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Rwanda Farming Systems Research Project
Diagnostic/Verification Survey
Consulting Report

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RWANDA FARMING SYSTEMS RESEARCH PROJECT DIAGNOSTIC/VERIFICATION SURVEY CONSULTING REPORT

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INTRODUCTION

The terms of reference for this consulting assignment were to provide technical assistance to the University of Arkansas technical assistance team implementing the Farming Systems Improvement Project (FSIP) in the Buberuka Highlands of northern Rwanda (recently renamed the Farming Systems Research Program - FSRP). The focus of the assistance was to be on setting up a diagnostic/verification survey to confirm the validity of the research themes on which the team members are working. A secondary objective included gathering information that will provide a base against which project accomplishments can be measured.

After consulting with CYMMIT/Nairobi and spending several days with ISAR and project researchers visiting farmers in the project area, it became clear that it is premature to prepare a verification survey at this time. One half of the team is not in country, including the new team coordinator who has computer skills and the agricultural economist who would most likely conduct the survey and take primary responsibility for analyzing the results. No one on hand is familiar with the various database programs currently available for tabulating and analyzing the results. Yet to reduce turnaround time to a minimum, the questionnaire should be built around the software that will be used to tabulate the data. Ideally, that would be a package that one of the new team members already knows.

In addition to data tabulation uncertainties, much work remains to be done in defining the types of farming systems the project intends to work with and how these relate to the research programs. Moreover, pending proposals for reorganizing the off-station component of the research program and for establishing informal links with extension will have a profound impact on the area likely to benefit measurably from the project in the intermediate term. Until these questions are resolved, a verification survey risks failing to obtain information needed to confirm the diagnosis of problems and research priorities and collecting data from areas not affected by the project. Neither of these consequences would result in an efficient use of researcher time.

There also was a perceived need on the part of FSRP team members and USAID that I could be very helpful in reestablishing a team-working environment that has been lacking since shortly after the project began. In conjunction with FSRP team members, we therefore decided that I should limit my work on the verification survey to identifying the procedures the team needs to follow in order to prepare for it. In that way the team can prepare sufficient groundwork so that a short-term consultant from CYMMIT could help them prepare a questionnaire in a week or so once they have decided what information they need. We agreed that I would spend the rest of my time helping work through a proposal for reorganizing the research effort and defining the farming system and constraints that research and extension can address. The output of this process will define what the research program should be and what information the verification survey needs to gather.

FARMING SYSTEMS RESEARCH

The underlying principle of farming systems research is simple: to educate researchers as to the kinds of problems and constraints facing farmers so that they can define more effective research programs. Beyond that straightforward statement, differences in concept and approach among various farming systems practitioners become more pronounced.

There are at least two ways to engage in farming systems research. One is to approach the farm household/enterprise as a system in need of improvement and pose the question "What are the most important constraints on the system and which ones can research/extension most effectively help to resolve?" With this approach the research/extension program is a residual that is developed almost entirely around the farming system.

A second approach, one we might call the commodity approach, involves approaching the farming system as a producer or potential producer of a particular commodity or set of commodities. In this situation we pose the question "What are the important farming system variables that researchers need to consider in designing their commodity research programs so that they can offer to farmers technologies that are more likely to be adopted?" These two approaches are not necessarily compatible. Indeed, in the FSIP project area they may be in conflict with each other.

Whatever the approach to farming systems research, eventually farming systems researchers will enlist the assistance of extension agents and begin testing research results on farmers' fields. However, there are important differences in when various researchers feel such testing is appropriate and what importance they attach to involving extension agents as opposed to research technicians in the on-farm trials.

On-station biological scientists tend to insist on rather complete testing on the research station and at multi-locational sites before proceeding with on-farm trials. They like to be 70-90% certain that a particular technology will work on a given farmer's field in order to avoid discrediting research programs. This usually involves a two- to three-year delay between the diagnosis phase and the on-farm testing phase. Underlying this preference one frequently finds a belief that farmers are not very sophisticated when it comes to research. The potential for negating whatever openness farmers have toward research is believed to be high should the technology fail.

Farming systems agronomists, agricultural economists, extension specialists and social scientists tend to be more aggressive in moving to the on-farm testing phase. Although not true in every context, they tend to view farmers as much more sophisticated about research than many biological scientists believe them to be. Farmers understand risk and recognize that one crop or variety may do well under one circumstance and fail miserably under another. Indeed, that is usually the major reason farmers give for planting crop and variety mixtures even though they recognize that one or two of the components usually do better than the others. With this perception of the farmer--recognizing that the diagnostic survey needs to determine that it is appropriate in a particular context--these practitioners are more willing to let farmers themselves decide what works best for them. By moving more quickly to the on-farm testing stage, researchers can save valuable time and gain important insight they will not usually get on the relatively fertile fields of researcher-maintained testing sites.

Less recognized as a benefit of moving quickly to the on-farm stage is the opportunity for individual farmers to discover and benefit from varieties and/or practices that may do very well on their own field or under their particular circumstances but that are mediocre overall. Analysis of test results for such varieties usually reveal large standard deviations and least significant differences. The large variability may lead the researcher to conclude that the variety is unstable in addition to being no better than existing varieties and therefore not suitable for extension. Rejecting such varieties in an area such as the Buberuka Highlands, where micro soil and climate and variation is pronounced, will only delay the discovery of improved technologies. A variety would indeed have to be robust in order to perform well under such a wide variety of circumstances. Many observers would view limiting research efforts to such varieties as unnecessarily restrictive.

Another benefit of aggressive on-farm testing is that when a farmer discovers a variety that is successful in his particular circumstances, he will move to the multiplication stage immediately. The FSRP allows farmers to keep the production from the test plots. So this is a very feasible alternative, one which I personally observed occurring several times in my four days of farm visits in the project area. In effect, a successful on-farm trial--one in which only one or two of the treatments are superior--spontaneously

creates a mini, private-sector seed farm. Once the farmer has the seed, it will spread--at least to a limited extent--without further action by researchers or extension. This benefit alone argues in favor of the more aggressive approach.

A second area in which farming systems researchers differ is the importance they attach to incorporating extension agents into the on-farm research process on an active and permanent basis. Most researchers acknowledge the benefit of taking advantage of the extension agent's knowledge of the area. Nevertheless, even where more or less formal agreements exist between extension supervisors and researchers, it is not always possible to control effectively the quality of the work of the agents. In order to maintain the integrity of the trials, researchers frequently seek permanent staff under their control to supervise the on-farm trials and avoid relying on the agents for this phase of their work. This is frequently a mistake.

Sooner or later extension will have to be brought into the process if research results are to be rapidly diffused outside the immediate area of the research. By working closely with researchers during the on-farm trial phase, especially with farmer-managed, on-farm trials, extension agents gain valuable training on the proper use of the technology. They learn how to do the experiment properly and what to do to get maximum benefit. They also allow the researcher to greatly extend the area that can be covered with their trials. Extension agents also gain confidence in their own competence and in what they are recommending to farmers. This can only increase their motivation. Moreover, once the agents observe that a technology works in a particular circumstance, they will probably be instrumental in spreading this technology long before research results confirm its usefulness and the extension service begins a training program to incorporate it into its extension program.

These benefits of incorporating extension agents into the on-farm research process are not insignificant. They argue for finding ways of obtaining the positive benefits of their participation while avoiding the potentially negative one of poorly managed trials that compromise the integrity of the research design. The best method may be to structure a minimum number of trials around research technicians and extension agents who have demonstrated commitment to quality work. Additional replications of farmer-managed trials could then be incorporated into the data base in all cases where some objective measure of agent performance has indicated that protocol procedures have been followed.

Another area in which a conscious decision should be made is the extent to which researchers may rely on purchased inputs in designing their research programs. At low levels of use, say less than 100 kg/ha of nutrients, fertilizer use will probably be economic at full delivered-cost prices, given current prices in Kigali and reasonably responsive varieties of most cereals. Generally, at a ratio of value of output to cost of fertilizer of two or more, farmers find it profitable to use fertilizer, given all the other costs associated with its use. While this may not be enough to get them to adopt fertilizer if they have never used it before, temporary subsidies of 20% of the full delivered cost would probably do the trick. Other inputs such as seed treatment, improved seed, insecticides and pesticides may prove quite cost effective once research confirms their value.

Although none of these inputs is widely available in the project area at the present time, that should not prevent researchers from pursuing promising lines of research related to their use. Although I don't know the official policy in Rwanda regarding the use of purchased inputs by small farmers, the fact that farmers are poor should not be grounds for limiting research to very-low-input technologies. Researchers need to lead development of the institutional environment by several years. Organic materials will probably not be able to generate production increases of more than 20-30%, given the size of most farms in the project area. At least limited use of chemical inputs will be necessary to move above this level of increase and probably to realize the full potential of organic fertilizers as well. Farming systems research should not be viewed as a substitute for purchased inputs but as a way of maximizing the economic benefit of what inputs are used.

FARMING SYSTEMS RESEARCH IN RUHENGERI

To date the FSRP has failed to establish credibility vis a vis the director of ISAR and USAID. It is important not to let the project's rather disappointing past obscure the tremendous potential for achieving meaningful, positive results from FSR in the project area. There is still time to set things straight and get on with the work at hand.

Farmers in the project area are among the most receptive to research of any I have seen in more than 25 years of working in African agriculture. Farming systems are surprisingly homogeneous, and one has the impression that important improvements will spread rapidly. The research team at Rwerere is dedicated if not always as aware of farming system constraints as a team more experienced with FSR might be. Yet with effective leadership, a bit more experience and a bit more patience from political leaders, I am convinced the team can become a very effective interdisciplinary unit that can quickly produce relevant research results. It has already made some discoveries that promise to produce significant increases in output if followed through and eventually extended.

The most serious lacuna in the current situation is the lack of an experienced, competent, farming systems economist who can communicate effectively in French and command the respect of his peers. All research needs to be placed in an economic context as soon as possible in order to avoid fruitless pursuits. At the very least, the questions of an economist will force researchers to think through the anticipated results of their work in terms of added costs and benefits and the impact on household resource use and income flows. In some cases even 50% increases in yield will not suffice to induce farmers to adopt a technology because of added costs associated with it. Moreover, the role of the crop in household income and expenditure patterns will often have a profound effect on how farmers will respond to improvements in technology. These are the kinds of questions an agricultural economist can answer. Some of these questions can also be answered via the verification survey.

The lack of leadership in the farming systems area is another problem facing the project. Recent changes in project administration promise to provide more administrative leadership, but this will not be sufficient to keep the project on track. The team would benefit from a continuing periodic input from CYMMIT or another source of farming systems expertise to keep things focused until the interdisciplinary farming systems perspective is more firmly ingrained in the present and future team members. The present hold on the concept is tenuous and will need periodic reinforcement over the first four or five months that the whole team is in place. Visits of three to five days per month from Dr. Ananda of CYMMIT/Nairobi would probably prove sufficient to do this. These visits should include brainstorming sessions that reexamine the team's evolving understanding of the various farming systems in the area and the implications this has for present and future research programs. Dr. Ananda has indicated a willingness to provide backup for the team if requested to do so.

Near the end of this period the team should be ready to execute the verification survey in order to confirm this understanding as a basis for programming research activities for the 1988-89 crop year. Dr. Ananda could assist with development of the questionnaire and execution of the survey as well, once someone who could take responsibility for the survey is at post and familiar with the farming systems.

As indicated earlier, the FSRP team spent a good deal of time during my first 10 days in Rwerere developing a proposal prepared by the Station Director for reorganizing the off-station research effort around four or five multi-locational sites. These would be spread across the eight to ten micro-ecological zones that the project covers. Each researcher would have responsibility for supervising one site, ensuring that other researchers were properly monitoring their trials and that overall maintenance reflected a serious research effort. On-farm trials would then be concentrated around these sites. They would expand outward as the trials prove viable and the extension service makes available agents to assist with the trials.

As part of this reorganization, the project would provide motorbikes and a monthly operation and maintenance allowance to the communal agronomes and to the monagris working with the project. It is expected that this approach will reduce logistical costs, promote interdisciplinary work and increase visibility and effectiveness of the project. The Annex includes a preliminary proposal for dividing the area into ecological zones prepared by Charles Yamoah and me. It includes suggestions for those zones that should probably have a site. The FSR team will discuss this document and come up with a final proposal.

Since on-farm research efforts will be concentrated around the multi-locational sites, it makes sense to concentrate the verification survey there as well. This would maximize the precision of the results for

informing research programs. Certainly, over the remaining three years of the first phase of the project, the impact of the research program will not be felt beyond the immediate area of research, no matter what successful technologies are tested and passed to extension. Since the multi-locational sites will be placed within the major ecological zones, the chance that this more limited coverage would provide misleading information concerning the area as a whole does not appear to be great.

Beyond the next three years, what the project can reasonably expect in terms of the impact of the research program will depend on as yet unanswered questions regarding the role of extension in the on-farm research program. The greater the involvement of extension, the more the team will have to expand the geographical coverage of the verification survey so as to be able to measure the end-of-project impact. The project director should move ahead quickly to define this role with the local extension leaders. If he can complete an informal agreement before the end of October, the team can proceed with the verification to cover all of the project area likely to benefit from the project over the next eight years.

The project also needs to improve its computer operation before undertaking a verification survey. At the present time the project has many of the popular programs for spreadsheet analysis, word processing and data management and analysis. But there is relatively little documentation in French and little control of access to programs. As a result, several programs are missing utilities disks or originals for installing them on the different systems. Operating systems are available in French, but no one seems to know how to install them. Diskettes containing files of departed team members abound, but no one seems to know what is on them or what to do with them.

Obviously, the departed team members were proficient in using the computers. But they have not trained Rwandans in computer system operation and maintenance sufficient to allow them to do more than boot a program with an autoexec.bat file that does everything for them. This works OK until there is a problem.

To correct this problem, I suspect the team will need a French-speaking computer systems specialist with substantial experience with microcomputers to come to Rwerere for about three weeks. One of the new team members may be able to do this, but one questions whether this would be a good use of their time. They could more effectively organize weekly training sessions for increasing the computer literacy of researchers and their skills in using some of the packages available for designing and analyzing experiments. In the meantime, the project needs French copies of Lotus 2.0 and Dbase III Plus and French documentation for SPSS PC+, DOS 3.2 and M-STAT, assuming French versions of the programs do not yet exist.

This raises one area in which the project has been very negligent: publishing reports and papers in French. Too much of the focus has been on whether other team members can read the documents and not enough on other Rwandans who do not speak English. Even the Rwandan team members do not speak English well enough to understand what is being said or written sufficiently well to be able to render the kind of critique needed to keep foreigners from going astray. There is no excuse for not providing whatever resources it takes to ensure that the output of a several-million-dollar project is appropriately reviewed and widely disseminated in the official language of the country. Hopefully, the wife of the new team coordinator will speak French well enough and be available to help project technicians translate their documents. She would probably appreciate the opportunity to find productive employment, though I do not presume to speak for her.

RESULTS OF THE DIAGNOSTIC PHASE

I have not found a great deal of printed material relating to the diagnostic phase of the research program, apart from that collected during project design by Franzel et al. (1985). What material is available from the present team suggests that most of the team's diagnostic efforts have gone into identifying problems constraining production, as indicated by farmers. Not much has been done to inventory what selected farmers were already doing to deal with the kinds of problems identified. Nor is there any indication that the team weighed Donald Humple's comments on the design team's preliminary diagnosis (Franzel et al., 1985). He raises several points that call into question some of the research now taking place. These questions should at least be addressed in the theoretical justification of the research. The apparent suitability of current cultural practices, the implications of various farmer resource endowments on the kinds of technologies they are likely to find useful and the relationship of the various agricultural enterprises to each other or to the system as a whole also need attention.

A study done by Voth (1985) provides background information on the farming systems in the area using data from the National Agricultural Survey, but it does not follow with an elaboration of the farming systems on which the team should be working. Brewster (summarized in Mayfield et al., 1988) looked at several variables that she felt influenced bean yields in the area, but questions relating to her methodology make it difficult to evaluate some of her conclusions.

The rather limited diagnosis conducted by the team following project commencement and reported by Charles Yamoah (1985) did not identify any problems not already raised in the Franzel report. The description of the farmers visited, however, indicates that progressive farmers with above-average resources are over-represented in their sample. Forty-four percent of the farmers interviewed had cattle versus 14% for the Buberuka Highlands as a whole, according to the National Agricultural Survey. Almost a third fewer grow sorghum and potatoes, and 50% more grow peas as compared to the region as a whole. Taken together, these data suggest that the team should be careful lest they concentrate their research program on farms with above-average soil fertility. While this may be necessary, it should be done consciously and should fit some overall concept of the farming system. In this context it would seem appropriate to return to Franzel et al (1985) and pick up where they left off in an effort to better define the context of research so as to be able to defend research programs.

TYPES OF FARMING SYSTEMS IN THE PROJECT AREA

Tables 1 and 2 present some data on the Buberuka Highlands and the Central Plateau taken from the 1984 National Agricultural Survey. That survey appears to have been very well done, and it represents the best source of representative data on the project area. Together with the experience and knowledge of the FSR team accumulated to date, the data in the tables can help us to formulate some initial hypotheses about predominant farming systems and the types of interventions on which researchers need to focus. The verification survey should then attempt to confirm the validity of these hypotheses as soon as possible. This will provide the kind of quantitative data needed to focus and justify research programs.

During my stay at Rwerere, I assisted the FSRP team in beginning the process of defining priority farming systems and the implications for research programs. We were not able to complete this task in the time available, but we made a sufficiently good start that the team should have no difficulty completing the process. It is, after all, a continuous and interactive process, informed both by the results of the on-farm trials and the observations of researchers gathered in the course of their field visits and studies.

On the basis of the data in Table 1, the diagnostic work done thus far, comments by the FSRP researchers and my own experience in similar areas of Africa, I would hypothesize that farm size, livestock holdings, the number of active farm workers per hectare and rainfall are four of the most important parameters for differentiating types of farming systems with different research implications. Altitude and soil type will also be important, but most farms as systems include variations in both. These variables define aspects of the farming system but are not really sufficient criteria for differentiating among systems, as opposed to different commodity constraints, for research purposes.

The diagnostic work indicates that various problems relating to soil fertility top farmers' concerns by a factor of three to one. Under current circumstances, the potential for increasing fertility is a function of the amount of manure and compost that the system can generate and the fallow cycle. These, in turn, are related to farm size and the availability of labor for feeding, watering and caring for animals and distrib-

uting the manure. Thus, we would hypothesize that larger farms and/or farms with more active workers tend to have more fertile soils and higher crop yields than the average farm.

According to Tables 1 and 2, there is an average of only 2.2 to 2.5 active workers per household. Across the two agricultural zones of the project, 25 - 30% of farms are 0.5 ha or less. Approximately 20% are in excess of 1.5 ha. Between 15% and 30% have cattle, and 65 - 70% have some sort of ruminant. Although the table does not show it, over 70% of cattle and 80 - 90% of other ruminants are not confined. (The survey report is not clear on whether or not such animals are confined at night.) For practical purposes, all farms produce sweet potatoes and beans. Most also produce bananas, sorghum and maize. Under half of all farms produce peas, and fewer than a third produce potatoes. Around 40 - 60% of total cultivated area is planted in mixed stands.

Using this information to define types of farming systems, one might begin with a classification based primarily on farm size. The systems might look something like the following.

High-Resource Systems. These include farmers with 1.5 ha or more of land and 2.75 or more active workers. We would hypothesize that the large majority of these farms have either cattle or more than seven or eight small ruminants. Because of their larger size and greater livestock holdings, they probably have more fertile soils than average. The greater flexibility accorded by their larger size suggests that owners of such farms would be more prone to assume risk and to experiment. Since these systems represent only about 20% of all farmers in the project area, it is important that researchers remain alert for evidence that the bulk of their on-farm testing is occurring on such farms. Results from such farms may not be entirely repeatable on farms with more limited resources. While some might argue that it is desirable to focus research efforts on these farms, such a focus should result from conscious and planned choice rather than happenstance.

Medium-Resource Systems. The majority of farms, 55% or so, would fall into this class. These systems have between 0.5 and 1.5 ha of land and between 1.5 and 2.75 active workers. They will usually have 2 - 5 small ruminants but no cattle. Soil fertility will be more of a problem, but these systems still have enough flexibility to permit a short fallow from time to time. While not abundant, they will have some manure to spread on fields surrounding the rugo. Because such systems still have some flexibility, they will probably be quite receptive to new technologies that are clearly superior and do not require significant investment of resources. More demanding technologies will require more than proportionally greater potential net returns.

Low-Resource Systems. About 25% of all farm households would fall into this class. Possessing less than 0.5 ha of cultivable land and fewer than 1.5 active workers, such farms are very limited in what they can do to maintain soil fertility. In general, one would expect the soils of such farms to be very poor. These farmers probably have only one small ruminant, if any, and cultivate all of their land every season. While this class of farmers may benefit from research programs directed at the other two farming systems, they will probably remain skeptical of new technologies until most of their neighbors have adopted them. For this reason, and because they account for such a small proportion of total cultivated area, it is probably not wise to develop research programs aimed specifically at this type of system.

In addition to resources, the farming systems classification may need to incorporate a rainfall dimension as well. This would raise the theoretical number of systems to six. But the relatively small differences in rainfall that exist in the project area probably do not cause changes in the farming system or farming practices as much as in the specific varieties that farmers would need to improve their incomes. This kind of difference can easily be accommodated within the context of commodity research programs.

At first glance, differences in cropping patterns suggest the need for a classification system that incorporates bananas and wheat, both highly correlated with altitude. I would suggest that the team hold this judgment in reserve until they obtain a better understanding of the systems. Although fields at high altitudes clearly contain fewer bananas and more wheat, we don't know yet whether they belong to different households or just tend to be parts of the same farming system. For bananas I suspect we are just talking of different parts of the same farming system.

Wheat is another matter. Its location, frequently far from the compound, suggests that this enterprise has minimal interaction with the rest of the system, except with respect to competition for labor. That

does not seem likely to generate a different research agenda than would otherwise occur, though the possibility should always be kept open.

This first attempt to define the farming systems that the FSRP team should be working with is tentative, to say the least. But it is a necessary step, one that must be completed before researchers can be confident that their efforts will have the anticipated outcome. Out of the process of defining these systems will come many hypotheses and questions that will need to be tested and/or answered before the research program becomes an easily defended plan of action. The verification survey can help to clarify and confirm some initial impressions. But until researchers get a better handle on the systems they are working with, the universe of potential questions is simply too great to expect a survey of other than grandiose proportions to deliver what is needed. Informal survey techniques, such as discussions with farmers and local leaders and brainstorming with technical staff and extension agents, are usually much more effective in narrowing the range of missing information to manageable proportions.

IMPLICATIONS FOR RESEARCH PROGRAMS

By way of example, this section explores some of the implications of the tentative farming systems classification for the FSRP research program. Only greater discussion and acquisition of information will provide a definitive classification and an appreciation of what this means for the farming systems research program. It is instructive to begin with soil fertility and see how various solutions are more likely to be acceptable, depending on the farming system.

According to all of the diagnostic work done thus far, poor fertility is the principal constraint on increasing agricultural production in the project area. There are four ways of improving soil fertility:

1) applying fertilizer;
2) using crop varieties that add nutrients to the soil, such as nitrogen fixing legumes;
3) incorporating organic matter such as animal and green manure; and
4) allowing land a fallow period.

Crop rotation is really a form of fallow. It allows the soil time to break down parent material for the next crop by planting a crop that is not exigent in its demand for the same nutrients as a subsequent crop.

Rwanda does not appear to oppose the use of fertilizer or other modern inputs on small farms. FSRP researchers are currently incorporating fertilizer in their trials, and it is readily available in Kigali. However, given the cost of fertilizer in Kigali, researchers will have difficulty demonstrating an economic response at application rates above 100 kg/ha of nutrient. Fertilizer would have to increase incremental production of grains by 13 - 15 kg/kg of nutrient applied before farmers would be likely to adopt it at current harvest-season prices for grain and pulses. Such responses are not likely at high rates of application.

The problem with fertilizer is that it is not a technology that will likely benefit the low-resource farming system. Operators of low-resource systems are frequently older and less amenable to changing production technology in a significant way. Even medium-resource farmers will have difficulty using fertilizer unless it is available in local markets and they have access to seasonal credit.

Unlike fertilizer-responsive varieties, nitrogen fixation is a promising avenue for research that should benefit all of the farming systems. It may be the only way to benefit the low-resource systems. K. B. Paul has identified a local bean variety that appears to be doing a good job of fixing nitrogen. Once ISAR begins producing inoculants for experiments, FSRP researchers can begin on-farm trials using this important technology. The tremendous variation in soil microbiology from one field to another argues strongly for a wide network of on-farm trials without first testing on the station, once researchers identify a potentially viable combination.

Most farmers utilize fallow and manure to enrich their soils. With the increase in population, fallow is becoming increasingly difficult for the medium-resource systems. At the same time, manure is not efficiently exploited since most of the animals run loose. Confining animals to a composted stall for the night can capture up to 70% of their daily output of manure if the stalls are properly bedded. Rarely, however, did I see an animal stall with sufficient bedding to catch urine, the source of about half of the nitrogen in manure. So, improving the generation and collection of manure is an extendable technology for increasing production in the short term on the medium-resource systems. High-resource systems may not yet feel enough soil fertility pressure to perceive much benefit from more labor-intensive management of livestock.

The agricultural economist will need to direct attention to measuring the added labor input and the expected additional outputs of stall feeding in order to see whether more intensive management pays and how manure can be more fully exploited. One way to make stall feeding more attractive would be to introduce grade dairy animals into the project area using the model provided by CRS projects elsewhere in the country.

Finding ways of encouraging farmers to shift to stall feeding of livestock is no small challenge. Caring for a bovine on a zero-grazing system requires about a half-time active worker if forage does not need to be carried too far. The labor requirement is not much different if the farmer must plant a forage crop nearby in order to obtain feed. For most farmers this will significantly increase labor inputs allocated to the livestock enterprise. Under the present system, however, adults will need to provide more supervision since the animals will depend 100% on humans for their survival. In addition, producing forage will take valuable land now used for food crops unless researchers develop cropping systems that integrate forage and food crops without reducing food production.

Researchers need to be realistic as to the amount of manure these various farming systems can generate with the labor at their disposal. One adult bovine in Rwanda should generate about 3.5 tons of manure per year if permanently confined. The exact amount will depend on the amount of bedding and other composting materials used as well as on the size of the animal. It would take 10 - 12 small ruminants to generate the same amount of manure. With this kind of potential output, even assuming that farmers apply manure to a given field once every two or three years, it does not make sense to conduct experiments using more than 7.5 - 10 tons of manure. Experience elsewhere suggests a fairly sharp drop in incremental grain production per ton of manure at application levels above 5 - 7 tons/ha on a sustained basis.

Whereas improving production and management of manure will benefit primarily the large group of medium-resource systems, agro-forestry and soil conservation research has a critical role to play with respect to all of the farming systems. Alley cropping and relay cropping of leguminous forage with food crops is more scale-neutral. However, the conditions of acceptability will probably be different between the low-resource system and the other systems.

Before operators of low-resource systems will adopt alley cropping or any other fertility management system, they will have to be convinced that total production of staple foods will not decline. This means not only that yields will have to increase as a result of the technology, but that they will have to increase by enough to offset the loss of production on the area where the tree crop or legume is growing. The closer the distance between the rows of trees or forage, the higher the yields will have to be on the rest of the field to offset the land lost to the fodder crop or trees. This means that the goal of producing the maximum amount of forage or green matter will be subject to a constraint that will force a wider placing than will be the case for the medium-resource farming systems that still have a bit of fallow to incorporate into the equation. On the other hand, provision of stakes by the alley crop may allow some farmers to increase production of the higher-yielding pole beans at the expense of bush beans.

Wheat provides another example of how the definition of the farming system conditions what might be considered an appropriate research agenda. Most wheat is grown on the upper slopes and hill tops, usually some distance from the rugo. This provides a measure of crop and climatic diversification, but it makes it next to impossible to get manure to the field. Farmers could apply mineral fertilizer, but the low amount of organic matter in many of the soils on the hilltops suggests that a good bit of the fertilizer may not become available to plants unless combined with some system for increasing organic matter. This suggests that fertility research for wheat should include fertilizer used in conjunction with green manure and alley cropping rather than animal manure.

Another example concerning wheat relates to cultural techniques. One of the FSRP researchers has noticed that the quality of land preparation has a profound impact on the rate of germination. Once advised of this phenomenon, I explored it with farmers and found clearly measurable differences in yields where farmers prepared a reasonably smooth seedbed prior to planting. This may be an example of a farmer-tested, though not researcher-measured, technology ready for on-farm trials. Before it will be ready for extension, however, the FSRP agricultural economist should focus on the additional labor required to accomplish the better seedbed preparation and see what other activities may be affected. It could be that certain factors not yet understood limit the ability of certain farmers to adopt the same practice. If these are system-related variables, the system may need to be reworked.

PREPARATION FOR THE VERIFICATION SURVEY

As mentioned previously, the verification survey should be conducted in those areas, and only in those areas, in which the project can reasonably expect to have an impact over the next 3 to 8 years. This, in turn, will be a function of how the research program is organized and, especially, the extent to which the project incorporates extension agents into the research process.

The purpose of a verification survey is to provide statistically valid measures of key farming system operations and performance measures so that researchers can confirm that their impressions of problems, constraints and potential as obtained from less formal diagnostic work are on the mark. This increases the likelihood that they will work on viable solutions to real problems. The verification survey should confirm both the definition of the problem and the viability of the proposed solution.

In most cases a properly designed verification survey can provide baseline data useful for project evaluation without adding substantially to the magnitude of the operation. This requires that researchers have a clear conception of the problems and the feasibility of potential solutions before they design the survey so that little time is spent fishing. Again, the purpose of the verification survey is to confirm, not to fish. As a consequence, it is normally carried out subsequent to a fairly detailed informal diagnostic process.

To increase the amount of information provided by the verification survey, the sampling methodology should conform as much as possible to that used by the National Agricultural Survey. It will then be possible to compare results in order to determine whether the multi-locational sites have been placed in representative areas. The survey should use the same definition of farm and household and the same method for measuring fields. This should include correcting area measures for slope.

In my visit to SESA, I was not able to get detailed information on several aspects of the 1984 methodology because of the absence of a key technical assistant involved in the original work. He was expected to return in late August. The methodology section of the report does not describe in sufficient detail how the sample was drawn within the selected census enumeration areas or how fields were measured. There is also some uncertainty as to the definition of an exploitation versus a menage.

One must be careful not to expect too much from the verification survey with respect to baseline data unless it is truly targeted to those areas in which the project will most likely have a measurable impact. During the next three years, this will hardly exceed the boundaries of those sectors containing the multi-locational sites. During the following five years, it will probably not exceed the boundaries of those sectors where extension agents are actively involved in supervising farmer-managed on-farm trials.

The necessity for a narrow focus is amply demonstrated by the magnitude of the sampling errors found in the national survey. The standard errors of the estimate of total production of beans and sweet potatoes in the Buberuka Highlands for the first season of 1984 were 10.9% and 8.8% of their means, respectively, based on 220 sample observations. For all other crops, the standard errors of estimate were at least double, and in the case of potatoes, peas and wheat, more than four times the percentage for beans. What this means in the case of beans, the most precisely measured priority commodity for Rwerere researchers, is that the statisticians are only 90% certain that the actual production of beans, as opposed to the amount calculated by the survey, is between 82% and 118% of the amount calculated. That's quite a range for a sample of 220 households. Considering that a verification survey seldom includes more than 100 households, we could expect the 90% confidence range for the same variable to be between 73 and 127% of the mean. If we attained the same level of precision in the final evaluation survey in three or eight years, then production from the project would have to rise by about 30% before we could say with 90% confidence that the increase was more than zero from a statistical point of view. At this point even the project's strongest supporters do not expect that kind of increase over the entire project area by the end of the project execution phase.

A more geographically limited survey can overcome this problem by reducing the variation in the data and concentrating on those areas most directly benefiting from the project. Maximizing the use of stratification in the selection process can also help. The sectors around a multi-locational site would constitute one stratum. To obtain a sample that will permit facile calculating of sampling variance, sampling at each stage except the last should proceed with probability proportional to household population. Then a constant size sample should be drawn from each selected last stage unit to get the actual households to be interviewed.

The sector household populations for 1986 listed in Table 3 provide an adequate sampling frame for

the first stage selection process for the survey. After identifying those sectors surrounding the multi-locational sites, supervisors should list all cells and, if possible, collines and their respective household populations. Within each stratum I would list the collines from one end of the area to the other in serpentine fashion in order to distribute the sample evenly throughout the area. Then a cumulative household population listing could be prepared, adding the population of each colline to the total of all previously added collines. The total population of the stratum is divided by five to get a sampling interval. A random number between one and the sampling interval should be drawn; to this number should be added multiples of the sampling interval until the list is exhausted. The first stage sample units consist of those collines that include the sampled household according to the cumulative population listing.

Once the first stage sample units (collines) have been identified, supervisors should list all households in each of the selected collines in each of the five strata (assuming five multi-locational sites are eventually chosen). These should be listed from top to bottom in order to ensure that all altitudes are proportionally represented. Using the same procedure as for drawing the collines, five households per colline should be selected. These are the households to be interviewed. This will give a total sample size of 125 households distributed across 25 collines in five strata. Means for each of the 25 clusters should provide the accuracy necessary both for baseline measures and for verifying research hypotheses.

For each field of each of the selected households, the verification survey should collect key crop input data, such as variety, approximate seeding rate, method of land preparation, planting date, date of first and second weeding, amount of manure and fertilizer applied over the past two years and when applied, date of harvest and any other easily measured variable likely to have a substantial impact on yield. This goes beyond the normal purview of a verification survey, but such data will prove useful for identifying key factors that affect yields and for providing baseline data necessary for project evaluation. I would not attempt to measure labor inputs.

Before the team can actually execute the verification survey, someone will need to take the final questionnaire and prepare field manuals for supervisors and enumerators. Such manuals cover definitions, measurement procedures and various contingencies likely to arise during survey execution. The person responsible for survey execution should also prepare coding manuals as part of the questionnaire design process. In that way data entry can begin in earnest as soon as the first questionnaires come in from enumerators.

Properly preparing and executing a verification survey that also provides essential baseline data for evaluating project impact is not a task that can be piggybacked onto an otherwise normal work load. Someone will have to take primary responsibility for the survey and devote nearly 100% of his time to it for at least four months, including preparation, execution, supervision, tabulation and analysis. The FSRP agricultural economist would be the person likely to assume such responsibility.

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ANNEX

AGRO-ECOLOGICAL ZONES IN THE FSRP PROJECT AREA: CLASSIFICATION SYSTEM AND PROPOSED SITES

Map A-1 reveals major soil types in the project area and shows average rainfall isohyets. The dark line at the bottom indicates the boundary between the Central Plateau and the Buberuka Highlands. Using this map as a reference, Map A-2 indicates the boundaries for the principal ecological zones proposed for the project. In general, these zones follow administrative boundaries so that their location is unambiguous. However, the zone dealing with bas fonds is spread throughout the other three and is not separately marked. Each zone is subdivided into a high- and low-altitude subsume using 2100 m as a more or less flexible dividing line.

Zone I-H: The high-altitude portion of all of Butaro commune and the northern half of Cyeru. This zone falls roughly above 1250 mm of annual rainfall and consists entirely of soil class 4 as defined on Map A-1. This area would have a multi-locational site.

Zone I-L: The low-altitude portion of Zone I. This area would also have a multi-locational site, preferably one near a bas fond so that it could be combined with the high-altitude subsume of Agro-ecological Zone IV.

Zone II-H: The high-altitude portion of Nyamugali Commune, with the exception of Kidomo and Rukore Sectors. Zone II receives more than 1250 mm of annual rainfall on average and includes a portion of the Central Plateau. It contains the same soils as Zone I. The high-altitude portion of the Central Plateau is assumed to be similar to the high-altitude portion of the Buberuka Highlands in this Zone. This area would not have a multi-locational site.

Zone II-L: The low-altitude subsume of Zone II. Because the low-altitude subsume is larger than the high-altitude subsume, this subsume would have a multi-locational site. Hopefully, it too will be located near a bas fond where it could incorporate the low-altitude subsume of Zone IV.

Zone III-H: The high-altitude subsume of Nyarutovu and southern Cyeru communes. It also includes the two sectors of Nyamugali not included in Zone II. Eventually, it will include the high-altitude portion of Ruhondo Commune as well. This Zone experiences rainfall in excess of 1250 mm annually and consists primarily of soils type 2 and 3 as defined on Map A-1. Type 3 soils are of lesser importance, however. This subsume will have a multi-locational site somewhere on soil type 2.

Zone III-L: This is the low-altitude subsume of Zone III. It too will have a multi-locational site, hopefully near a bas fond where it can include the low-altitude subsume of Zone IV.

Zone IV-H: This includes the bas fonds of low-rainfall Zone I. The surrounding hills receive less than 1250 mm of rainfall annually. The valley bottoms in this subsume lie at relatively high altitudes. This subsume will not have a separate multi-locational site. Rather, it will be included with the multi-locational site for Zone I-L. This will not require that the two sites be contiguous, only that they lie in the same sector.

Zones IV-L: This includes the bas fonds of Zones II and III where rainfall on the surrounding hills usually exceeds 1250 mm per year. These bas fonds tend to lie at a lower altitude than those of Zone IV-H. This subsume also will not receive a separate site but will be incorporated with the site for Zone III-L. Both Zone IV-H and Zone IV-L contain soils of type 5 as defined on Map A-1.

PERSONS CONTACTED

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Table 1. Selected characteristics, crop production and livestock holdings for households in the Buberuka Highlands and the Central Plateau, 1984.

Item	Average Values			
	Buberuka Highlands		Central Plateau	
Household Characteristics:				
Headed by a Male (%)	75.6		75.2	
Members	4.6		5.1	
Active Workers	2.2		2.5	
Non-Permanent Roof on Dwelling (%)	47.3		28.6	
Possession of Compost Pit (%)	83.5		81.6	
Renting Some Fields (%)	50.7		48.1	
Farm Characteristics:				
Size (ha)	1.0		1.1	
Number of Fields	7.0		6.0	
Number of Parcels:				
Season A	15.2		14.5	
of which cultivated	9.6		10.5	
Season B	16.7		16.6	
of which cultivated	11.7		12.5	
Crop Production (kg/household):				
Sweet Potatoes	982.0	(99.0)[1]	833.6	(97.3)
Bananas	766.0	(76.2)	1,531.2	(97.4)
Beans	177.4	(98.0)	225.0	(99.4)
Sorghum	125.8	(94.7)	105.2	(77.8)
Potatoes	93.3	(33.2)	24.6	(14.3)
Maize	89.5	(78.8)	36.6	(83.3)
Manioc	41.4	(29.5)	294.4	(77.5)
Peas	33.0	(47.6)	10.1	(31.5)
Wheat	14.1	(24.6)	0.1	(0.2)
Coffee	5.1	(19.9)	34.3	(67.5)
Soja	0.0	(1.3)	6.4	(26.2)
Livestock Holdings (units/household):				
Cattle	2.3	(14.0)	2.6	(29.1)
Goats	3.6	(32.1)	2.7	(51.7)
Sheep	2.7	(50.1)	2.3	(25.6)
Pigs	3.3	(5.4)	1.5	(21.3)
Any Kind	4.5	(67.0)	4.2	(74.3)

Source: Service des Enquetes et Statistiques Agricoles. 1985. Resultats de l'Enquete Nationale Agricole, 1984, Vol. I, Rapport 1. Ministere de l'Agriculture, de l'Elevage et des Forets, Kigali.

[1]Numbers in parentheses are the percent of households actually producing the crop.

Table 2. Area in crops in the Buberuka Highlands and the Central Plateau: First season, 1984 (ha).

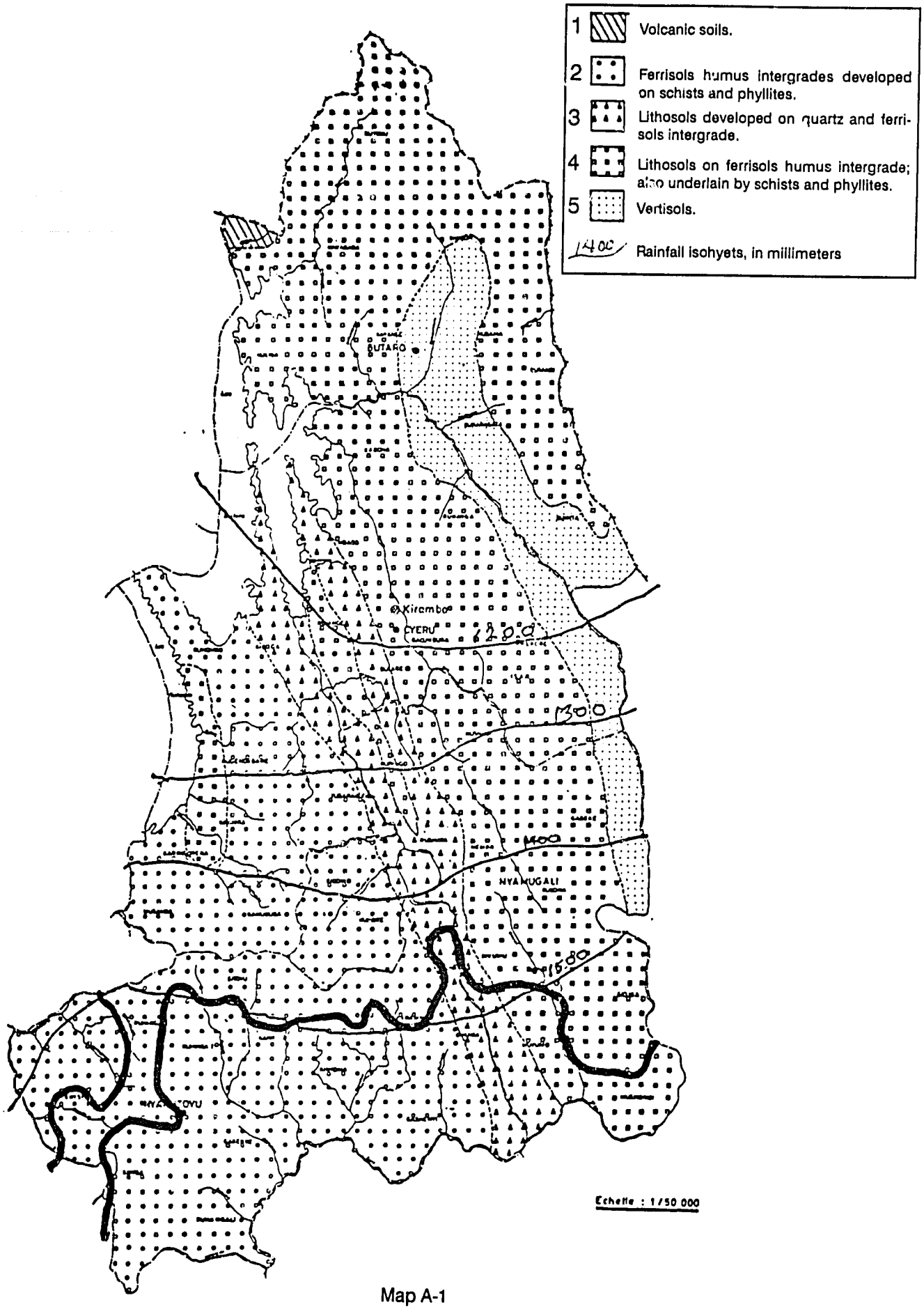
Crop/Association	Buberuka Highlands	Central Plateau
Pure Stands:		
Sweet Potatoes	12,216	13,748
Bananas	3,338	9,895
Beans	5,027	9,237
Sorghum	44	373
Potatoes	694	66
Maize	57	2,241
Manioc	532	10,700
Peas	3,966	1,639
Wheat	259	0
Coffee	1,122	10,067
Soja	33	318
Other Pure	3,422	1,979
Sub-Total Pure	30,710	60,263
Mixed Stands:		
Banana/Beans	473	11,369
Banana/Other	540	4,187
Beans/Maize	6,310	10,370
Beans/Bananas	3,062	25,949
Beans/Peas	3,472	6,174
Beans/Sweet Potatoes	1,593	3,435
Beans/Other	657	3,211
Maize/Beans	223	137
Maize/Other	843	3,895
Sorghum/Maize	709	2,995
Sorghum/Other	0	171
Sweet Potatoes/Other	932	1,399
Potatoes/Other	0	59
Manioc/Other	111	3,561
Other Associations	569	2,524
Sub-Total Mixed	19,494	79,436
Total All Crops	50,204	139,699

Source: Service des Enquetes et Statistiques Agricoles. 1985. Resultats de l'Enquete Nationale Agricole, 1984, Vol. I, Rapport 1. Le Ministere de l'Agriculture, de l'Elevage et des Forets, Kigali.

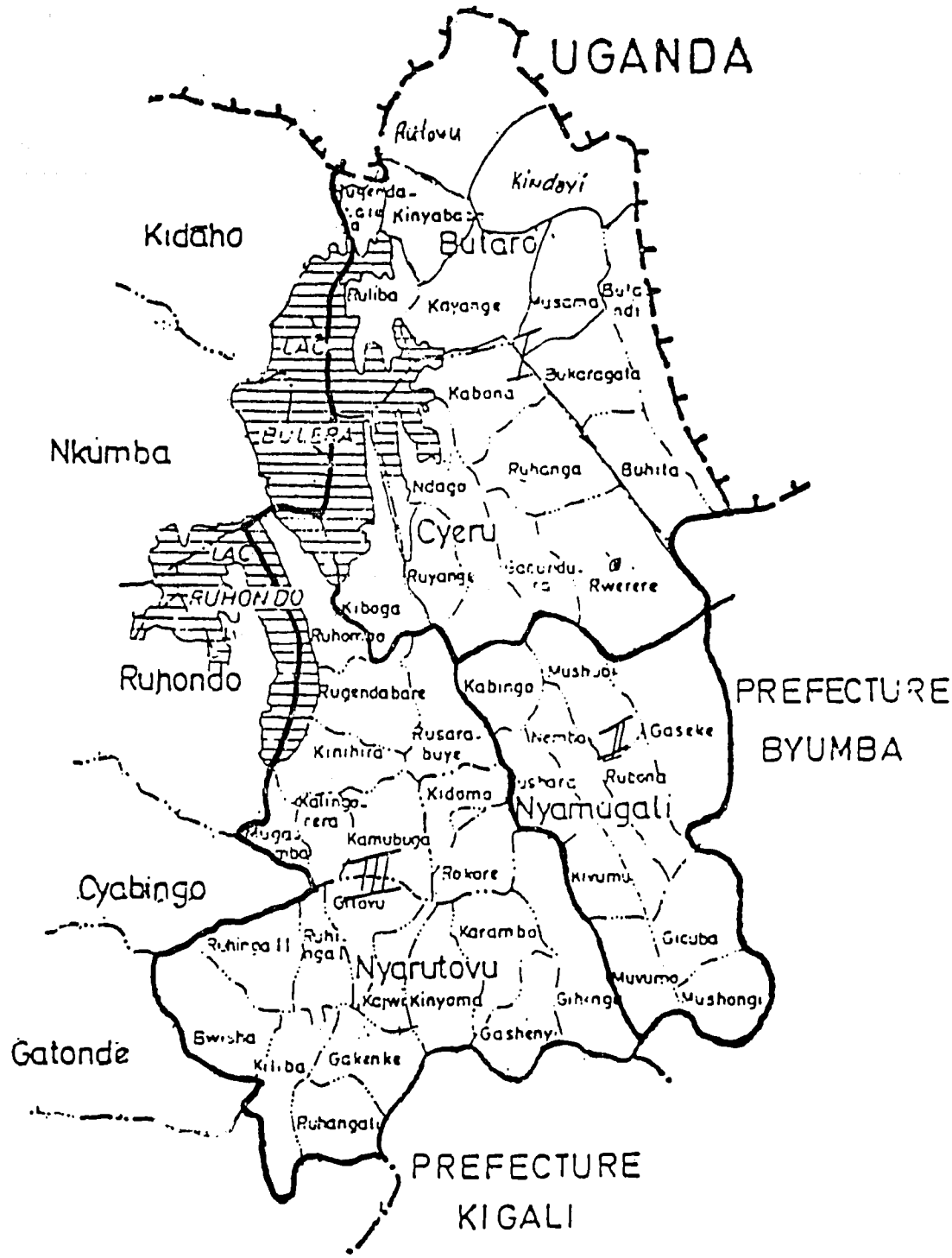
Table 3. Number of households by sector in the FSRP project area, 1986.

Commune	Secteur	Number of Households	Commune	Secteur	Number of Households
Nyarutovu	Gihinga	1,112	Nyamugali	Kabingo	708
	Karambo	965		Mushubi	814
	Gashonyi	850		Gaseke	927
	Kinyoma	1,105		Rubona	759
	Kajwi	809		Nemba	743
	Gitovu	1,063		Rushara	610
	Ruhinga I	871		Kidomo	717
	Ruhinga II	853		Rukore	693
	Ruhingali	793		Kivumu	780
	Bwisha	890		Gicuba	819
	Kiliba	1,122		Mushongi	819
	Gakenke	869		Muvumo	621
	Sub-Total	11,302		Sub-Total	9,010
Cyeru	Kabona	868	Butaro	Rutovu	1,222
	Ruhinga	757		Kindoyi	1,243
	Ndago	1,046		Rugendabare	367
	Rwerere	1,004		Kinyababa	1,114
	Gacundura	751		Ruliba	816
	Ruyange	971		Kayange	1,470
	Kiboga	752		Musama	839
	Ruhombo	912		Butandi	605
	Rugendabare	1,142		Bukaragata	722
	Rusarabuye	659		Buhita	717
	Kinihira	787		Sub-Total	9,115
	Mugamba	556			
	Kalingorera	831			
	Kamubuga	1,078			
	Butare	684			
	Sub-Total	12,798			

Source: Communal Census Offices.


1 Volcanic soils.
2 Ferrisols humus intergrades developed on schists and phyllites.
3 Lithosols developed on quartz and ferrisols intergrade.
4 Lithosols on ferrisols humus intergrade; also underlain by schists and phyllites.
5 Vertisols.
1400 Rainfall isohyets, in millimeters
BUTARO
Kirambo
CYERU
1200
1300
1400
1500
NYAMUGALI
Echelle : 1/50 000

Map A-1


UGANDA
Kidaho
Nkumba
Ruhondo
Cyabingo
Gatonde
PREFECTURE
BYUMBA
PREFECTURE
KIGALI
Kindayi
Kinyaba
Butaro
Ruliba
Kayange
Musama
Bukaragata
Kabona
LAC
BULERA
Ruhanga
Buhita
Ndago
Cyeru
Ruyange
Rwerere
LAC
RUHONDO
Kiboga
Ruhombo
Rugendabare
Kabingo
Gaseke
Rusara-
buye
Kinihira
Kidomo
Nyamugali
Kamubuga
Rokore
Gitovu
Karambo
Nyarutovu
Kinyoma
Gicuba
Muvumo
Mushongi
Gasheny
Gakenke
Ruhangali
Echelle : 1/250.000

Map A-2