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Rwanda Farming Systems Research Program
Technical Paper Series

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between

The University of Arkansas, Fayetteville
(International Agricultural Programs)

and

The Rwandan Ministry of Agriculture
Rwandan Institute for Agricultural Sciences (ISAR)

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Preliminary Diagnostic Survey of Five Communes of Ruhengeri Prefecture, Rwanda

Steven Franzel, K.B. Paul, Barbara Yates,
Donald Voth

Report # 6

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Preliminary Diagnostic Survey of Five Communes of Ruhengeri Prefecture, Rwanda

Steve Franzel, K. B. Paul, Barbara Yates and Donald E. Voth.

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I. INTRODUCTION

This document provides a preliminary description of the farming system used by farmers in the Ruhengeri prefecture of Rwanda. The area has been selected for a farming systems research project that will be a cooperative effort of the Government of Rwanda (specifically, l'Institut des Sciences Agronomiques du Rwanda, ISAR), USAID and the University of Arkansas as the lead institution among a group of U.S. universities. In January and February of 1984, a team of six persons from these universities, with the assistance of Dr. Steven Franzel of Development Alternatives, Incorporated, prepared the Project Paper for this project, under contract with USAID. This "Diagnostic Survey" is one of the products of this project design process. Since it provides a preliminary description of the farming systems of the project region, it should be useful to project staff and also to others involved in similar farming systems projects. It is for this reason that it is published here as a separate document.

A. Background

1. Situation

Rwanda is a landlocked country with an estimated area of 26,338 km^2, and is located between 1°5' and 2°50' south latitude, and 28°5' and 30°5' east longitude. The country is characterized by a series of sharply defined hills with steep slopes and flat ridges intersected by deep valleys with marshy plains at the bottom. The project area lies in the Ruhengeri Prefecture, one of the ten administrative subdivisions within the country, and covers an area of 1687 km^2. This prefecture is divided into 16 communes. The Ruhengeri region is characterized by a generally cool, humid climate. Average annual temperatures vary from 15° to 18°C. Rainfall is distributed bimodally, with a short rainy season from September to December, followed by the principal wet season from February to May. Total annual rainfall in the prefecture increases from east to the west and varies between 1200 and 2000 mm. The Ruhengeri Prefecture can be subdivided into five ecological zones. The four communes in the project lie in the ecological zones of the Buberuka Highlands (zone 6) and the Central Plateau (zone 7).

Rwanda is one of the poorest nations in the world, with a per-capita GNP at US$ 239 in 1982. Over 95% of the population lives in rural areas, mainly engaged in subsistence agriculture. Rwanda is Africa's most densely populated country, with 380 persons/km^2 of land and an estimated population of 5.5 million. The present annual population growth rate is about 3.7%. The first-year infant mortality rate per 1,000 births was 127 in 1982, and the 1981 life expectancy at birth was 45.6 years. The adult literacy rate is estimated at only 23%.

The traditional socio-political system of Rwanda was based on three factors: the hierarchical Tutsi-Hutu caste division, a strong family rather than communal organization and the superiority of the male as expressed in the customs of patrilineal descent and paternal authority. Since achieving independence in 1962 and a gradual shift toward a monied economy, the caste division has changed substantially. The egalitarian base of the new government is constitutionally reinforced, and the resourceful Hutus, using their educational opportunities and administrative and technical skills, are seeking full economic and social equalities.

Over 90% of the Rwandan labor force is engaged in agriculture. Almost each of Rwanda's approximately 1 million farm families operates a complex farming system on a mere 1.15 ha of land. Main food

crops grown are beans, bananas, sorghum, sweet potato, maize, Irish potato, cassava, peas and colocase. Intercropping of food crops is a common phenomenon. Because of the country's year-round mild temperature and fairly good rainfall and rainfall distribution, crops are grown throughout the year. Coffee is the most important export crop, earning about 60% of the country's foreign exchange, while tea, pyrethrum and cinchona also contribute in maintaining the country's trade balance. In addition to crops, Rwandan farmers also raise some livestock and poultry. Cattle are generally owned by the wealthier farmers, while goats, sheep and pigs can be seen in many farm households.

Historically food production has kept pace with the increasing population through bringing more land into production. These newly farmed lands are mostly marginal and infertile. The productivity of land is generally decreasing because of soil erosion, shortened fallowing and lack or absence of manure and fertilizer inputs.

Farm production is oriented toward subsistence crops, and little surplus is available for marketing. Inadequate storage and transportation facilities reduce commercial supply even further. The gradual increase in crop production area has considerably reduced both pasture and forest lands.

2. Future outlook

The principal causes of poverty and leading constraints to Rwanda's development are the lack of agricultural technology and extension, limited trained manpower and physical infrastructure, high population pressure, poor off-farm employment opportunities and land-locked geographical location.

The Government of Rwanda (GOR), in its Third Five-Year Economic, Social and Cultural Development Plan, 1982-1986, emphasized strengthening of the agricultural sector of the economy. This is understandable, given the magnitude and urgency of the problem (Chang, 1983). A rapidly increasing population and the shortage of arable land in a predominantly subsistence economy mean that a rapid increase in productivity per unit of land is urgently needed. This task, although it seems formidable, could be realized through GOR's determination, institution building, adaptive research, and through an effective extension service.

B. The Project within the Context of the Country Development Strategy Statement (CDSS) and GOR Development Plans

The Farming System Improvement Project (FSIP) follows directly from and is consistent with both the FY 85 Rwanda CDSS and the current (1982-1986) GOR five-year plan. The goals of AID programs in Rwanda are (1) to increase per-capita food production through appropriate interventions at the national and farm levels; and (2) to effect a general improvement in the health status of the Rwandan family. Over the next five years, GOR has as a major goal the intensification of agricultural production. Specifically, the four following goals are identified in the five-year plan:

*To achieve food self-sufficiency both quantitatively and qualitatively,
*To promote employment sufficiently remunerative to satisfy basic needs and education and/or training for each Rwandan, allowing him or her to be able to fully play his or her part in the country's economic and social life,
*To promote the level of health of the population, the assurance of housing, the production of mass consumer goods and the development of a cultural life,
*To develop Rwanda's external relations in the sense of reducing isolation of the country and achieving a balanced foreign trade.

To realize these goals, the plan proposes to focus upon increasing national production and productivity, especially in agriculture. Increased production can be achieved only through increases in yields, given current limits on land availability. This will require, it is recognized, provision of agricultural inputs but, even more important, redirection and strengthening of Rwanda's agricultural research and extension institutions.

AID responses, as identified in the FY 85 CDSS, address these issues directly by focusing upon technology generation and transfer and upon the institutions responsible for these functions. The main components of AID's strategy include:

*Approaching agricultural research on the basis of ecological zones and identifying productivity-limiting problems spanning regions;
*Developing regional networking;
*Making a long-term commitment to strengthening national agricultural research institutions;
*Establishing longer-term links between national and regional research institutions and U. S. universities;
*Focusing research on systems of production (as well as on specific commodities) by supporting a farming systems approach to adaptive research, technology development and extension.

The FSIP, then, is the first phase of a proposed commitment to introduction of the farming systems approach to agricultural development and research in Rwanda. Because of the seriousness of Rwanda's projected food production problem, and because of the need to build basic agricultural research and extension institutions, it is anticipated that the process undertaken by the FSIP will require a commitment of at least another five years after the project is completed.

C. Preparation

Part of the responsibility of the Project Paper Design Team for the Farming Systems Improvement Project (FSIP) (formerly referred to as the Cropping Systems Improvement Project) was to perform a preliminary diagnostic survey of the constraints to and opportunities for increases in agricultural production in the five project communes of Ruhengeri Prefecture in the northern part of Rwanda (Butaro, Cyeru, Nyamugali, Nyarutovu and Ruhondo)[1]. This paper presents the results of that survey.

Approximately three weeks were spent preparing, executing and writing the survey during the project paper design process, which took place from January 14 until February 23, 1984. Results are preliminary and should not be viewed as a substitute for the implementation team's own diagnostic work. Rather, the survey should be used to guide the implementation team's own diagnostic survey and to provide hypotheses to be tested.

D. Purpose

The specific purpose of the preliminary diagnostic survey was to gather data on agricultural practices, relevant institutional linkages and agronomic, economic and social factors related to agricultural productivity and economic welfare of small-scale farm households in the project area. The survey team sought: (1) to describe the major types of farming systems and ecological zones, (2) to describe farm characteristics, including farming practices and trends, (3) to identify farmer-perceived constraints and (4) to make recommendations useful to the FSIP implementation team.

E. Procedures

Questionnaire planning began at the University of Arkansas during the late fall of 1983 and was continued by the survey team in Rwanda in mid-January 1984. Utilizing the Farming Systems Research and Extension (FSR/E) preliminary diagnostic model developed by Collinson (1982), supplemented by a household study questionnaire previously used by a member of the Arkansas team, a strategy for interviewing was devised. A short list of demographic, agronomic and attitudinal questions was developed to be asked of all farmers. A further set of topics was included that addressed (1) cropping patterns and trends, (2) the agricultural calendar and food preferences, (3) production methods and output variations, (4) agricultural resource availability (land, labor and cash), (5) crop and livestock husbandry, (6) time and task allocation within the farm household and (7) farmer-perceived constraints to agricultural productivity. The whole set of seven topics was not pursued with all farmers. Rather, each of the seven topics was explored in-depth with at least two farmers.

The actual survey took place January 23 to February 1, 1984, in the five project communes. The survey process was as follows. The team made courtesy calls to the Sous-Prefet and Prefet explaining the purpose of the survey. Cables announcing the team's arrival were then sent by the Sous-Prefet to the

[1]Originally the project was to include these five communes. During the design phase, Ruhondo was deleted. However, the survey was still performed in all five. Consequently, subsequent references may include either four or five communes.

bourgemasters of the five communes to be visited. The team split into two groups for the fieldwork. Discussions were held in turn with each bourgemaster and with the communal agronome. Selected farms (2-4 per day by each team) were then visited. Initially, efforts were made to select farms of average size (1 ha), off the main roads, farmed by a family of "medium" economic status. As many sites as possible were selected at random and not chosen by the escorting agronome. As information in the field was gathered, the range of farms selected was broadened to include those of different sizes and economic statuses.

Interviews with farm families lasted one to two and a half hours each. Twenty-three farms were visited. Members of the team also visited selected schools (ecoles primaires Grades 7 and 8, and CERAIs), adult rural education centers (Centres Sociaux de Developpement), traders, market officials, extension staff, church mission staff and representatives of other institutions involved in rural development in the project area.

F. Organization of the Report

The survey report is divided into five sections. The first is a description of the physical, socio-economic and institutional features of the communes targeted to be served by the FSIP. The second section describes "recommendation domains," or the grouping of farm households into several homogenous categories or types exhibiting similar physical and social characteristics. The third section describes and analyzes the inputs, outputs, resource management and farm practices utilized by the farm households. The fourth section describes and analyzes principal agronomic, economic and social constraints to increased agricultural productivity. Finally, ideas are offered for improving farming practices to increase agricultural productivity and household economic welfare. Suggestions are also made about solutions to institutional constraints.

II. ENVIRONMENTAL FEATURES[2]

A. Physical/Biological

The Republic of Rwanda is divided administratively into 10 prefectures of which Ruhengeri is one of the northernmost. The prefecture of Ruhengeri, in turn, is divided into 16 communes. Five of these communes in the eastern quadrant were visited by the field survey team. However, since the project area was reduced to four communes during the project design process, statistical data presented below are based on only the four project communes.

According to Delapierre (1982), the entire communes of Butaro and Cyeru, almost all of Nyamugali and a part of Nyarutovu fall in the Buberuka highlands zone, while the remainder of Nyarutovu lies in the central Plateau zone (agro-ecological zones of 6 and 7, respectively). In fact, the line between the two zones is fairly arbitrary--the 1800 m isohyte--and parts of each commune actually belong in each zone. The total land area in these four communes is 602.6 km^2, and the altitudes vary from 1500 to 2500 m with an average altitude of about 2000 m.

1. Climate

The climate of this area is generally cool, with an average annual temperature of about 17°C. The daily fluctuation of temperature is rarely more than 12°C, and there is only a slight temperature variation during the 12-month period.

Annual precipitation at Rwerere station averages 1100-1200 mm, as shown in Table 2.1. According to reports at the commune level, the area's annual precipitation ranges from 1100 to 1650 mm, but it is not clear that accurate data is available for anywhere except Rwerere. There are two rainfall seasons: the principal rainy season between March and May and the short season between late September and December (see Figure 2.1) The major dry season runs from June through the middle of September. Long-term evaporation at the Rwerere Colline (upper station) and at the Rwerere Marais (lower station)

[2]More detailed information on social organization, marketing, educational institutions and private voluntary organizations is available in Appendix 1.

has been recorded as 1015 mm and 836 mm, respectively, well below the annual precipitation. Moderate temperature and moderate solar radiation help to maintain this positive water balance. Figure 2.2 shows the net gain/loss of soil moisture content at different periods of the year. Drought appears not to be a significant crop production constraint in these communes (ISAR, 1980).

2. Soils

Oxisols represent the dominant soil order in the Buberuka highlands, interspersed with lithic entisols on quartrite ridges. These soils are generally considered good for agricultural production. They are, however, subject to very high erosion risks, if not managed properly.

The soils in the four-commune area vary considerably in both color and texture. Most of the hill slopes and valleys are being extensively cultivated, and soil erosion of extensive magnitude appears to be a major problem. Despite heavy soil losses, there still is considerable depth of workable soils left on the hill slopes. This was evident in several recently dug compost holes on the farmers' fields and from observing the hillsides along the roads. Only on a few isolated fields could some exposed rocks be seen.

Most of the soils in the area are apparently well-drained, except for the bottom lands, where crops are grown on raised beds. These bottom lands appear to be very fertile, with extremely high organic matter content, so much so that they gave a cushiony feeling when walked on.

Principal crops grown in the four-commune area can be divided into two groups based on altitude, although some overlapping exists for a few crops (Table 2.2). For example, up to a dividing line of about 2000 m, sorghum dominates over maize. However, over 2000 m, maize is the dominant crop, although both crops can be found on both sides of the dividing line.

B. Social/Institutional

Each commune is sub-divided into sectors and these in turn into cells (Table 2.3). Cells are further broken down into "hillsides" (collines).

1. Socio-Economic Context

The basic unit of analysis for the survey was the small-scale farm household of which there are approximately 30,000 in the four communes. The population of the four communes is about 175,000, which is relatively evenly divided among the four communes. The population growth rate (1979) ranges from -1.5% in Butaro to between 3% and 6% in Cyeru. Estimates of population growth rates for Nyarutovu and Nyamugali are from 1.5% to 3%. The bourgemaster of Butaro was unsure of the reasons for the negative growth rate in his commune. An analysis of age cohorts for the commune indicates that the percentage of the population under age 15 is only 30%, well under the national average of 50%. The drop could be explained by a decrease in the birth rate and/or an increase in infant or child mortality, since migration rates of all age groups are reported to be minimal. Moreover, the average life expectancy appears not to have substantially increased. The more probable explanation, however, is the lack of reliable data.

Social organization of the family is patrilocal, patrilineal and patriarchal. Upon marriage women leave their natal family to reside with their husband in a separate dwelling close to his family. Land and other capital assets pass from father to son(s).

It is unclear whether a dual economy exists within the farm family in the sense that men and women have separate and different responsibilities for certain major family expenditures, such as those for school fees, school uniforms, shoes, clothing for children and the purchase of non-food products at the market. Interviewees gave vague and sometimes contradictory responses to questions concerning the control of money within the family.

Just over 20% of households are female-headed (USAID, 1982) due to divorce, death or desertion.[3] Female-headed households visited noted an acute shortage of labor due to the lack of male help. One dealt

[3]There is apparently little male migration to work in the mines from the four communes. In one young family interviewed, however, the husband had begun going back and forth to Kigali in search of unskilled employment. During the times of his absence (sometimes for several weeks), the burden of farm management and labor fell to his wife.

with the problem by letting fields lie fallow, another by exchanging labor with a household with a male present.

The general impression of the educational level of the farm families visited is that it is well below the official figure for the national average of literacy or participation of the relevant age cohort in formal schooling (59.8% nationally in 1980/81 and a reported range of from 43% to 65% for the four communes in their respective Monographie Communale.)[4]

2. Agricultural Labor

The basic unit of agricultural production is the nuclear (or polygamous) family. The average family size is 5.3 persons, of whom 2.6 are in the productive age range of 15 to 64 years. Children much younger in age, however, engage in herding, harvesting and transportation of produce from the field to the home.

a. Crops. While there is gender and age differentiation in the allocation of tasks and time devoted to agricultural production, the general impression is one of considerable household cooperation in the planting, care and harvesting of the major food staples (beans, sweet potatoes, Irish potatoes, peas and sorghum) in the four communes. As Table 2.4 indicates, the cultivation of Irish potatoes is the principal responsibility of males while sweet potatoes are the responsibility solely of females. Beans, peas and sorghum (as grain) are more nearly family enterprises, although women usually market the beans and peas and men predominate in the marketing of sorghum. Subsidiary crops (maize, wheat, barley) are also worked by most family members.[5] Bananas and sorghum are also grown for beer production, a predominantly male enterprise. Newly-introduced vegetable crops tend to be the responsibility of adolescent boys and girls, who have frequently learned about the cultivation of the crop at school (Grades 7-8 in primary school, or the CERAI or CSD). Some respondents indicated that fathers show an interest if there appears to be any commercial market for the new produce.

Farm labor is also to some degree gender and age differentiated by task as well as by crop. With the exception of bananas, weeding is a female task, while men predominate in clearing land. With the exception of bananas, sorghum and Irish potatoes, both men and women, assisted by teenagers, participate in the heavy work of preparing the soil even in the swamp areas. With the exception again of sorghum, women predominate in the harvesting of grain crops (maize, wheat, barley), beans and peas. Fertilizing is done mainly by adults, while all family members help to transport produce from the fields to the home. It is quite common to see children 5 or 6 years old carrying large headloads along the roads and paths. Both men and women do seed selection.

If the household has sufficient cash, hired labor may be used, usually for the morning (7 a.m. to noon). Daily wages for weeding (women) and harvesting (men and women) are from 40 FRw to 50 FRw; for heavier work, men usually earn 60 FRw.

Labor exchange is a frequent occurrence. It works in two ways. About 10 men or women on a particular colline may form a group and work on each other's fields in turn; or such a group may ask communal authorities for a piece of land to cultivate. This would usually be swamp land. The group then cultivates the land together (see the section below on land).

b. Livestock. The principal animal population includes cattle, sheep, goats, pigs and chickens. Evidently only a few families keep pigs. Rabbits were introduced recently. With the exception of pigs and rabbits, most animals are not penned. The care of livestock is the responsibility of children, especially young boys. Before children come, the husband usually does the herding. When children come, if there are no boys, then young girls assume the responsibility. On occasion, older men become shepherds, especially for the larger animals, such as cattle. Some informants noted that if animals are an important element in the farm household economy, one boy in the family might be kept out of school to herd them. If the animals are penned, then all members of the farm household share in the search for food and the provision of water.

[4]These are small monographs that communale officials are required to have and to update periodically. They contain basic information about the population, social organization, economy and institutions of the commune.
[5]Men primarily do the threshing of grain, women the winnowing and grinding.

3. Marketing

There are about two to three markets per commune, and these markets function from one to three times per week.

Market prices are not available for the project area; however, we obtained some prices from residents of the area that should be indicative of approximate levels and annual cycles. The data are summarized in Table 2.5

The data show that prices fluctuate greatly between different months of the year; the ratio between highest and lowest price is between 2 and 3 for most crops. Highest prices are recorded at planting time and just before harvest; lowest prices are during harvest periods. The tremendous fluctuation in prices underscores the importance farmers attach to providing food from their home stocks rather than purchasing foods on the market.

It is interesting to note that prices of many crops that have high seed requirements--Irish potatoes, beans and peas--actually peak during the planting season, not just before harvest. This supports the finding that many farmers exhaust their stored supplies before planting time and bid up the price in order to obtain seed.

4. Credit

Institutional credit is not available to small farmers in the project area. Several banques populaires operate in the zone, but in fact, the services they offer are very limited. Only farmers with deposits are able to take out loans, and the procedures for borrowing money for agricultural purposes are very tedious. In fact, only a tiny percentage of loans taken out are for investment in agriculture; most are for off-farm businesses and building houses.

Money lenders, per se, do not operate in the project area. Farmers may sometimes borrow money from a friend or relative, but the practice does not seem to be common. However, many farmers are members of traditional savings societies in which members contribute a fixed amount each month and take turns collecting the entire sum of contributions. Funds are generally used for house construction; little appears to be invested in agriculture.

5. Agriculturally Related Institutions

a. The Ministry of Agriculture Extension Service. The extension service in the project area includes 4 Agronomes de Commune (A2 level), one for each commune, and approximately 25-30 moniteurs, or about one for every two sectors. Given a population of 175,000 persons and 5.2 persons/family, the ratio between families and extension workers is approximately 110 to 1. In addition, there is a veterinary monitor in each commune in charge of a small veterinary dispensary.

Agronomes (A2 level) have a primary school education plus 6 years of training at an agricultural training school; monitors have a primary school education plus 3-6 months training.

The primary components of the extension program include planting in rows, composting and manuring, planting grass on contours, keeping to the crop calendar and managing tree/grass nurseries. Seed is distributed very infrequently--the seed selection service does not provide seed very often in the area. Principal problems noted by extension service personnel include lack of transport, lack of work materials and lack of space for holding meetings. Extension agents focus their activities on selected model farmers, 20 per cellule.

b. The Rwerere Research Station. A major agricultural institution in the project area is the branch research station of l'Institut des Sciences Agronomiques due Rwanda (ISAR) that is located at Rwerere. This station engages in a variety of agricultural researches focusing, at the present time, primarily upon variety trials of maize, beans, wheat and sweet potatoes. Although the Rwerere research station does not, at present, have a formal extension component designed to disseminate the results of its research to the farmers in the project area, researchers on the station report that farmers do both ask for and obtain assistance from station researchers.

6. Educational Institutions

In addition to the regular extension service of the Ministry of Agriculture (MINAGRI), various other GOR institutions provide formal and nonformal agricultural education at the commune level (Table 2.6). These include primary schools, CERAIs, CSDs and cooperatives. Technical advice to these institutions is the responsibility of the commune agronome.

a. Primary schools. The curriculum in the 7th and 8th years of Rwandan primary schools is heavily weighted to agriculture, building trades (carpentry, masonry, blacksmithing for boys) and home economics (for girls). The co-educational primary school visited at Runaba, near the town of Butaro, used the experimental fields and workshops of the immediately adjacent CERAI for boys. Both boys and girls followed the agricultural part of the primary school curriculum, which is concerned with both crops and livestock. Observations of other primary schools indicate that agricultural facilities (buildings, availability of livestock and diversity of crops planted) vary greatly among schools.

b. Centres d'Enseignmment Rural et Artisanal Integre (CERAI). These three-year schools evolved from the Centre d'Enseignment Rural et ARtisinal (CERAR) for boys and Sections familiales for girls. As part of the 1977 Education Reform, they became part of the formal school system. The general education part of the program (35%) continues the subjects of the eight-year primary school, while the majority of time (65%) is devoted to agriculture (both boys and girls), home economics (girls) and rural artisan skills (boys) such as woodworking, masonry and blacksmithing. Students are encouraged to request small plots of land from their parents so as to practice their agricultural skills at home.

CERAIs are to enroll 90% of the pupils finishing the primary school sequence of eight years who wish to continue their formal schooling and who are not admissible to secondary education. The purpose of the CERAIs is to better prepare students to be more productive farmers or artisans in the traditional rural sector. By government edict there are to be at least two CERAIs in each commune, usually one for girls and one for boys.

7. Donor Agencies

A number of donor agencies have programs that are located in or that serve the four communes. These include bilateral and multilateral programs of industrialized nations.

a. Bilateral Donors

(1) Volontaires de Progres Francais (VPF). The VPF is the French version of the American Peace Corps. Four male volunteers are stationed at Butaro (2) and at Kirambo (2) in Cyeru commune. Two are concerned with agricultural extension; their principal activities include managing small extension centers, which include a classroom, flour mill and demonstration plots. In addition, they assist the National Potato Improvement Program to conduct on-farm experiments in the area.

(2) Japanese Funded Land Reclamation Project (Kamiranzovu Swamp, Butaro Commune). The Ministries of Agriculture and Plan are participating in a land reclamation project in Butaro to reclaim 615 ha of swampland at a cost of 695,000 FRw over three years.

(3) Canadian International Development Agency (CIDA). Extension Project. The Canadian International Development Agency (CIDA) expects to launch a 10-year extension project entitled "The Improvement of Agricultural Production - Ruhengeri" in four communes (Nyamutera, Kigombe, Nyakinama and Ruhondo) to the southwest of the four communes of the FSIP (USAID). Following the MINAGRI organizational plan for a National Extension System, the CIDA project will concentrate on agroforestry.

b. Multilateral Donors

(1) National Potato Improvement Program (PNAP), Ruhengeri. Irish potato is a relatively important and popular crop in Rwanda. It is grown primarily in the high-altitude regions of Byumba, Gikongoro, Gisenyi, Kibuye and Ruhengeri Prefectures. The average yield of potatoes in Rwanda is about 7.2 tons/ha, with a total annual production of 250,000 tons. There are several factors that stand in the way of increased potato production per unit of land. Poor quality seeds, disease, unavailability of fungicides and fertilizers and poor cultural practices all contribute to its low per-hectare yield in Rwanda. (Bicamumpaka and Haverkort, 1983).

In 1977, GOR contacted the International Potato Center (CIP) to help them initiate a national potato improvement program (Nganga. 1983). In 1979, the National Program for Potato Improvement (PNAP), a section of ISAR, was established in cooperation with CIP, financed by Belgian Technical Cooperation, the GOR, CIP and PNAP itself from its own seed potato sales. The PNAP has a 4-ha research station in Ruhengeri and a 45-ha seed farm in Kinigi. PNAP currently employs 5 Rwandan scientists, 2 expatriate CIP scientists, some 10 technical and clerical staff and about 80 laborers (Bicamumpaka & Haverkort, 1983).

The main emphases of PNAP are twofold: production of seed potatoes and on-farm research. The aim is to develop healthy, viable, disease-resistant, high-yielding foundation potato seed stocks and make these available to Rwandan farmers through a government-supported seed multiplication scheme. They also conduct on-farm research to test the validity of their on-station research findings. Three members of the FSIP design team visited the PNAP station at Ruhengeri and also a few of their on-farm trials in the FSIP project area and were quite impressed with PNAP's operation.

Training and outreach activities have become part of the transfer of technology program at PNAP. Short (2-3 day) and longer-term (several weeks) courses have been given annually in Kinyarwanda for "progressive farmers," monitors and communal agronomes. Jointly organized with other donor agencies, these sessions in 1982-83 were held in the prefectures of Gisenyi, Ruhengeri, Kibuye and Gikongoro. More than 100 participants attended. PNAP also worked with nine trainees for between one week and nine months from the secondary agricultural schools (A2), the National University of Rwanda and from other local and international organizations (PNAP, 1983).

(2) Projet de Technologie Approprie (located at the Centre Nutritionel in Ruhengeri). This project, begun in 1979 and co-sponsored by UNICEF and the Canadian Service Universitaire de la Cooperation d'Outre-Mer (SUCO), designs, manufactures and sells (at subsidized prices) locally-adapted items (i.e., stoves, ovens, cisterns, water filters, raised crop storage bins, open kitchen cupboards) suitable for use in rural households. Models are in use at certain educational establishments (e.g. the CSD at Runaba-Butaro) that serve as demonstration centers. The project is well worth visiting to gain an idea of what local materials can be used to increase household efficiency and sanitation and conserve energy at low cost. The project provides expert advice and the buyer the materials and labor.

III. RECOMMENDATION DOMAINS

In Farming Systems Research/Extension (FSR/E), experimental programs take into account the circumstances and problems of specific locations and specific groups of farmers within these locations. Farmers with similar farming systems have similar problems and opportunities; therefore, they require a common experimental program and set of recommendations. A preliminary step in an FSR/E program is to identify fairly homogenous farmer groups, or recommendation domains (RD's). Only differences between farmers likely to cause significant variations in appropriate research programs are to be used in defining RD's.

In demarcating RD's in the study area, we took into account both agro-physical variables (such as rainfall, soils and topography) and socio-economic variables (such as resource levels, objectives and food preferences). We found altitude to be a critical variable in differentiating farming systems in the study area. Differing altitudes are associated with somewhat different rainfall, evapo-transpiration patterns, cropping patterns and growing seasons. Moreover, other system characteristics, such as availability of grazing land, hazards and access to potable water, also differ among Farming Systems at different altitudes.

For the purposes of the study, we divided farms in the study area into two RD's: middle altitude, 1700-2000 m, and high altitude, 2000-2400 m. Of course, the dividing line is somewhat arbitrary since system characteristics change gradually, not abruptly, as altitude increases. Nevertheless, differences between the two zones are marked, as summarized in Table 2.7. These differences are explored in greater detail in the sections that follow.

It is also worth noting several other variables that we considered in identifying RD's. It is possible that proximity to roads has an important bearing on the farming system. Income is another variable that might be important, especially since it is likely to be correlated with cattle ownership and thus manure availability and soil fertility. The FSR/E team should further investigate the importance of these variables and their influences on the farming system.

IV. FARM MANAGEMENT

This section describes how farmers manage their available resources to satisfy their objectives within the environment they face. First, we present farmers' objectives and the enterprises they select to meet their objectives. Next we examine farmers' available resources--land, labor and capital--and how farmers make use of these resources. We then look at the crop calendar, food consumption and supply and the hazards farmers face in meeting their objectives. Finally, we focus on husbandry of selected crop and animal enterprises.

A. Farmer Objectives

The most important objective of farm families in the study area is to provide a stable supply of preferred foods throughout the year. Because of the shortage of cash resources and the unreliability of local markets for purchasing foods, farm families seek to provide food from their own farms, using their own resources rather than purchasing food or hiring resources from outside.

Over the years, farm families have developed a complex system involving, on the average, 10 to 15 different enterprises on a single 1-ha farm in order to meet their primary objective and to hedge against the risk of food deficits.

A second important objective of the farm family is to provide cash for essential needs--such as clothes, soap, salt and school fees. As the study area becomes more and more integrated into the national economy, it is likely that the cash needs of local farm families will increase. However, at this time, it is clear that food needs predominate. For example, there are very few cash crops, such as coffee or tobacco, in the study area. Farmers claimed that they did not cultivate such crops because they could not be consumed, reflecting both a fear of relying on external markets as well as the importance of maintaining flexibility in their system by cultivating crops that can be both consumed and marketed.

B. Enterprise Choice and End Uses

Table 4.1 shows the end uses of products produced by farmers in the study zone.

Specific food objectives differ somewhat between the two zones. In the middle altitude zone, sweet potatoes and beans are the principal food staples, with bananas being produced for beer and sorghum both for beer and for a morning porridge. Maize and peas are also of some importance. In the higher zone, beans again predominate, but sweet potatoes become less important, being replaced by Irish potatoes, sorghum, peas, wheat and maize. Sorghum is again important for beer and morning porridge; bananas are of much less importance.

Sources of cash also differ between the two zones. Banana beer is the principal cash source in the middle areas though sweet potatoes, beans, sorghum and sorghum beer are also important. In the highlands the principal cash sources include beans, sorghum, sorghum beer, some Irish potatoes, wheat and peas. Goats and sheep are kept by most farmers in both zones and serve two principal functions--a source of manure and a quick source of cash in times of emergency.

C. Land

The soils on both the highlands and the low-lying areas appear to be easily tillable. This was apparent by observing women of all ages preparing land with relative ease. The soils of the highland slopes are supposed to be inherently fertile. However, some farmers indicated low soil productivity as their principal constraint. These farmers are generally farming a land area of 1 ha or less and are trying to feed a family of 5 to 7 people. Apparently, they cannot afford to leave any of their plots fallow and are thus preventing the land from building up natural soil fertility.

Farm families in the area do not use chemical fertilizers of any sort. Green manure crops are also unheard of, although many use some compost or manure, applying it to those fields close to the homestead, especially on cash crops. However, the quantities applied are very limited. Legumes planted in rotation certainly help to restore at least part of the soil nitrogen lost through cropping and/or leaching. Faced with increased population pressure, the farmers are bringing less desirable lands into cultivation, thus complicating an already serious problem. The lands that should ideally be left under grasslands or forest are being exposed to erosion.

In many parts of Rwanda, one can observe beautiful terracing with contour ditching meticulously done and maintained. However, in the area of this survey, such contour ditching was rarely evident. Lands with slopes even greater than 40% were being farmed with few measures adopted for controlling erosion. On the contour lines, only a few bunches of Setaria or Pennisitum could be seen. The rationale for not building ditches was that the soil was too weak and friable and hence not suited for such measures. Even if this is true, it is hardly justification for not maintaining a strip of suitable grasses on the contour lines. The real reason could be that the farmers are interested in their short-term gains and are not aware of the long-term benefits to be derived from adopting conservation measures. It is possible that they would be willing to invest their time and labor in such practices.

The average farm family in the study area farms about 1 ha of land, which may be all in one contiguous piece at the homestead or may be divided into as many as 7 to 10 individual parcels. Some of these parcels may be located as far as 1 to 2 miles from the homestead, permitting the farmer to take advantage of a wide range of conditions--e.g., high altitude/low altitude, swamp/hillside, etc. Thus a family may be cultivating peas and maize in their high-altitude parcels, sweet potatoes and sorghum in their low-altitude parcels and sweet potatoes during the dry season in the bottomland. Table 4.2 shows the approximate areas of land devoted to different crops for a typical 1-ha farm at middle and high altitudes.

Field management may vary considerably depending on the distance from the field to the homestead. Manure is applied only to fields near the homestead; thus these fields usually contain the most valuable crops (e.g., banana) and/or those that respond most to manure (e.g., maize). Crops that are susceptible to being stolen from the field are also placed near the homestead (e.g., bananas and Irish potatoes). Other factors also influence where crops are grown. Irish potatoes tend to be cultivated, whenever possible, on rented or borrowed land because potatoes exhaust the soil more than other crops. Bananas are generally cultivated near the bottom of hills or in folds between hills because these areas have higher fertility.

Individual fields are usually "owned" by the family, as recognized by traditional law. Renting and borrowing are common. Land is sometimes sold; land in the hills ranges from 500 to 2,000 francs/ha and land in the bottomlands from 2,000 to 3,000/ha.

Land in the swamps is owned by the commune and may be rented out to informal farmer groups or, less frequently, to individuals. Farmer groups are generally made up of 10 to 30 persons (all male or all female) who live together on a hillside. They generally pay an inscription fee of 50 to 200 francs to an elected treasurer for the purchase of seed and payment of rent, about 1,000 francs/ha/year, to the commune. Members generally work one day per week on communal land, sell all produce at harvest time and divide up the returns among themselves, setting aside some money for rent and seed for the following season.

Farmers like cultivating in the bottom lands and swamp areas because the soil is fertile and because crops can be grown during the dry periods when cultivation on the hillsides is not possible. However, cultivating in the swamps and bottomlands is risky; flooding or drought sometimes occurs. Farmers generally plant their swamp crops on high ridges to protect against flooding. Crops grown most frequently in swamp land include sweet potatoes, Irish potatoes and beans.

D. Crop Calendar and Periods of Peak Season Labor

Tables 4.3 and 4.4 show the crop calendar for middle- and high-altitude farmers.

Middle-altitude farmers have fairly distinct seasons for planting; plantings are concentrated during the first two months of each rainy season--March/April/May and September/October. Sweet potatoes are generally planted in March/April/May and September to January--that is, plantings of sweet potatoes continue throughout the principal rainy seasons. Beans and peas are planted March/April and September/October, coinciding with the start of the rainy seasons. Sorghum is planted in September or December/January and maize primarily in September/October. Farms with access to swamp land are able to plant some crops, particularly sweet potatoes and cocoyam, during the dry seasons.

Harvest times are spread throughout the year. Sweet potatoes may be stored in the ground for several months following harvest time. Thus, sweet potatoes are harvested in every month. However, the harvest is particularly scanty during February to April, as sweet potato plantings are few during the dry months of July to August. Bananas are also available throughout the year, though most trees bear fruit during the rainy periods, especially March to May. Beans and peas are harvested in December/January and July/August, maize in January to March and sorghum in March/April and July.

Labor peaks are primarily at the beginning of the March/April rains during land preparation, planting and, to a lesser extent, weeding. Farmers explained that this season is busier than the second season for three reasons:

1. Timely planting is more important during the March/May season since rainfall falls off abruptly at the end of the rains in June. Farmers must plant on time to take full advantage of available moisture and avoid diseases and pests, such as the black bean fly, associated with late planting.

2. The second weeding of the sorghum crop coincides with the March planting season.

3. Yield potential is generally higher during the first season; thus the area cultivated during the first season is often slightly greater.

The cropping calendar for highland farmers is considerably more flexible than that for middle-altitude farmers. Rainfall and evapo-transpiration rates are more evenly distributed at higher altitudes than at lower altitudes, permitting farmers to plant at many different times. Moreover, cropping cycles are two weeks to two months longer at higher altitudes than in the middle altitudes due to lower prevailing temperatures.

Beans, maize and peas are planted primarily in March/April and again in September/October, though in the second season, maize plantings continue until January. Sweet potatoes are planted any time between September and May. Irish potatoes have two planting dates, May and November, coinciding with the end of the main rainy season, and sorghum is planted in January.

As in the lowland areas, harvest periods extend throughout the year in the highlands. Peas and beans are harvested in August and January/February; maize in August/September and January-July; and sorghum in August. Irish potatoes are harvested in March and August, whereas wheat is harvested in February and August. Bananas and sweet potatoes bear throughout the year though April and May are periods of low sweet potato production.

The peak season labor period for farmers in the highland zone is also March to May. However, the peak is much less marked than for the middle zone because the planting period is more spread out in the highlands.

E. Sources of Cash and Use of Cash Inputs

1. Cash Sources

Principal sources of cash for farmers include sales of crops and beer. Banana beer is the most important cash source in middle-altitude areas, followed by sweet potatoes, beans, sorghum and sorghum beer. In the high altitude areas, beans, sorghum, sorghum beer, Irish potatoes, wheat and peas are the principal cash sources.

Aside from crops and beer, two other important cash sources are:

a. Sale of small livestock (sheep, goats and chickens). These are generally sold only to meet an urgent need for cash, e.g. to buy seed, food, medicine, etc.

b. Hiring out family labor to neighboring farmers. Both men and women hire out their labor to work on neighboring farms, especially during the land preparation/planting/weeding season, as stated in the previous section concerning labor.

Other sources of cash that are less common include off-farm jobs (schools, mines, tea plantations, etc.) and crafts (weaving baskets and mats) and remittances from relatives working outside the area.

2. Use of Cash Inputs

Farmers in the four-commune area use practically no "improved" inputs, such as improved seed, fertilizers or insecticides. Improved seed from the SSS (Service des Semences Selectionnees) are available only sporadically in quantities sufficient only for a relatively few farmers. Fertilizer is not available in the area, and reports are that fertilizer is not profitable on food or cash crops in the area. The only chemical input used by more than a few farmers is Malathion (commonly referred to as "DDT," its predecessor) for storing beans. The principal tools used by farmers include the long-handled hoe, a machete and a small weeding hoe.

F. Food Supply and Consumption

1. Principal Dishes

The principal dishes of farmers in the study area vary somewhat according to the crops they produce, which in turn vary somewhat according to altitude. Medium-altitude farmers have three principal dishes:

a. Boiled sweet potatoes with vegetable (dodo or embiga) and beans. This is the most important dish eaten by families in the study area. If sweet potatoes are lacking, bananas or manioc are substituted. The vegetables are wild and thus are always available. Squash leaves or cabbage may also be used, but few farmers grow these crops. Substitutes for beans include peas or bean leaves, though all may be omitted if not available.

b. Boiled maize and beans. Peas or bean leaves may be substituted for beans.

c. Boiled bananas and beans. Again, peas or bean leaves may be substituted for beans.

d. Sorghum porridge. Sorghum porridge is eaten in the morning as a breakfast dish. It is an especially important food for children.

In addition, home-brewed banana beer and sorghum beer are consumed in large quantities. Sorghum pate (a solidified porridge), boiled cocoyams, roasted maize and boiled Irish potatoes are other foods that are eaten on a less frequent basis. Milk is consumed only by those few families that have cows and is also regarded as primarily a food for children. Meat is eaten only on special occasions--most families probably consume meat less than once per month.

For high-altitude families, foods consumed are similar but with the following differences:

a. Sweet potatoes and bananas are less important foods than in the lowlands. On the other hand, highland farmers consume more maize, sorghum pate, wheat pate and Irish potatoes than do lowland farmers.

b. Most of the beer consumed at higher altitudes is from sorghum.

2. Food Availability and Deficits

Table 4.5 shows the availability of principal foods from home production for low-altitude and middle-altitude farmers.

For low-altitude farmers, sweet potatoes are in plentiful supply throughout the year, with the exception of the February through April season. Sweet potatoes are scarce during this period because few can be planted during the dry months of June through August. However, bananas are generally in plentiful supply during March and April and are a ready substitute. Moreover, sorghum and maize are also generally available during the period when sweet potatoes are scarce.

The supply of beans, middle-altitude farmers' other principal food staple, is much less certain. Beans are of particular importance because sweet potatoes and bananas, the principal starch staples, are very low in both protein and calories on a per-kilogram basis. The supply of beans is particularly uncertain during the period from April through mid-July. The crop planted in September often performs poorly, and a portion of the harvest is often sold to meet urgent cash needs while another portion is kept for seed. Following the March/April planting, beans may be unavailable until the first harvest in mid-July. Farmers consume bean leaves during May and June as a substitute for beans but try to avoid this, recognizing the detrimental effect on yield. Peas are also used as a substitute for beans, but, since they have approximately the same growth cycle as beans, they are available only when beans are available. Farmers may also run short of beans just before the December/January harvest, though the July/August harvest is usually sufficient to last until the December/January harvest.

Farmers in the high altitudes have problems similar to those in the middle altitudes. At least several of the principal starch staples, such as maize, sorghum, Irish potato and sweet potato, are generally in supply at any given period of the year. However, as in the middle altitudes, beans are often in short supply, as are the principal substitutes, bean leaves and peas. Thus, the most critical food problem facing farmers in both RD's is the lack of beans during the three- to four-month period before the major bean harvest in July/August. The supply of sweet potatoes and other starch staples is also a serious, though less frequent, problem during the months of February through April.[6]

How do families obtain food and seed when home supplies run short? Several possibilities were mentioned by local farmers. First, farmers may hire themselves out to other farmers during the March through May period to assist with land preparation, planting and weeding. Since March and April are peak periods for labor use, the demand for hired labor is fairly high. Second, farmers may sell some livestock, a chicken, sheep or goat, to obtain cash. Third, farmers may borrow food and seed from a relative. Fourth, farmers may sell sorghum, sorghum beer or banana beer in order to obtain cash to purchase food and seed.

In any case, the supply of foodstuffs, and particularly beans, is a critical problem for farmers in April through June and requires farmers to take rather drastic measures that may jeopardize their productive capacity.

G. Crop and Animal Husbandry

1. Crop Rotations

Nearly all farmers in the project area cultivated their crops in rotation. In fact, the rotations were generally sound from an agronomic view as farmers generally went from legume to grain to tuber crop and then back to the legume. For example, two rotations practiced by medium-altitude farmers include:

1.	Sweet potatoes Sept - Feb.	Beans Mar.-July	Sorghum/maize Sept.-Mar.	Beans or Fallow March-July

[6]Farmers' opinions that the period April through June is the most serious period for food deficits was confirmed by two other sources. First a local primary school principal stated that attendance was often low during April and May because many families kept their children at home because of the lack of food. Second, a commune employee in charge of a livestock market stated that the prices of sheep and goats was lowest in April and May at least partly because farmers lacked beans for seed and food and were forced to sell livestock to obtain cash for buying seed and food.

2.	Sweet potatoes January-July	Beans Sept.-Jan.	Sorghum/maize January-July	Beans or Fallow Sept.-Jan.

Rotations by high-altitude farmers include:

1.	Peas Oct.-Feb.	Beans Mar.-July	Fallow July-Dec.	Sorghum Dec.-July
2.	For high income farmers:			
	Maize/beans Oct.-Feb.	Irish Potatoes Apr.-July	Fallow Aug.-Nov.	Sorghum Dec.-July
3.	For low-income farmers:			
	Maize/beans Oct.-Feb.	Beans Apr.-July	Fallow Aug.-Nov.	Sorghum Dec.-July

Since Irish potatoes require a substantial investment in seed, many low-income farmers cannot afford to cultivate them.

In previous years, fallow periods were an important part of the rotation. However, because of pressure on land, most farmers do not fallow their land more than a few months every two years. The only families fallowing land for longer periods are those with high land/labor ratios.

2. Beans

Beans are generally grown twice per year in both high and low altitude farms. Most of the beans grown are bush beans though climbing varieties are also common, especially during the April/May rains. Farmers recognize that climbing beans give higher yields and are less risky, since beans and leaves are damaged less by heavy rainfall and moisture-born diseases. Furthermore, climbing beans require a very low seed rate. This is important because many farmers lack bean seed at planting time.

On the other hand, climbing beans have two disadvantages. First, they require much more labor for weeding since they do not provide as good a ground cover as do bush beans. Second, they must be staked, and finding stakes is difficult. Climbing beans are more common during the April/May season because expected yields are higher, thus justifying the extra labor required. Climbing beans tend to be planted in pure stand, whereas most bush beans are intercropped with maize or sorghum. When planting bush beans, farmers tend to mix together many different varieties in order to hedge against risk. Some principal varieties and their characteristics include:

*Nyamushali:	white, black stripes. Resistant to drought, high price, good taste. Climbing. kidney shaped.
*Urunyamanza:	gray, black stripe. Resistant to heavy rains.
*Rwagacuekano:	red, white spots, kidney shaped.
*Nyirakeimugo:	white, small in size, oval.
*Nyiracyunyu:	red/purple, large, similar to Canadian Wonder, susceptible to heavy rainfall.
*Nyiramamisa:	yellow, also called Bataaf. About one week shorter than other varieties. Heavier in weight per unit volume than other varieties.
*Nyagakecuru:	light brown, resistant to heavy rain.
*Niamrushori:	resistant to heavy rain
*Kivu:	violet, kidney shaped.
*Gwamirebo:	resistant to heavy rain.

All bush varieties have approximately the same vegetative cycle--3 to 4 months at the middle altitudes and 4 to 4.5 months at high altitudes. Climbing beans take approximately 2 to 4 weeks longer to mature than bush varieties.

Many different opinions were expressed about the best time for planting beans. Some claimed that disease problems (e.g., Aschochyta, a fungus) were particularly acute if one planted early (e.g., March or

September) while others stated that pests (e.g., black bean fly) did more damage to late-planted beans (e.g., April/May and October/November). Moreover, late-planted beans are more susceptible to drought. Disease and pest problems are especially acute in swamp areas. Other important bean diseases include angular leaf spot, anthracnose, rust and mildew.

Farmers generally hoe their land twice before planting beans in order to establish a fairly fine seed bed. Beans are planted by hand; one seed is placed in a pocket and covered, and then another seed is planted. Beans are never planted in rows. If sorghum and/or maize is intercropped with beans, all crops are planted at the same time. Sorghum is sometimes relay cropped with beans; beans are planted in September/October, sorghum in December, and beans are harvested in January/February.

Beans are generally weeded only once and are harvested only after the entire crop has dried down. Leaves are picked and eaten as a bean substitute if beans are lacking in the store. Beans are stored with ashes or malathion.

3. Sweet Potatoes

Sweet potatoes are planted and harvested throughout the year. Varieties generally take six months, though farmers may begin harvesting after four months and have tubers in the ground for up to eight months after planting.

Principal sweet potato varieties include:

Mugara:	black
Gikuma:	white, highest yield
Ndiaurukoma:	white, big tuber but few in number.
Nyirabwiya:	black, good yield in clay soil, low in sandy soil.
Nyirabusera jenya:	red, produces many medium size tubers.
Kwezikumwi:	5-month variety. Yields well in swamps but not in hills.
Akateye:	purple-leafed variety. High concentration of arthrocyanide in leaves, thus resistant to insect damage.

Land is hoed twice to provide a fine seedbed. Stem cuttings from plants being harvested are used as planting material. No special selection of cuttings is made. Plant density appears to be so high as to depress yields. However, planting at a high density provides a quick soil cover that, in turn, curtails weeds and soil erosion. The principal pest problems include a white caterpillar that ravages leaves and moles that consume tubers.

March/April and September/October are the periods when sweet potato is lacking in the project area. This appears to be because tubers ready for harvest must be removed from the ground before the rains begin to avoid rot during the rains. As sweet potatoes cannot be stored, the quantities harvested must be consumed or sold; hence February, the month before the rain starts, is the month when the sweet potato prices are lowest.

4. Notes on Husbandry and Other Crops

a. Sorghum. Most sorghum is planted in December/January, but in middle altitudes, farmers also plant in August/September. Plant population appears to be so high as to depress yield, but, once again, a high density controls weeds and soil erosion. Sorghum is planted by broadcasting seed across a field.

b. Banana (musa spp). Banana groves usually occupy the lower edge of the hill slopes where soil is more fertile than the eroded soil near the upper end of the hills. Out of the three principal types of banana--beer, table and cooking--beer banana is the most widely grown. Conditions permitting, the farmers like to plant banana because of its relatively high yields (about 10 tons/ha) and because it is perennial and requires less labor for production. Banana is not a principal staple, however, and is grown primarily for the production of beer.

c. Irish Potato (Solanum tuberosum L.). Most farmers plant potatoes as a monocrop, frequently in rows. Improved seeds from PNAP are available to a limited number of farmers for on-farm trials. The

PNAP varieties were obviously superior to the local varieties.

Potatoes are planted in the survey area in two seasons: in November/December and May/June. May/June plantings usually perform somewhat better.

Potato production in the project area is affected by two major diseases, late blight and the bacterial wilt. At the advice from PNAP, farmers are adopting a practice to delay plantings by 1-2 months after the rains start to avoid heavy rainfall. By doing so, the risk of late blight attack is greatly reduced. PNAP is also making an effort to introduce to the farmers an improved potato storage facility.

d. Maize (Zea mays L.). Maize is generally intercropped with sorghum and/or beans. It is also seen growing in banana groves, but the growth is very poor. Maize is not planted in any definite pattern, and in most instances, the plant population appeared to be quite low.

Principal varieties include:

Nyirakagori: small grains, early maturing (4-5 months), drought avoiding.
Bamboo: larger grains, better taste, higher yield, late-maturing (6-7 months).

Rust and Helminthasporium turcicum are the major diseases affecting maize.

e. Cocoyam (Colocasia esculenta Schott). This crop was grown primarily in the wet bottom lands on ridges as a mono-crop or as an intercrop in the banana groves. The leaves are also utilized in the preparation of certain dishes. Colocase appeared to grow well with little care, as long as the soil remained relatively moist. Plant population appeared to be too high, and bacteria disease is a problem.

f. Coffee. Coffee is the only major export crop grown in the survey area. However, it was grown by only a small number of farmers, on their own fields, at altitudes below 1800 m. The number of trees per farm varied considerably but averaged about 50. These were all row planted, neatly mulched and mono-cropped, as required by law.

g. Peas (Pisum sativum L.) and Wheat (Triticum spp.). Peas were seen growing on a few fields only at the higher altitude (above 2000 m). They were not doing well on the farmers' fields. However, on certain experimental plots, their performances were quite spectacular. Perhaps with improved seeds and better management practices, the farmers at the higher altitudes could obtain equally good harvests.

Farmers like to plant peas and wheat because they require so little labor--neither crop requires weeding, and peas do not require a fine seed bed.

h. Cassava (Manihot esculenta Crantz). Cassava was found growing on many farms up to an altitude of about 1600 m. It was not mentioned by the farmers as a major crop or a main food staple, but it was often used as a substitute for other starchy foods. Some farmers also used the leaves as greens in their diets. Bacterial blight is a main problem in cassava production. It was rarely seen grown as monocrop. Quite often it was planted on the field boundaries or intercropped with bananas.

i. Soybeans. A few farmers in the survey area grow soybeans, but varieties found on farmers' fields were not suitable to the area. Farmers growing soybeans sell most of their produce at local markets but keep some for home consumption. Peanut Mottle Mosaic virus is a problem.

5. Livestock

According to official data at the communal level, there are 10,242 cattle in the study area. Given a population of 177,000, an average family size of 5.2 and an average of 3 cattle per cattle-owning family, it can be estimated that about 10% of farm families in the project area own cattle. The percentage is higher in the high-altitude zone than in the middle-altitude zone.

Nearly all cattle in the project area are of local Ankale breed. Farmers indicated that their primary purpose in owning cattle was to obtain manure for their fields; milk and security (an outlet for savings) are other reasons. Cattle are grazed along roadsides and in swamp areas where communal grazing areas are located. Children do most of the herding work, but men sometimes help out. The principal problem

facing cattle owners, the lack of grazing area, is the primary reason the numbers of cattle are decreasing.

The lack of grazing area is particularly acute during the months of March-June because nearly all land is cultivated during this period. Principal feeds given to cattle at this time include sweet potato leaves, maize and sorghum leaves and grasses grown on contour rows such as Setaria and Tripsicum. Farmers indicated that there were no important diseases or pest problems affecting cattle.

We did not find any farmers practicing minimum or zero-grazing, nor did we see any fields allocated to forage crops. Apparently farmers are not willing to replace foodcrops with forage crops on the small areas they cultivate.

Sheep and goats are much more common than cattle; most farmers own 2-3. The principal reasons for keeping sheep and goats, as well as the principal problems encountered, are the same as for cattle. Most families also keep a few chickens for consumption and sale. Pigs are also kept by some farmers.

V. PRINCIPAL CONSTRAINTS AND FARMER PROBLEMS

Farmers in the study area face a number of important constraints in trying to meet their objectives. Table 5.1 presents farmers' own perceptions of the principal problems they face. These problems are discussed below under three headings: agronomic/biological, socio-economic and institutional.

A. Agronomic/Biological Constraints

1. Declining Soil Productivity

Increases in population bring about increasing pressure on land, resulting in more intensive land use and decreasing yields. Thus soil productivity is on the verge of decline; in fact, many farmers feel that yields in the project area are decreasing. Soil erosion is severe and, with the exception of bottom lands, fields in the study area contain very little organic matter.

Several strategies are employed to minimize these problems. All farmers owning livestock in our sample said they used manure on their fields and, indeed, we were usually able to confirm their claims through observation. Unfortunately, the quantities applied are often negligible given that the only livestock owned by most of the farmers are a few sheep, goats and poultry and that only night manure is available.

Farmers in the area use a number of methods to minimize soil erosion. Breaking the slopes with small ledges, grass bands and ditches is among the most common. Some farmers employ improved grass bands such as Tripsicum and Setaria. Cultural practices to maintain a good cover include intercropping and piling weeds in the field. Only a few bench terraces were observed in the study area.

2. Insect Pests

Pest damage was noted by over one-third of the farmers. The farmers' most serious insect problem is with a white caterpillar, called ubulima in Kinyarwanda, which ravages sweet potato leaves, especially during dry periods. One farmer we met spread eucalyptus leaves over the crop to repel the caterpillars, claiming that they did not like the odor of the leaves. Almost no chemical controls are available to farmers. Thus, they are forced to use cultural methods that help but are often not very effective.

3. Climate-related hazards

Climate-related hazards were mentioned by over half of the farmers questioned. The most important of these appears to be the incidence of rainfall during normally dry-season months, June to August and December to February, which can damage the harvest of several crops, especially beans, peas and potatoes. Heavy rains during the rainy season were also cited as sometimes damaging the bean crop, especially at the germination or flowering stage. Staggered planting is one strategy farmers use to avoid the effects of heavy rains during the harvesting periods.

B. Socio-Economic Constraints

1. Lack of Land

Land is a major constraint in the survey area as average farm size is only about 1 ha. Every meter of tillable land is intensively cropped, and little land is left fallow under any kind of soil-improving crop. Even contour strips have been brought down to a bare minimum, adding to the soil erosion problem. Also, a lot of marginal lands are being brought under production.

2. Lack of Labor

Despite the small size of farms in the study area, there is a shortage of labor during the peak periods of the cropping season, land preparation, planting and weeding. Labor shortages are especially acute in female-headed households, particularly where there are no teenaged daughters. All land preparation is done by hand hoe, and the time necessary for preparing 1 ha of land has been estimated at 40 to 70 person-days. Planting requires less time but must be completed in a timely fashion once the rains have started in order to take full advantage of the available moisture, nitrates in the soil and the warm soil temperature. Weed infestation was observed to be an important constraint on yields, and farmers complained that they lacked labor to complete weeding.

In addition, a number of farmers mentioned problems related to illnesses, not only because of the discomfort caused but also because illness prevents them from carrying out critical tasks when required.

3. Lack of Capital

Farmers lack cash for purchasing inputs, such as improved seed, tools, fertilizers and chemicals. In any case, these products are not readily available, due at least in part to the weak effective demand for such products. However, many farmers lack cash for meeting their most basic needs--purchasing food when home supplies run out, buying locally available seed at planting time and paying school fees. Institutional credit is not available to farmers in the study area; credit from other sources is scarce, and interest rates are high.

4. Poor Transportation

Despite the efforts of local agencies to improve the road network, transportation remains an important constraint to rural development. Rainfall exceeds 100 mm per month during eight months of the year, and many roads are impassible during these months. Thus, because of the high risks and costs that transporters face, relatively few vehicles enter the area to purchase farmers' produce, and prices paid to farmers are low relative to prices the produce would bring in urban markets.

Transportation from farm to market is also an important problem. Produce is carried almost exclusively by headload, and trips exceeding 10 km are not uncommon. Animals are not used for transportation, and bicycles are rare.

C. Institutional Constraints

1. Lack of Social Organization Data

Little up-to-date information is available on social aspects of the rural milieu. Most of the standard ethnographies were published before independence (1962) and describe the traditional feudal structure, which has now eroded. No study has been found on the nature of off-farm local employment opportunities, although impressions are that rural artisans coming out of the CERAIs will have difficulty finding jobs and that they will have insufficient capital and skills to set up small businesses on their own. There are no studies of the patterns of expenditure of disposable income within the farm household. Therefore, there will be difficulty in evaluating any change in the economic well-being of the farm household. There is also little empirical social data on the incentives and constraints to innovation within the household and no study of the role of women in agriculture.

2. Lack of Institutional Linkages

While commune agronomes are responsible for providing technical advice to commune educational institutions (i.e., Grades 7-8 in the primary schools, CERAIs and CSDs), this task is done only infrequently due to competing demands on the agronomes' time.

3. Lack of Trained Agricultural Cadres

While agronomes had completed A2 level secondary studies (5-6 years at the secondary level), the typical monitor had only finished primary school (then six years) followed by a 3- to 6-month training course. Agricultural teachers in the CERAIs and CDSs had little more training than the monitors. This level of training does not provide fluency in French nor sufficient agricultural knowledge.

4. Insufficient Extension and Training Components in Research Stations

While the ISAR/PNAP station at Ruhengeri has added an Outreach and Training Division, the ISAR station at Rwerere has yet to do so. The lack of impact of ISAR/Rwerere on agricultural development of the surrounding rural population is vividly portrayed in the contrasts between the government Centres Sociaux de Developpement located at the White Father mission at Runaba and that on the ISAR/Rwerere complex.

VI. OPPORTUNITIES FOR INCREASING PRODUCTIVITY AND WELFARE

A. Farming Systems in Perspective

The area encompassing the communes of Butaro, Nyamugali, Nyarutovu and Cyeru was largely uninhabited forest land before 1950. Around the turn of the century, population increase and warfare caused an expansion of the population living in lowland areas into highland areas such as the project area (World Bank, 1983).

Farmers cultivated finger millet, beans, sweet potatoes, peas and sorghum and grazed their cattle in the swamps. Bananas and maize were introduced into Rwanda around the turn of the century and became important crops in the project area. Irish potatoes, wheat and coffee were introduced following the First World War.

In recent decades, population increases in the area reduced the availability of new tillable land to near zero. Even marginal lands, at slopes of 40% and over, are being cultivated. Land is almost never fallowed for more than a few months per year, and the number of cattle in the area has declined significantly as areas previously used for grazing are now under cultivation. Only about 10% of farm families own cattle.

As population has increased and farm sizes have decreased, farmers have expanded their production of tuber crops, which give a higher yield of calories per unit area than grain or legumes. Thus production of sweet potatoes and Irish potatoes has increased dramatically in recent decades. Finger millet has been almost completely abandoned, and legume and grain production have not kept up with the increase in population (Ministry of Agriculture and Livestock, 1980).

Farmer objectives in the project area emphasize producing a continuous and stable flow of preferred foods during the year and selling surplus produce to meet essential needs. To accomplish these objectives, farmers have developed highly complex farming systems, including as many as 10 to 15 enterprises on small, 1-ha farms.

Farmers in the project area are divided into two recommendation domains, which are fairly homogenous farmer groups: 1) middle-altitude farmers (1700-2000 m) and high-altitude farmers (2000-2400 m). Middle-altitude farmers have somewhat different cropping patterns, cropping seasons, vegetative cycles, rainfall distribution, cash sources and hazards than farmers in the highlands. Beans, sorghum and maize are important crops in both zones; however, sweet potatoes and bananas are also important in the middle-altitude area while peas and Irish potatoes are also important in high altitudes.

Rainfall seasons in the high-altitude areas are somewhat less distinct, permitting more flexibility in planting dates. Moreover, because of the high altitude, vegetative cycles are longer. Hazards also differ

somewhat, with winds and hail being problems in the highlands and caterpillars ravaging sweet potato vines an important problem at middle altitudes. The principal cash sources at middle altitudes are banana beer whereas sources are more varied at high altitudes, including Irish potatoes, beans and peas.

The resource bases--land, labor and capital--are similar for farmers in both RD's. Farms are about 1 ha in size and are usually divided into 3 to 7 non-contiguous parcels. The nuclear family, averaging 5 to 6 members, is the basic unit of production. While there is gender and age differentiation in the allocation of tasks and time devoted to agricultural production, there is considerable inter-household cooperation in the cultivation of the predominant food staples. Cash is extremely scarce, and most farmers use no cash inputs in agriculture.

The crop calendar is highly seasonal with plantings taking place during the two principal rainy seasons, March to May and September to November. These periods are also the busiest periods of the year for farmers as land is prepared, crops are planted, and weeding begins. The principal period of food deficit is in April, May and June. In the middle altitudes, both principal food staples--beans and sweet potatoes--are lacking. In the high-altitude zone, the problem is somewhat less severe; beans are lacking, but Irish potatoes and maize are usually available.

Primary farmer problems--problems that a research program must address or, at least, not exacerbate--are listed below. Although the problems of farmers in the two RD's are fairly similar, it is likely that solutions will be different for the two groups, given the important differences in environment and cropping patterns between the two areas.

1. Low soil productivity/soil erosion.

Increasing population pressure has brought about increasing pressure on land--depletion of soil productivity, cultivation of marginal lands and increased soil erosion. Farmer attempts to increase soil productivity through increased use of animal manure and compost are inadequate. Attempts to limit erosion have emphasized breaks in the slope--grass bands and ditches are rare and bench terracing virtually non-existent.

2. Food deficit in the March to June period.

The deficit period begins in March/April because many farmers exhaust their stocks of beans in order to obtain enough seed for planting. Beans are often lacking until the July harvest. The situation is especially acute at lower altitudes because sweet potatoes are also often lacking during April/May.

In the high altitudes, however, the deficit period is less severe because Irish potatoes and maize are generally available at the time beans are lacking.

3. Crop Pests and Diseases.

Insects and disease ravage crops in the project area, and there is little farmers can do about these. Principal problems include caterpillars on sweet potato leaves and Aschuchyta fungus and angular leaf spot on beans. Many diseases are seed borne and are particularly severe because seeds are generally not treated.

4. Peak-Season Labor Shortage.

Despite the small size of farms in the project area, available labor is lacking, especially during the peak season of land preparation and planting in March/April. Because of the shortage of labor, many families are not able to perform essential tasks when required. Weeding labor is also lacking; weed infestation was found to be an important constraint on yields.

5. Cash shortage and low return to investment in agriculture.

Farmers lack cash for purchasing seed--either improved or local seed--and other inputs. Moreover, agriculture does not appear to be a preferred outlet for investment, even when cash is available.

6. Lack of grazing area for animals.

Farmers lack grazing area for feeding their animals, especially during the April-June period. The lack of grazing area is the principal reason for the decrease in cattle production in the area, which in turn decreases the manure available for cropping.

Farmers are caught in a cycle of decreasing productivity that the Farming Systems Improvement Project must attempt to break. Population pressure on land results in continuous cropping, decreasing soil productivity and decreasing yields. Farmers in the project area recognize these problems and use their own resources to deal with them the best they can--the FSIP project must seek to supplement farmers' own measures to improve soil productivity in order to reverse the downward trend in yields. Thus a primary objective of the program should be improving soil productivity. Also of great importance, and related to the above objective, is the need to increase food availability, especially during the deficit period of April-June. Other objectives include combatting pests and diseases and improving the availability of feed for animals, especially during the March to June period. The following section outlines research proposals to meet the objectives.

B. Improving Agricultural Productivity

The following research proposals are grouped according to the specific farmer problems they address. The research proposals were selected according to two principal criteria. First, the suggested proposals should generate technologies that significantly increase agricultural productivity. Second, given our understanding of farming systems in the project area as developed in this paper, the proposed technologies should be acceptable and feasible for farmers to adopt. Many of the proposals will be relevant to farmers in both the high- and low-altitude areas. Others are specific to only one area.

1. Problem: Poor and declining soil productivity.

Two separate but related problems are addressed in this section, soil erosion and poor soil fertility.

a. Soil erosion. Soil erosion needs to receive immediate attention. Once the productive top soil is lost, the land will be lost forever from agricultural production. There is no shortage of knowledge and advice to keep erosion to a bare minimum. What is needed is to identify those practices that work most effectively in the project area, that will have the most significant impact on reducing erosion and that will be acceptable and feasible for farmers to adopt. Soil erosion can be minimized through at least three separate measures: shortening the slope and length of runoff, maximizing the ground cover and improving soil tilth. Farmers already have significant experience with soil conservation measures; the Belgians and the government of Rwanda have been promoting soil conservation measures for years. In proposing specific measures, farmers' past experiences with proposed soil conservation measures must be examined. Moreover, on-farm research is needed to permit farmers to participate in the development and evaluation of soil conservation measures and to assure that measures are appropriate to local conditions. Some possible measures are suggested below.

(1) Shorten slope and reduce runoff. This can be achieved by maintaining and strengthening the contour line. The contour strips are disappearing from many fields. These strips should be rebuilt and planted to grasses or to leguminous trees. The various types of legumes that can be planted and their advantages have been adequately described (Nair, 1983). However, some research should be conducted to identify adapted plant species that will fit into local farming systems. Pigeon pea and Sun Hemp are two excellent anti-erosion crops. Both are legumes, both are efficient nitrogen fixers, and both can be grown as annual or perennial crops. They will also provide a good source of green manure. Research on maintaining and strengthening the contour line needs to be done in close collaboration with USAID's Agro-forestry project.

(2) Maximizing ground cover. This can be achieved by promoting relay cropping. Introducing a relay-cropped legume into the farming system could help reduce runoff and help maintain and/or improve soil fertility. For example, in the target area, a drought-resistant crop such as Sun Hemp or

Mucuna could be planted in May into a standing cereal or root crop. At the beginning of the dry season, when the crop is harvested, the legume would continue to grow. After about four weeks, some legumes could be fed to livestock, and then three weeks later, the remaining crop could be hoed under as green manure, just before the start of the next cropping season.

(3) Slowing down expansion of cropping land. Increasing food demands are currently being met by bringing more land into production. The lands are mostly marginal or too steep for cultivation and require higher levels of management capabilities. Production of all major crops per unit of land is still very low in Rwanda and could be increased with minor inputs. Increased food demands should be met by increased per-hectare production and not by increasing crop acreage.

b. Improving soil fertility. Many of the farmers in the area told the survey team that their soils do not produce as much as they once did. The soils appeared to contain little organic matter, and the soil structure seemed to be deteriorated. Although most farmers followed some sort of crop rotation, fallowing was rarely practiced. Mulching was rarely seen other than on coffee plots, and the amount of compost/manure applied to the fields was generally insignificant.

(1) Increasing soil organic matter content. All animal stall litters and manure, along with all farm and household decomposable wastes, should be properly composted and applied to the fields. Transportation of compost to distant fields poses a problem. Use of animals for transportation might be a possible solution.

(2) Relay cropping of legumes (see above).

(3) Use of mulch. When bare soil is stirred and exposed to weathering conditions, the organic matter content breaks down, and valuable soil microbes are lost. The practice of building up a mulch layer, as done in no-tillage or reduced tillage systems as opposed to soil incorporation of crop residues, should be evaluated. Planting of leguminous trees on the hedge rows or on the contour lines may provide additional mulching materials.

(4) Live mulch systems. This is essentially a practice of planting a food crop directly into a living cover of an established crop. This incorporates the soil conservation features of organic mulch and no-tillage and has the advantage of smothering weeds and adding nitrogen to the soil if the live mulch happens to be a legume crop. This technique should also help reduce peak season labor bottlenecks at the land preparation and weeding periods. Furthermore, if the live mulch is a legume crop, it will add nitrogen to the soil. In an IITA experiment, when maize was planted in a standing crop, Psophocarpus palustris, maize yield was significantly increased. Sweet potato, which provides a nice ground cover, is generally grown as a monocrop in the target area. Performance of planting maize, sorghum, or beans into a sweet potato crop should be evaluated. This proposal is particularly relevant to the middle altitude RD.

(5) Soil reaction and nutrition status of soil. Any recommendation on the use of chemical fertilizers should be made only as a last resort, given its prohibitive cost and unavailability in the project area. However, attempts should be made to analyze a good number of soil samples from the project area to identify soil nutrition constraints. Perhaps correcting soil pH using soil-amending materials will provide sufficient increases in yield to justify its use. Similarly, if correcting a micro-nutrient deficiency results in a substantial yield increase, then its application should be considered.

One advantage of growing a legume crop is its ability to fix atmospheric nitrogen, and this is made possible through its inoculation with appropriate strains Rhizobium bacteria present in the soil. The efficacy of the local strain of bacteria should be evaluated along with some improved strains, especially for the newly introduced legume crops.

2. Problem: Food deficit in March/May

Increasing food production should help reduce the problem of food deficits. However, early-maturing varieties can be of particular use in reducing the length of the hungry season before the June sweet

potato harvest and the July bean harvest.

Currently used bean varieties have maturity periods of 100 to 120 days. Varieties maturing in 40 to 70 days are available in Kenya and should be tested in the area. Sweet potato varieties are generally 6 months in length; earlier-maturing varieties could contribute greatly towards limiting the severity of the hungry season.

3. Problem: Poor-quality seeds

Unavailability of good-quality seeds was a subject repeatedly mentioned by the area farmers. If the seed is poor, even the best farmer with all other inputs available to him will not be able to harvest a good crop. Good-quality seeds of promising, adaptable, disease-resistant varieties should be made available to the farmers.

4. Problem: Disease and Pest Control

The best way to combat disease would be to plant disease-resistant, fungicide-treated seeds. By changing the date of planting somewhat, it is possible to reduce the incidence of disease and insect pest damage. Since application of a small amount of insecticide or fungicide often could save a crop, it would be considered as a worthwhile investment by the farmers. These suggestions need to be tested under farmer conditions on stations or on farmers' fields.

Many diseases, especially viruses, are seed transmitted. If farmers are using their own seeds for planting year after year without discarding seeds that they harvest from disease-infested plants, the yields will be reduced. Local varieties should be grown under continuous selection, discarding infected plants, for two or three seasons. The objective would be to produce high-quality seeds to be used by the FSIP project and by farmers. Another alternative would be to provide training to the farmers so that they could recognize and discard the disease-infected plants and plant seeds from healthy plants.

Weed competition is a major cause of yield reduction. Yet many crop fields were seen infested with weeds. The incidence of all major pests could be reduced by modifying the existing cropping practices.

Rust and Helminthasporium Turcicum are major disease problems in maize at high altitudes. High-yielding varieties that are resistant to these diseases are available from IITA, Kenya and Tanzania.

5. Problem: lack of feed for cattle

Leaf stripping of maize and sorghum is a common practice among farmers in the project area. However, no work has been done on how stripping should be done to minimize the effect on yield and still obtain a large vegetal harvest for livestock. Researchers need to examine the effects of timing and number of leaves stripped on yield and nutritive content.

6. Other Possible Interventions

a. Screen materials available from Rwerere station for relevance to farmers. A large amount of planting material that may be appropriate for farmers is available from Rwerere station. These include sorghum, bean, maize, wheat and sweet potato varieties.

b. Production Practices. Optimum planting time, depth of planting and proper plant density are all important prerequisites to establishing a good stand and should be individually worked out for each crop and variety. Constraints keeping farmers from carrying out a practice in the optimal matter and the costs associated with suboptimal performance need to be investigated. It is also important for farmers to know that emergence of seeds planted at optimum density eliminates the need for thinning or replanting and thus saves seeds and labor. In this regard, introduction of a cheap, easy-to-operate and -maintain seed-drill should be considered.

c. Intercropping. Intercropping banana with colocase or maize is a common practice in the project area. Established banana plants cause considerable shading. Therefore, in order to intercrop banana groves, one should look for shade-tolerant crops or varieties. Another area of research could be to

establish the minimum number of banana leaves needed to produce maximum yields. Then the excess leaves could be trimmed and used for other purposes, making more light available to the associated crop.

In summary, the primary goal of the Farming Systems Improvement Project (FSIP) is to develop methods of land use and crop management that will enable efficient, economic and stable production of food crops in the target area. Research efforts will be directed primarily at solving the production constraints of the areas' small farmers, bearing in mind at all times their scarce resources. Appropriate land and soil management practices that will maintain soil productivity and minimize soil erosion and degradation will also be emphasized.

C. Toward Institutional Development

The FSIP can directly address institutional constraints to increased agricultural productivity and the economic welfare of the farm household in at least four ways.

1. Research on Household Economics and Farm Management.

A short-term social science consultant to undertake a study of household economics, especially patterns of expenditure of disposable income, and economic decision making within the farm household is planned for the first year. Such a study should answer the basic question of whether there is a "dual economy" in the family and thereby provide a base for evaluating changes in economic welfare as a result of increases in agricultural productivity.

2. Linkages between Research and Extension.

The major focus of the FSIP is to enhance not only the research capacity of ISAR, but the communication of technologies and strategies through the Extension Service of MINAGRI to the small-scale farmer. As the Preliminary Diagnostic Survey has shown, the spread effects of research are limited, even in the immediate vicinity of ISAR research stations.

3. Training of Extension Cadres.

Not only do formal enabling linkages need to be established between the ISAR and the National Extension Service, but training of extension agents especially needs to be strengthened. The FSIP provides for participant training in the U.S., third countries and in-country.

4. Extension Linkages with Other Rural Development Organizations

For a variety of reasons, agronomes and moniteurs have not been able to carry out their responsibilities of giving advice to commune organizations already engaged in training young people in improved agricultural methods and practices. To neglect assisting agricultural agents in fulfilling this task is to miss an easy opportunity to extend the spread effects of the FSIP.

D. Conclusion

The preliminary diagnostic survey presents results of the survey team's first entree into the FSIP target area. Its intention is to capture perceptions of existing conditions in the project area and lay a base for initial research. As the FSIP advances, possibilities for further research will present themselves as the project team responds to new conditions resulting from their original work. Thus, this paper is only the first step in what must be a continuously evolving project.

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APPENDIX I

Additional information obtained about customs, social organization, institutions and other agencies in the project area not presented in the body of the report are presented here. Some are, obviously, impressionistic, like the rest of this report. They should be used as suggestive of things that the farming systems research team may need to examine further.

I. Social Organization

Upon marriage women leave their natal family to reside with their husband in a separate dwelling close to his family. The family of the prospective husband pays a bride price to the father of the prospective bride. Families interviewed indicated this bride price usually took the form of a gift of a large animal and other commodities of lesser value. In principle, the husband is the head of the family, exercising this role through "discipline," a concept never fully explained in interviews.

Vague and sometimes contradictory responses were given to questions concerning who was responsible for major expenditures for the family. For example, some said that the man brought home his earnings from the sale of bananas and other products at the market and gave the cash to his wife as "family banker." Others said that the husband "put the money in his pocket" and doled out parts of it to his wife to buy products for family use. Most said that the wife used her cash earnings from market sales to purchase products such as salt, soap and cloth for the family. Yet others indicated that cash earnings of both husbands and wives were pooled to be spent on education and clothing for the children.

Farmers were interviewed regarding the rhythm of daily life. Most men and women rise just before or at dawn, wash and eat a breakfast prepared by the wife. The wife may then clean the house and courtyard. Both try to be in the fields by 7 a.m. If the wife does not go to the field, she prepares food for that day and perhaps for the next. Depending upon the season, agricultural work includes clearing and preparing the land, planting, weeding, manuring and harvesting. If the field in which they work is far from the house, the women carry lunch. Otherwise, both husband and wife return for lunch and, after a brief rest, return to the field at about 4:00 p.m.

After returning from the field, the wife may go search for water and wood for fuel. For this she may have the help of the children. She may also weave mats. On the average, the search for fuel and water takes one to two hours each day. However, as one farm woman said: "The search for wood could take from dawn until dusk, if you can't find any." The man may spend the late afternoon hours either drinking, grazing animals, making large baskets or other items for sale or tending the banana fields near the house. If the wife has not prepared food in the morning, she does so after gathering fuel and water. Dinner is eaten after dark and takes only a short time. The family then bathes and retires about 8 p.m.

The women interviewed did not leave the farm frequently, except to visit friends on neighboring farms. None belonged to any formal associations, although one said she attended church (Anglican) on Sundays. While many women knew about agricultural cooperatives, none belonged, primarily because of lack of money to pay the membership fees. One widow claimed she rarely left the colline because, living alone, she had no one to stay in the house to protect it against theft. Most women said they went to the market from time to time to sell produce and to buy small articles such as salt, soap and cloth for the household.

It is impossible for a sociologist/anthropologist to gain more than superficial impressions in a ten-day survey covering an area of several hundred square miles. Yet an astute observer can be sensitive to a variety of socio-cultural cues that suggest the direction of more in-depth investigation.

One set of socio-cultural cues involved observation of the choice of farmers to be interviewed (see procedures for criteria of selection). The first three potential farmers suggested by the escorting agronome had to be rejected by the survey team for the following reasons: the first was found to have been consuming banana beer with friends for some time during the morning; the second had a son living in the household who had a salaried position in the modern economic sector, and the third was a woman, obviously acutely ill. A second set of socio-cultural cues involved responses by communal officials to the question of who did what agricultural tasks on the farm. One instant reply was: "Women do most of the work; men drink in the cabaret." A third set of cues flows from observations of farmers walking along the side of the road en route to market. Over a ten-day period, at least half of the men were observed to

be wearing some sort of foot covering. Few women or children wore even plastic sandals. The explanations offered for this phenomena were (1) poverty and (2) "men were more interested in prestige than were women and children."

While these comments may be regarded as routine or stereotypic social pleasantries (as contrasted with seriously thought out responses), they do give insight into social behavior and suggest that much more in-depth research is needed concerning status attribution, communication patterns and other attitudes, beliefs and norms of project beneficiaries. Since an understanding of the social attributes of farmers and technical personnel responsible for the delivery of services is a central feature of the FSR/E approach to agricultural development, reliable and valid social data is essential to project success.

II. Marketing Organization

The marketing system appears to be quite competitive. There are about two to three markets per commune, and these markets function from 1 to 3 times per week. Marketing starts on the hillside where the farm is situated. On the morning of a market day, one observes small groups of people around numerous central points within a 1-10 km radius of the market. At these assembly points, local traders, generally farmers themselves, purchase produce from their neighbors to carry to the main market for sale. At the major markets, transporters, generally owning 1/2- or 3/4-ton pickup trucks, purchase foodstuffs to carry outside the project area, mostly to Kigali or Ruhengeri. Many of the cattle, sheep and goats purchased in local markets are taken on foot to Kigali. A broad array of consumer goods are also sold at the markets.

The infrastructure for these markets is minimal. Most simply meet at a common open space and have no roof or stalls.

Observations at several communal markets showed social differentiation of merchants on the basis of gender and age by agricultural crops and by manufactured consumer items. No children (though they were omnipresent as onlookers) and few elderly persons were selling items or offering their services as artisans. Root, tuber and other vegetables were sold by women, while processed salt, sorghum and wheat flour were sold by men. Meat was being slaughtered and sold by men; men also sold soya, peanut and palm cooking oil and cloth and clothing. Imported consumer items (e.g. matches, batteries, nails, hinges) and locally-made soap were sold primarily by men. Large straw grain containers and other big baskets were offered by men and straw mats and small baskets by women. Local artisans (e.g. the repair of plastic shoes and plastic jerry cans) were observed to be only men.

III. Educational Institutions

A. Centres d'Enseignment Rural et Artisanal Integre (CERAI)

Two of the seven CERAIs in the four communes were visited, both for boys: one at Runaba-Butaro on the White Father mission (with government subvention) and the other next door to the bourgemaster's office at the commune of Nyarutovu.

The CERAI for boys at Runaba is part of a complex on the White Father mission that includes a primary school, a CSD and a Nutritional Center. The boys had available a wood-working shop where they constructed rabbit hutches, chicken coops and pens for larger animals from locally grown eucalyptus. The woodworking was done with locally made large wood planes and small imported tools (metal planes, augers and vises). The classrooms and workshops bordered a half hectare of fields growing both well-tended field crops and garden vegetables. There were three classrooms, a teachers room, storeroom and the office of the director in addition to a forge and a kiln for making bricks and cinder blocks.

The CERAI at Nyarutovu had similar physical facilities, but the fields and animal pens were rudimentary. Some of the demonstration fields were lying fallow because of severe erosion caused by rains that had carried away the seedlings. The commune agronome had attempted to help but was unsuccessful in devising a suitable method of control. Other problems included a severe shortage of qualified teachers, especially for the agricultural and technical classes.

B. Centres Sociaux de Developpement (CSD)

These are non-formal adult education facilities that evolved from the former Foyers Sociaux for women, introduced in 1947. The name change (1973) was an effort to extend their program from a concentration upon home economics to include agriculture and also an effort to expand their clientele from women and adolescent girls to all adult members of the rural community. An interview with the director of these educational institutions for the prefecture of Ruhengeri indicated, however, that few men attended. Therefore, an even further name change is being progressively made to Centres Communaux de Developpement Rural et de Formation Permanente (CCDRFP), providing a variety of rural-oriented skills for adolescents and adults of both sexes. CDS's depend for technical advice not only upon the commune agronomes, but upon PNAP, the Appropriate Technology Project and other technical services in the Prefecture.

Three of the nine CDS's in the four communes were visited: one each in Butaro, Cyeru and Nyarutovu. They varied significantly in their facilities and the quality of their programs. The CDS at Runaba enrolls 21 men and 137 adolescent girls and young women who follow a three-year program. Classes are given three days a week (double shift) by four young monitrices. There were three large classrooms, a director's office, storeroom and at least one half hectare of fields. The program became co-ed just the past year after young men requested entry, especially to learn how to sew by machine. The program is free, students buying only salt, sugar and peanut or soybean oil for their cooking class and cloth or yarn for the knitting and sewing class.

In the first year of the program, all students (young men and women) learn to sew by hand, the men making cloth hats and wallets and the young women baby and toddler clothes. In the second and third year of the program all learn to stitch by machine. Young women also learn nutrition, cooking, ironing (with charcoal iron), health and family budgeting. An hour of reading and writing is offered in the afternoon to those who are illiterate or who wish to improve their literacy skills. The central purpose of the CSD, however, is not the provision of literacy, but the upgrading of practical skills useful in a farm household. Practical agricultural work is a central part of the curriculum. New vegetables and forages (e.g. vetch) are being tested, and attempts are being made to teach farm record keeping. Improved vegetable seeds are sold in small quantities at low prices to local farmers, especially young people. Each student is required to ask parents for a small plot of land in which multiple cropping is practiced in order to teach crop rotation. The Director of the CDS made 125 visits to pupils farm homes during the first six months of 1983 in order to supervise agricultural and domestic science work.

The CSD visited at Nyarutovu was housed in a small building near the commune office. The pupils had been sent home due to the illness of the monitrice. Agricultural work was limited to one small cabbage patch, although peas and sweet potatoes were planned for the future. Several dozen young adolescent girls attended daily when the CSD was in session.

The CSD visited in Cyeru commune was on the Rwerere ISAR station. The center was housed in a room of the dispensary that was used also as a laying-in room. There was no blackboard, no desk and only one chair. The one monitrice held class on the ground outside. The 140 students, divided into three groups, came once a week and cultivated amaranthe, a pigweed-like plant used as a grain or like spinach, on a 10 ft by 50 ft plot loaned by the Centre Nutritionel. Students also had cooking classes on an open brick barbecue stove, also loaned by the neighboring Centre Nutritionel. The monitrice noted the lack of hoes, machetes, sewing machines, knitting needles and other instructional materials.

C. Cooperatives

Cooperatives in the region are primarily consumer-orientated trade organizations that bring in non-farm products from Kigali for sale to members. Some cooperatives produce, store and sell locally grown food as a secondary activity. No cooperatives were visited due to the temporary absence of key personnel.

IV. Private Voluntary Organizations (PVO)

There are a number of PVO's serving the four communes. These are church-related organizations that provide a variety of services for visitors in addition to their local programs.

There are four christian "missions" in the four communes to be served. The word mission is in

quotation marks because some organizations (e.g. the White Fathers) are organized on a diocesan basis (as contrasted with a mission basis) in that it is considered that there are sufficient numbers already in the flock requiring pastoral care so that aggressive prostelization is not necessary. Others (e.g. the Spanish fathers at Nemba) are secular priests pursuing largely service activities.

(1) White Fathers and (Canadian) Sisters at Runaba (5 km from Butaro). The mission is served by four priests (Fathers Carl Winters, Guy Pinard, Andre Dolliard and a retiree) and seven sisters. Fathers Winters and Pinard are parish priests serving the main Cathedral at Runaba and itinerately giving mass and pastoral care in smaller churches throughout the neighboring region. Father Dolliard is the agricultural expert and also advises the regional chapters of two national organizations: the Jeunesse Agricole Catholique (JAC) and the Jeunesse Ouvriere Catholique (JOC).

The main mission compound includes a large cathedral, a common living room and dining room, living quarters for the staff and five guest rooms available to travelers. The team utilized these guest rooms for one night and obtained dinner, bed and breakfast for US$ 10 per person. The food was excellent and the staff cordial and well-informed on local development. The rooms were simple (cold water sink only); rest rooms and bathing facilities (hot water available) were common. Boiled water is provided in the rooms and can be obtained from the cook to refill portable containers.

The interior of the main mission compound is "landscaped" with paths interspersed with small garden plots growing most of the well-known European vegetables. These vegetables are for consumption by the mission staff and guests.

Adjacent to the central mission compound is an educational complex including an ecole primaire (grades 1-8), a CERAI (boys only), a Centre Nutritionel (girls only) and a Centre Social de Developpement (CSD-coed). The Sisters also direct the nearby (10-minute drive) Centre de Sante for the commune. The primary school and CERAI share extensive agricultural fields (at least an acre) used for agricultural instruction and experimentation. The CSD has its own adjacent fields for the same agricultural purposes. The CSD has the services of an American agricultural specialist (Sister Julie Tremblay), who was on home leave during the visit of the Survey Team.

The White Father staff and most of the Canadian Sisters have served in Africa for more than a decade; all spoke Kinyarwanda. They pointed out that their operation was "small" compared with the larger White Father establishment at Rwaza (Ruhondo commune), which has a much more extensive school complex (groupe scolaire), although it does not stress agriculture to the same degree as Runaba. The mission at Rwaza was not visited by the Survey Team since Ruhondo was dropped from the proposed communes to be served.

It should be noted that the huge Catholic complex at Remera (Ruhondo commune) is not a mission or parish establishment, but rather a rest and recreation center (able to accommodate 40-50 guests, including tourists) and a Foyer de Charite. It is run by the Brothers of Charity with lay workers and one priest.

(2) Protestant Mission at Mucaca (Cyeru Commune). This Episcopalian Mission is headed by a Rwandan, Pastor Simon. The mission location (mentioned to the team by the White Fathers at Runaba) does not appear on the Republique Rwandaise Carte Administrative et Routiere. Due to limited time, the establishment was not visited by the Survey Team.

(3) Nemba Mission (2 km from Nyarutovu). This establishment is served by three Spanish secular priests and Rwandan sisters. The mission is not engaged in extensive agriculture; the priests and sisters operate a small hospital/dispensary.

(4) Comite Diocesin de Developpement (Ruhengeri). The CDD is a subsidiary unit of the Catholic Bureau Bureau Episcopal de Developpement (BED), headquartered in Kigali. The CDD in the Diocese of Ruhengeri is engaged in various health, educational, social, religious and agricultural programs. The committee examines all proposed projects, gives advice, undertakes feasibility studies and the initial design of construction, supervises implementation and maintains financial records of projects.

An agro-pastoral project is now in the planning stage under the direction of Father Franz Maurer, an Austrian priest. Expected to begin in April 1984 in Cyeru commune, the project involves the introduction of a new breed of sheep and teaching women and young girls to make wool thread from the fleece and to weave it into saleable consumer products.

Another project underway involves the development of a potato storage and marketing co-operative in an effort to both increase the price paid to the producer and stabilize market prices. The CDD hopes to initiate other projects concerned with soil erosion, seed selection and diversification of crops.

CDD works only with small-scale farmers and with both men and women using a "bottom up" approach. CDD prefers not to work with commune moniteurs, but rather has hired its own agronomes and moniteurs. Interested local participants are found at church and commune meetings. They are formed into small groups where a participatory approach is used to encourage the farmer to assess his/her own problems and to think about possible solutions.

APPENDIX II

This report was submitted to Dr. Don Humpal, an agronomist with extensive experience in less-developed countries of this part of Africa, for evaluation. His observations, though not able to be incorporated into the body of the report, are of significant value and are thus included here as an appendix.

1. As I read the report, I was constantly asking "why" questions. While the sections of the report that discuss constraints helped to answer my question, I never got a feel for the larger environmental, economic and institutional elements of the area. I assume that the project paper deals with the general topics of where Rwandan agriculture is headed, what land pressure is on the average, what the demand and supply situation is on the agricultural marketplaces, what the return is to agricultural investment in Rwanda relative to other investment opportunities, etc. If this contextual information is provided in other parts of the Project Paper or other documents produced by the larger team, it would be valuable to make reference to it. Then the reader would be able to get a better feel for why these communes were chosen for the survey and why they will be part of the FSIP project. [The Introduction was added since this comment was written.]

2. I think that there has probably been more work done on the agricultural economy of the area in the past than the report indicates. The Belgians, for all of their heavy-handedness in colonial administration, usually did detailed studies of soils, climate, cropping patterns and practices, labor budgets and marketing cycles. While it might not be politic to dredge up too many past studies, ISAR archives and those in Belgium should contain a lot of material that would help winnow out some of the research recommendations made in the report and provide perspective on the information provided by your survey. The FSIP project could do worse than review these materials before undertaking further survey work. It would certainly strengthen efforts to identify trends.

3. Were there any paysannat schemes in the area surveyed? Each paysannat had a detailed survey performed before infrastructure was developed. In Rwanda, the paysannats were designed to take advantage of the favorable climate while reducing erosion. Most combined food and cash crop production with emphasis on wheat, maize, barley, coffee and bananas. Forage rotations, grass absorption bands and grass-planted risers on bench terraces were all common (imposed) practices.

4. One of the key points in the survey is the danger of loss of productivity and farming systems sustainability because of high rates of erosion. Yet, this does not seem to be a priority problem in the farmers' minds. Also, on page 5, the statement is made that, "there still is considerable depth of workable soils left on the hill slopes." I would ask three questions: what is the current rate of erosion in tons/ha, what is the geologic rate of soil formation, and what is the potential erosivity of the soils given current cover and recorded rainfall intensities? Given other statements about the unavailability of fallow land, the survey's commentary about grass bands and hillside ditches that consume surface area needs to be balanced with how serious the erosion problem really is. Maybe it was visible in rilling, gullying and sheet wash, but no mention is made of these.

Also, I don't think the agronomic research proposals starting on page 22 really take into account what is said in the earlier sections about land, labor and market availability. I don't think that the green manure option is an option at all. In hand-tilled systems, the labor costs of hoeing green matter in are horrendous. In land-short small-holdings I would never recommend a contour-line crop such as sun hemp that did not have a harvestable part. I doubt that there is any market for its fiber. Relay cropping is a good idea. However, it is not necessarily a plus from the standpoint of maintaining productivity while increasing cover. More intense use of the land through grazing of an undersown Mucuna stand would lead to more rapid export of minerals. I would expect little or no nitrogen gain and potential nitrogen lags early in the next cropping season if the green matter is hoed in without fertilizer. Slowing down the expansion of cropped land area seems to me to be more of a general wish than a research proposal. You might call it a goal of the research proposals and include it in the introductory material to the proposals, but I would strike it from the list using the criteria of the introductory paragraph to the proposals.

The soil fertility recommendations are a little better. The proposal to increase soil organic matter

content is valuable for family garden patches around the household. If you are dealing with a low base status, highly acid oxisol, you will probably have to put about 4-8 tons of organic matter on the land to significantly affect the physical and chemical properties of the soil. I doubt whether the typical household produces enough decomposable waste to cover more than a tiny fraction of its available surface area. Overall, I would concentrate on first answering very quickly some of the questions about soil fertility status raised in 1.b.5., then focus on the mulching alternatives.

5. As a general comment on the research proposals, they could do with some reordering. I would make an argument for investing most of your FSR monies in short-turnaround research with noticeable payoff potential for smallholders--varietal screening, seed quality improvement, seed dressing--using the evaluation criteria of farmers, e.g., ability of maize to yield under leaf stripping regimes. The seed question is a complicated one that requires as much institutional investigation as technical analysis. After getting these two programs under way, I would do the soil testing program as a background investigation needed to better identify and prioritize the soil fertility and soil erosion efforts.

6. How do the research proposals match up against the farmer problem list given in Table 5.1? There the eight top problems were:

--Unspecified rainfall problem (42%)
--Poor soil (37%)
--Caterpillars on sweet potato (32%)
--Lack land (21%)
--Lack seed (21%)
--Dry season rain (16%)
--Lack tools (16%)
--Family illnesses (15%)

There is certainly enough of a hint at key problems to suggest research proposals on weather-related crop production problems, e.g., resistance to high humidity conditions at critical growth and harvest periods, lodging resistance, etc. Both the unspecified rainfall and the poor soil problems seem to beg for follow-up work to define the problems. The caterpillar problem on sweet potato suggests a wealth of varietal, cultural and protection investigations that would probably be well-received by farmers. Handling the seed question is a big undertaking in any developing country. The throwaway line about making good quality seeds available is a weak response. I sort of expected to see a little more organization of research proposals according to recommendation domains. You hint at this with the breakdown of importance of some problems by altitude categories. Do you intend to lay out the research proposals by RD with a third category of research issues that apply to both?

Table 2.1 Total Annual Precipitation (mm), Frequency and Intensity of Precipitation at Rwerere (1979).

Month	Total Annual Rainfall	No. days with Measurable Precipitation	Precipitation Recorded in 24-hr Period	Long-term Annual Rainfall
		Rwerere - Colline		
Jan	119.7	20	53.6	82
Feb	121.5	18	23.3	108
Mar	111.2	12	36.6	138
Apr	158.8	22	50.6	197
May	139	26	33.2	109
Jun	67	7	22.7	24
Jul	45	4	36	12
Aug	66.6	10	13.4	40
Sep	25.8	10	9.8	113
Oct	76.3	19	17.6	111
Nov	80.9	24	14.8	136
Dec	107.3	23	21	96
Year	1119.1	195	53.6	1166
		Rwerere - Marais		
Jan	93.9	20	21.8	81
Feb	141.1	19	24.9	99
Mar	133.5	17	41.2	126
Apr	167.4	25	53.6	181
May	149.5	24	20.8	103
Jun	55.2	9	17.7	24
Jul	48.9	5	36.4	9
Aug	65.3	9	14.5	35
Sep	21.4	12	4.6	107
Oct	74.7	16	22.5	109
Nov	89.1	22	15.8	124
Dec	112.1	24	20.6	98
Year	1152.3	202	53.6	1096

Source: ISAR, 1980.

Table 2.2 Principle Crops by Altitude.

Below 2000 m	Above 2000 m
Banana	Maize
Beans	Peas
Cassava	Potato
Coffee	Wheat
Cococase	
Maize	
Sorghum	
Sweet Potato	

Table 2.3 Civil Subdivisions of the Project Area.

Commune	Sectors	Cells
Butaro	10	53
Cyeru	15	47
Nyamugali	12	36
Nyarutovu	12	53

Table 2.4 Small Scale Farm Task and Time[1] Allocation for Major Crops by Gender and Age.

Crops	Growing Season	Plantings per year	Clearing Land M W B G	Preparing Soil M W B G
Sorghum	8 mo.	1	x x x x	x x x x
			<---------- 1-2 weeks---------->	
Maize	6-8 mo.	1-2	x x x x	x x x x
			1-2 weeks	<--2 weeks --
Wheat	5 mo.	1-2	x x x x	x x x x
			1 week	<--2 weeks --
Barley	5 mo.	1-2	x x x x	x x x
			1 week	<--2 weeks --
Sweet Potato	6 mo.	throughout year	x	x
			<------- 3 mo. per year --------->	
Irish Potato*	4 mo.	2	x x x x	x x x x
			3 days	<----1 week---
Manioc	1 yr	1	x	x x
			3 days	3 days
Colocase (Cocoyam)	?	?	x x	x x x x
			2-3 days	2-3 days
Peas	4-5 mo.	2	x x x x	x x x x
			<---------- 1-2 weeks ----------	
Beans	3-5 mo.	2	x x x x	x x x x
			4 weeks	<--2 weeks --
Bananas	1 year	every 2 years		x x
			none	<- 1-3 days -
Vegetables*[2]	3-4 mo.	2	x x x x	x x x x
			<---------- 1/2 day ----------	

Crops	Planting M W B G	Weeding M W B G	Fertilizing M W B G	Harvesting M W B G
Sorghum	x x x x	x x	x x	x x
	3 weeks	1 mo.	1/2 day	<-- 4 days ---
Maize	x x x x	x x	x x	x x
	---------->	1 mo.	1/2 day	<-- 2 days ---
Wheat	x x x x			x x
	---------->	none	none	<-- 5 days --
Barley	x x x x			x x
	---------->	none	none	<-- 5 days ---
Sweet Potato	x x	x x		x x x
	1/2 day	1 hr/day	none	each day as needed
Irish Potato*	x x x x	x x x x		x x x x
	---------->	2 days	none	<-- 1 week ---
Manioc	x x x x	x		x x x
	1 hr.	2 weeks	none	<-- 3 days ---
Colocase (Cocoyam)	x x	x	x x x x	x x x x
	1 day	1 week	4 days	<-- 3 days ---
Peas	x x x x			x x x
	---------->	none	none	<-- 1 week ---

continued

Table 2.4, continued

Crops	Planting M W B G	Weeding M W B G	Fertilizing M W B G	Harvesting M W B G
Beans	x x x x ---------->	x x 1 week	x x x x 1/2 day	x x x x <-- 1 week ---
Bananas	x x ---------->	x x 2 days	x x x x a bit	x <-- 1 day ----
Vegetables*[2]	x x x x ---------->	x x x x several hrs	x x x x 1 hr.	x x <-several hrs-

Crops	Transporting M W B G	Storage M W B G	Marketing M W B G
Sorghum	x x x x ---------->	x	x x
Maize	x x x x ---------->	x	x x
Wheat	x x x x ---------->	x	x x
Barley	x x x x ---------->	x	x x
Sweet Potato	x x x each day as needed	none	x
Irish Potato*	x x x x ---------->	x x x x	x
Manioc	x x x ---------->	x x	x
Colocase (Cocoyam)	x x x ---------->	none	x x
Peas	x x x x ---------->	x x	x
Beans	x x x x ---------->	x x	x
Bananas	x x x x ---------->	none	x
Vegetables*[2]	x x ---------->	none	little or no surplus

Source: A panel interview of 5 monitrices (farm raised) at the Centre Social de Developpement at Runaba (Butaro commune). The interview was conducted in Kinyarwanda.

Symbols: M = men W = women B = boys G = girls; x = The task is shared by all persons indicated; x = The person who does the principal amount of work for the task; * = Recently introduced crop.

[1] Time allocated to the task is approximate only and obviously varies among farm households due to size of holdings, the amount of paid labor hired, the general condition and location of the land and individual efficiency. The purpose of including time devoted to each task is to show the relative intensity of labor expended per task. Time allocation estimated on the basis of total land holdings of 1 ha.
[2] Cauliflower, tomatoes, leeks, onions, carrots, spinach, eggplant. Sunflower and soya beans are also being grown experimentally by young people, but as yet there is no market.

Table 2.5 Prices of Foodstuffs at Cyeru Market, 1983.[1] (Fr./Rw./Kg, unless otherwise stated)

Product	Beans	Peas	Sweet Potatoes	Sorghum
Annual Avg. price/kg	25	25	7	20
High				
Price	35	35	1023	
Month	March-June	March-June	March/April	January
Period	Planting, Pre-harvest	Planting, Pre-harvest	Pre-harvest	Planting
Low				
Price	16	20	5	15
Month	July/August	July/August	February	August
Period	Harvest	Harvest	Harvest	Harvest
Ratio of High/Low	2.2	1.8	2.0	1.5

Product	Maize	Irish Potatoes	Wheat[2]	Goats
Annual avg. price/kg	3/ear	10	25	1,600/hd.
High				
Price	5/ear	15	25	1,800/hd
Month	Dec./Jan.	May/June	--	March/April
Period	Pre-harvest	Planting	--	Hungry Season
Low				
Price	2/ear	5	25	1,300/hd.
Month	Feb.-May	March/April Aug.-Oct.	--	December
Period	Harvest	Harvest	--	Christmas
Ratio of High/Low	2.5	3.0	--	1.4

[1]Source: Informants from Project Area.
[2]Price is fixed by the government.

Table 2.6 Educational Institutions in the Project Communes.

Institutions	Butaro[1]	Cyeru[1]	Nyamugali[2]	Nyarutovu[1]
Primary Schools	14	12	13	11
CERAI's (post-primary schools)	2	2	1	2
CSD (Adult Education Development)	1	3	2	3
Co-operatives	2	1	0	1

[1]1983.
[2]1979.

Table 2.7 Summary of Principal Characteristics Differentiating Recommendation Domains in Study Area.

Item	Middle Altitude	High Altitude
Altitude	1700-2000	2000-2400
Rainfall	Two distinct seasons	Seasons much less distinct
Cropping season	Fairly distinct planting periods	Less distinct planting periods
Vegetative cycles	Generally, 1/2 - 2 months shorter than in high altitude for given crop	Generally, 1/2 - 2 months longer than in low altitude for given crop
Crops	Sweet potatoes, beans, bananas, sorghum, maize important. Some coffee, peas, manioc, cocoyam	Beans, maize, sorghum, peas irish potatoes important, sweet potatoes, wheat
Hazards affecting one RD significantly more than the other	Caterpillars ravaging sweet potato vines Hail damages crops	Winds cause lodging of crop.
Peak season labor bottlenecks	March-April, Sept-Oct.	Same, but less of a bottleneck
Crops sold	Banana beer is the most important. Sweet potatoes, beans, sorghum, sorghum beer also sold	Beans, irish potatoes, peas, sorghum and sorghum beer, wheat
Approximate population in the four study communes	110,000	65,000

Table 4.1 End Uses of Products Produced by Farmers in the Study Area.

Enterprises common to most farmers	Middle Altitude	High Altitude
Banana	Beer for cash and consumption, bananas for food, leaves for roofing	-
Sweet potato	Tubers for cash and consumption, vines for fodder, planting material	Same
Beans	Beans for cash and consumption, leaves eaten, vegetable material for manure	Same
Peas		Food and cash, vegetable material for manure
Maize	Food, stalks as manure	Same
Sorghum	Beer, food, sale of sorghum and beer, stalks for roofing and manure	Same
Sheep/goats	Manure, source of cash to meet urgent needs	Same

Enterprises common to some farmers	Middle Altitude	High Altitude
Bananas	-	Primarily for beer
Peas	Food, vegetable material for manure	-
Irish potatoes	-	Food and cash
Cassava	Food	-
Coffee	Cash	-
Cocoyam	Food	Food
Tobacco	Cash, consumption	Cash, consumption
Wheat	-	Cash, food
Cattle	Manure, milk	Manure, milk
Squash, cabbage	Food	Food
Eucalyptus	Firewood, construction	Firewood, construction

Table 4.2 Area Cultivated During a 1-Year Period on 1-ha Farms, Middle and High Altitudes.

Middle Altitude		High Altitude	
Crop	Area(ha)	Crop	Area(ha)
Banana/cocoyam	0.2	Maize/bean	0.3
Sweet Potato	0.3	Sweet potato	0.1
Sorghum/maize/beans	0.2	Beans	0.3
Sorghum/beans	0.2	Sorghum/Maize	0.2
Sorghum	0.2	Irish Potatoes	0.1
Beans	0.2	Peas	0.1

NOTE: Areas sum *o greater than 1 ha because most fields are double-cropped.

Table 4.3 Crop Calendar for Middle-Altitude Farmers.

	Month																			
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
First Farmer																				
Bean				+		P	-	-	-	H						+				
Bean[1]				+								P	-	-	-	H				
Sorghum												P	-	-	-	-	-	-	H	
Sorghum				+								P	-	-	-	-	-	-	-	H
Peas				+								P	-	-	H					
Sweet Potato	P	P	P	P	-	-	-	H	H	H	H					+				
Sweet Potato				+		P	P	P	-	-	-	-	H	H	H	H				
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Second Farmer																				
Sorghum				+		P	-	-	-	H						+				
Bean[1]				+		P	-	-	-	H						+				
Peas						P	-	-	-	H										
Bean[1]				+								P	-	-	-	H				
Maize												P	-	-	-	-	-	H		
Sweet Potato				+		P	-	-	-	-	H	H				+				
Sweet Potato				+			P	P	P	-	-	-	H	H	H					
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M

continued

Table 4.3 continued

	Month																			
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Other Farmers				+	|	|	|	|	|	|	|	|	|	|	|				
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
						P	-	-	-	H										
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	H	H				
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	H					
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
						P	-	-	-	H										
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	H				
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
						P	P	-	-	H	H									
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
							P	-	-	-	H									
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
							P	-	-	-	H									
Maize	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	-	H			
Sorghum	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	-	-	H		
Sorghum	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
			P	-	-	-	-	-	H											
Sorghum	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
			P	-	-	-	-	-	H											
Sorghum	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
				P	-	-	-	-	-	H										
Peas	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	-	H			
Sweet Potato	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
								P	P	-	-	-	H	H						
Banana	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M

P Planting date
H Harvest date
[1] These crops are intercropped

Table 4.4 Crop Calendar for High-Altitude Farmers.

	Month																			
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
First Farmer																				
Sorghum				+																
				+												+				
				P	-	-	-	-	-	H										
Maize				+																
							P	-	-	-	H					+				
Maize				+																
				P	-	-	-	-	H							+				
Maize[1]				+																
								P	-	-	-	H				+				
Bean								P	-	-	-	-	H							
Maize[1]				+												+				
														P	-	-	-	-	H	
Bean														P	-	-	H			
Maize[1]				+												+				
												P	-	-	-	-	-	H		
Squash												P	-	-	-	-	-	H		
				+												+				
Sweet Potato	P	P	-	-	-	-	-	H	H	H	H									
				+												+				
Sweet Potato							P	P	-	-	-	H	H	H	H					
				+												+				
Pole Bean													P	-	-	-	H			
				+												+				
	O	M	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Second Farmer																				
				+																
Bean				+												+				
							P	-	-	-	H									
Peas				+												+				
						P	-	-	-	H										
Maize[1]				+												+				
												P	-	-	-	-	-	H		
Bean												P	-	-	-	H				
Sorghum												P	-	-	-	-	-	-	H	
Irish Potato				+												+				
								P	-	-	H			P	-	-	-	H		
Peas				+												+				
						P	-	-	-	H										
				+												+				
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M

continued

Table 4.4 continued

	Month																			
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Other Farms				+	|	|	|	|	|	|	|	|	|	|	|				
Bean	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
						P	P	-	-	H		P	-	-	H					
Bean (Swamp)	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
			P	-	-	H														
Bean (Swamp)	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
				P	-	-	-	H												
Bean[1]	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
Peas						P	P	P	-	-	H	H	H							
						P	P	P	-	-	H	H	H							
Bean[1]	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
Peas												P	-	-	H					
												P	-	-	H					
Maize[1]	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
Bean												P	-	-	-	-	-	-	H	
												P	-	-	-	-	H			
Maize[1]	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
Sorghum				P	-	-	-	-	-	H										
				P	-	-	-	-	-	-	H									
Sorghum	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
			P	-	-	-	-	-	-	-	H									
Wheat	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
						P	-	-	-	-	H									
Wheat	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	-	-	H		
Sweet Potato	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
			P	-	-	-	-	-	H	H	H									
Wheat	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
												P	-	-	-	-	H			
	|	|	|	+	|	|	|	|	|	|	|	|	|	|	|	+	|	|	|	|
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M

P Planting date
H Harvest date
[1] These crops are intercropped

Table 4.5 Availability of Principal Foods from Home Production.

Altitude and Crop	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Middle Altitude												
Starch												
Sweet Potato	\\\\	""	""	""	\\\\	\\\\	\\\\	\\\\	""	""	\\\\	\\\\
Banana	""	""	\\\\	\\\\	\\\\	""	""	""	\\\\	\\\\	\\\\	""
Sorghum	""	""	\\\\	\\\\	\\\\	\\"	"\\	\\\\	\\\\	\\\\	""	""
Maize	""	\\\\	\\\\	\\\\	\\\\	""	""	""	|			|
Legume												
Beans	\\\\	\\\\	""	""	|		|\\	\\\\	\\\\	\\"	""	\\\\
Peas	\\\\	\\\\	""	""	|		|\\	\\\\	\\\\	\\"	""	\\\\
Bean Leaves	|				|	\\\\	\\\\	|			|	\\\\\\\\
High Altitude												
Starch												
Maize	""	\\\\	\\\\	\\\\	\\\\	\\\\	\\\\	\\\\	\\\\	""	""	""
Sorghum	""	""	""	""	""	""	""	\\\\	\\\\	\\\\	\\\\	\\\\
Irish Potato	|	|	\\\\	\\\\	""	""	|	| \\\\	\\\\	""	""	| |
Sweet Potato	""	""	""	""	""	""	""	""	""	""	""	""
Wheat	| |	\\\\	""	""	|		|	\\\\	""	""	|	|
Legume												
Beans	\\\\	\\\\	""	""	|		|	\\\\	\\\\	\\\\	""	""
Peas	\\\\	\\\\	""	""	|		|	\\\\	\\\\	\\\\	""	""
Bean Leaves	|				|	\\\\	\\\\	|		|	\\\\	\\\\

\\\\ Always available
"" Sometimes not available
\| \| Frequently not available

Table 5.1 Environmental Hazards and Other Farmer Problems.

Item	Number of Farmers Mentioning	Percentage of Farmers Interviewed
Environmental Hazards		
Climate Related		
Dry season rain spoiling harvest	3	16%
Heavy rains spoiling beans at germination or flowering	2	10%
Wind lodging of maize/sorghum[1]	1	5%
Too much/too little water in swamp	1	5%
Unspecified rainfall problem	8	42%
Pests		
Caterpillars (Ubulima) consuming sweet potato leaves[2]	6	32%
Rodents consuming tubers in field	2	10%
Black bean fly	1	5%
Livestock eating crops	2	10%
Other Farmer Problems		
Land		
Lack of land	4	21%
Poor soil	7	37%
Lack of Inputs		
Lack seed	4	21%
Lack improved seed	2	10%
Lack tools	3	16%
Lack manure	2	10%
Lack labor/cash	2	10%
Lack stakes for beans	1	5%
Other Problems		
Family illnesses	3	15%
Poor roads/marketing	2	10%
Lack food	1	5%
Lack grazing land	1	5%
Fields far from house	1	5%
Lack potable water	1	5%

[1] The hazard is much greater in the higher zone
[2] The hazard is much greater in the lower zone

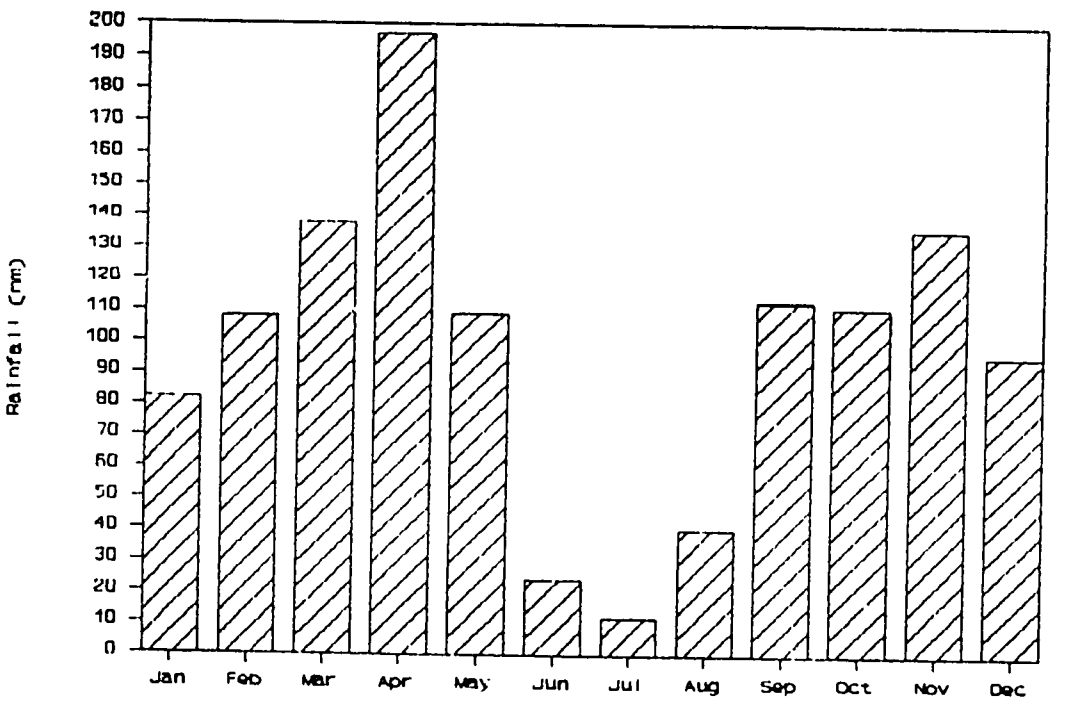

Fig. 2.1 Long-term annual rainfall, Rwerere - Colline.

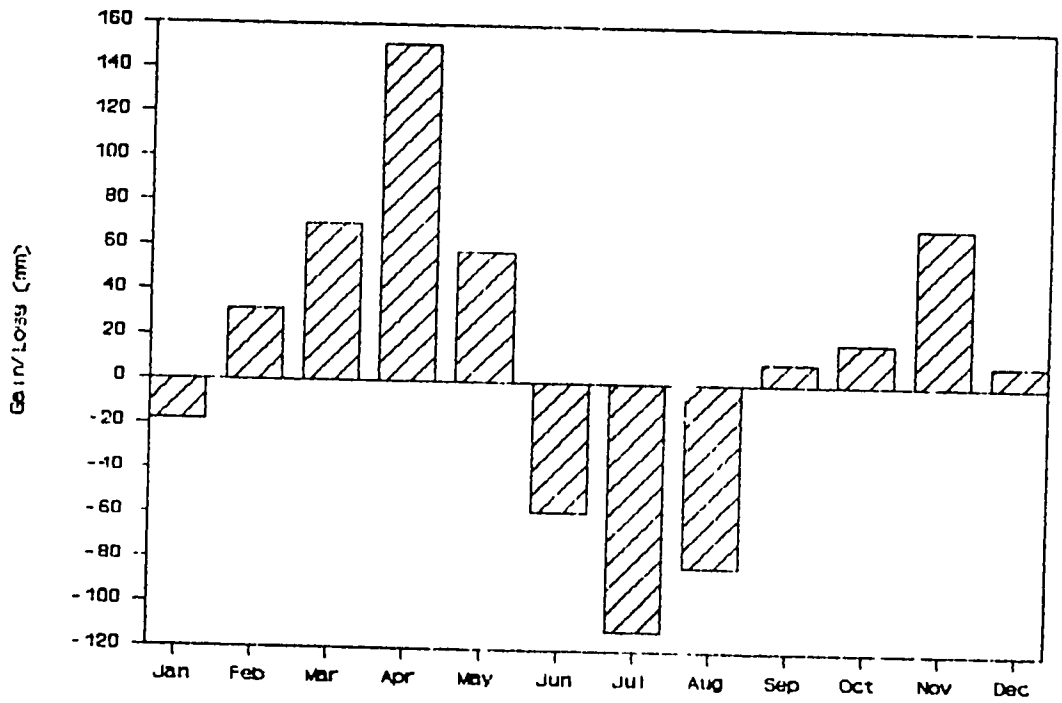

Fig. 2.2 Net gain/loss of soil moisture content, Rwerere - Colline.