility, effects on the water balance, creation of micro-environments, etc.) and their productive capacity (wood, fruit, fodder, etc.).

* If research on fodder trees is not planned, there is a risk that livestock will be forced off the agricultural smallholdings in Rwanda. At present, fodder trees are not deliberately grown in Rwanda. In fact, few species adapted to the country's different ecological zones are currently available, and there is in Rwanda little information on fodder tree species that would be worthy of introduction into Rwanda;

* Reforestation programs have conferred a priority to the Eucalyptus as a wood-producer without giving enough attention to other criteria, such as restoration of soil fertility and the effects of the plant canopy on the water balance.

* Very high priority should be given to research on alternative sources of energy -- sun, biomass, wind, biogas, methane, peat, etc.

Fruit trees

Rwanda produces little edible fruit. The avocado and, on a smaller scale pineapples, are the only exotic fruits that have developed spontaneously. Citrus crops prospered until 1960, but then were wiped out by "tristeza" and "greening," probably the two combined.

The avocado tree was imported into Rubona 40 years ago and spontaneously spread, but tree yields are very uneven. The fruit is highly palatable and nutritive. Large quantities are found in the Rubona region. ISAR has built up a remarkable collection of avocado genotypes, many of which can already be considered as a very valuable grafting stock. When disseminating grafted trees, care needs to be taken to distribute a mixture of genotypes in order to ensure good pollination (and hence fruiting) and protection against diseases. In general, the farmers seem to prefer grafted trees to seedlings which mature later and are more variable.

Introduction of new plant species

Reference is often made to the need for programs that focus on the genetic improvement of existing crops, seldom to the possibility of introducing new species. Yet, it is often easier to solve the problem of adapting plants to the extreme conditions encountered in high-altitude agriculture and in the semi-arid zones by introducing new species, rather than by the selection of existing ones, just as it should be easier to diversify food, fodder, and industrial crops through the introduction of new species adapted to the diverse agroclimatic conditions and to national needs. For instance, for the high-altitude areas thought should be given to introducing fruit trees from temperate zones or from other high-altitude tropical regions; for the semi-arid regions there are many unexplored possibilities in the area of "multipurpose" and fodder trees.

2. Animal production

The Rwandan livestock figures have changed as follows over the last decade:

	1970 (thousands)	1980 (thousands)	Change %
Cattle	752	634	- 16
Goats	480	885	+ 84
Sheep	185	295	+ 59
Pigs	55	120	+118
Poultry	510	1020	+105
Rabbits	55	134	+144

These figures clearly show the major trends: a slight drop in the cattle population and a big increase in the small stock. These trends, which are the result of the increase in the croplands at the expense of the grazing lands, unfortunately can be expected to continue.

Cattle

Areas traditionally reserved for extensive stockfarming are steadily growing smaller. The high mountain rangelands (Zaïre-Nile Crest) are deteriorating, and the eastern savanna is rapidly being invaded by agriculture.

In the Third Five-Year Development Plan (1982 to 1986), the cattle herd is expected to continue declining and level off in 1986 at 500,000 head.

With the rapid drop in both quality and quantity, the grazing lands will not be able to sustain this many head unless an increasing part of the stock is raised with zero-grazing. Raising cattle for meat production will also be impossible. If feed concentrates are made available, they will probably be used for pigs, poultry, and rabbits; cattle raised under traditional conditions will be mainly fodder-fed.

This means that Rwandan farmers primarily need dairy cows fed on farm-produced fodder with zero-grazing. This will require research on fodder crops, although studies should continue on the possibility of using by-products from the farming units and the agro-industries.

Breeding programs for the Rwandan Ankole have been underway since 1945 and have demonstrated that the Ankole is better adapted to Rwandan conditions than the Sahiwal. Until 1976, emphasis was placed on meat production, thereafter, on milk production. Results to date indicate that the Ankole has a good potential for milk production. The breeding program should be continued.

The Ankole x exotic breeds improvement program started around the 1950s. Results, especially as concerns milk production, were positive. The difficulties encountered in distributing crossbred Ankole x Jersey, Ankole x Sahiwal, or hybrids of all three stemmed from inadequate intake facilities in the rural areas (hygiene, nutrition, cattle dips, etc.). If an agricultural intensification policy involving cattle is to succeed, good dairy cows raised under zero-grazing conditions are needed as a source of both milk and manure (milk being the only product the farmer can sell to compensate him for his efforts). The Ankole should be bred to develop its milk potential and also as a component of a crossing program targeted to stabilize a bona fide hybrid breed. It is often argued that there is no place for highly demanding crossbred animals in the Rwandan context. However, the counter-argument could be that even the improved purebred Ankole dairy cow, which at best will become available in some 15 years, will have great difficulty in overcoming the off-station conditions in the rural areas as they exist today. Hence, improved farm hygiene, nutrition, and health are preconditions to the survival of crossbred and improved purebred cattle alike.

Goats

As available lands become rarer, farmers tend to replace their sole cow by a goat or two which explains the 100%-increase in the goat population over the last 10 years. Goats fit well into the farm setting, thanks to their organically rich droppings and their capacity to subsist on farm waste. Studies have indicated that the genetic potential of the local

Rwandan goat is worth developing through a selection program. The very small selection program ISAR has been running for the last few years should be expanded so that it can produce significant results. Problems related to a stall-fed goat production program merit special attention.

Sheep

There are about one-third as many sheep as there are goats, although flock numbers have risen about 60% over the last 10 years. Sheep, mainly found in the north, are reared for their meat, which is now considered almost as palatable as goat's meat.

In the past, little research was carried out on sheep. In 1975, an ISAR study of the genetic potential of the local breed showed that sheep have low demands and are better converters than goats of the kinds of feed available on smallholdings. In general it is easier to penfeed sheep than goats.

As has been suggested for goats, it would be advisable to draw up a good selection program for local sheep and study their behavior under pen-fed conditions.

Other small animals

During the last 10 years, the number of pigs, poultry, and rabbits has more than doubled. All these animals are likely to become increasingly important in the future because of their capacity to adapt to small agricultural units.

Research on these animals is new and is conducted under the National Center for the Production of Small Farm Animals (Centre National du Petit Elevage), a project that deals with all aspects of production, from the provision of animals and technical guidance for farmers to the production of nutrient concentrates, health control, slaughtering, and marketing.

The main problem is animal nutrition. The ingredients for animal feed are either by-products from industrial processing (wheat or rice bran, molasses, blood and bonemeal from the Kigali slaughterhouse, cotton seed cake imported from Burundi), of which only limited quantities are available, or food crops that could be used for (and therefore compete with) human consumption: maize, soybeans, cassava, beans.

It would be well to carry out more research on:
* animal nutrition;
* animal health, especially prevention of poultry typhoid;
* animal physiology, especially fertility of pigs and rabbits.