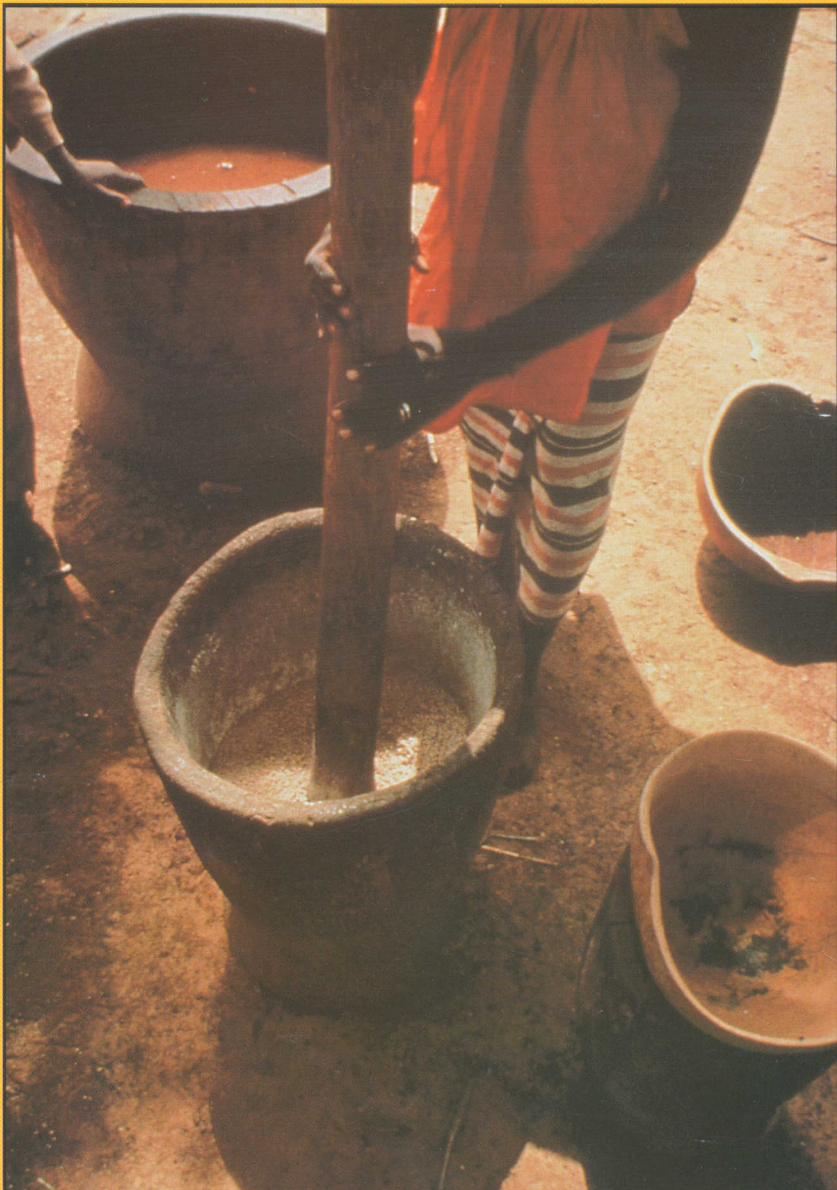

Farming Systems Research and Extension in Mali 1986-1994

Farming Systems Research and Extension in Mali – 1986-1994

ACKNOWLEDGEMENT

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Farming Systems Research and Extension in Mali — 1986-1994

Anthony K. Yeboah and Richard L. Guthrie[1]

Introduction

HISTORY OF FSR PROGRAM IN MALI

The Department of National Farming Systems Research (NFSR) is one of six departments in the Institute of Rural Economy (IER). The department is charged with conducting farming systems research (FSR) throughout Mali by establishing FSR teams in each ecological zone (Long-term Plan, OHV Volet, March 1990).

During the initial stages of its creation, the department's activities were concentrated in the southern part of the country: the Fonsebougou volet initiated research activities in the following zones: Tominian, Koutiala, et Kadiolo, while the Bougouni-Sikasso volet started activities in Yanfolila, Kolondieba, and Koumantou.

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In 1986, the OHV volet was started with funding from USAID and the Government of Mali to carry out farming systems research work in central Mali. Finally, in late 1991, a FSR team was set up in the fifth region of Mali based at Mopti. The Mopti team of the NFSR program is now operational with the financial and technical support of USAID and the Government of Mali.

Thus the department has four major projects each managed by a coordinator, however, this document deals only with the OHV and Mopti Volets.

(1) Fonsébougou Volet: This project is financed jointly by the Dutch and Mali governments and is in its fourth phase. The project currently has both research and pre-extension activities.

(2) Bougouni-Sikasso Volet: This project was initially financed by the Canadian government then brought under

USAID funding until this year. The project currently has both research and pre-extension activities.

(3) OHV Volet: This project started in June 1986 is financed jointly by USAID and the Government of Mali. The project has research, pre-extension and demonstration activities.

(4) Mopti Volet: This volet was started late in 1991, after a two-year delay, under the joint funding of USAID and the Government of Mali. The main activity performed last year was a rapid reconnaissance survey. The 1992-93 agricultural season will be its first research year.

OBJECTIVES OF THE PROGRAM

THE NATIONAL OBJECTIVES

The overall objective of the National Farming System program, is to enhance the development of technologies and rural development policy actions that are adapted to the actual conditions of farmers in order to increase food production and enable the country to achieve self-sufficiency in food production and a greater food security. Specific program objectives include the following:

(1) To study the current farming systems in Mali so as to identify farmers' problems and particulary the technical and socio-economic constraints to new technology adoption.

(2) To develop a system of communication between farmers, thematic researchers, and developers so as to influence the objectives and the methodology of the thematic research and developmental programs in the rural areas to address the actual problems and needs of farmers.

(3) To develop in full collaboration with farmers, thematic researchers and extension agents, farming technologies that are adapted to farmers' conditions and which alleviate the major production constraints faced by farmers.

(4) To propose to development policy makers elements for the design of agricultural development policies which are adapted to the farming systems conditions.

(5) To train national scientists and technicians to assume full responsibility in the implementation of the national program for Mali.

FOCUS AND OBJECTIVES OF THE FSR/E SUPPORT TO THE NATIONAL FSR PROGRAM

The main focus of the FSR/E support to the national FSR program is to improve the research capabilities of the program. The output of the support is to lead to a better understanding of the total farm environment and systems of production through identification of major constraints and providing solutions through uninterrupted research and technology evaluation. USAID/IER FSR/E is expected to facilitate the evolution of integrated FSR activities that strengthen the linkages between on-station researchers, extension agents and farmers.

The global objective of the program support is to facilitate the realization of the national objectives:

(1) by providing technical and resource support to the national program in deficient areas or research gaps;

(2) by developing agricultural technologies which are relevant to farmers' needs and circumstances;

(3) by assisting in the evaluation of technologies and by evolving approaches and methodologies for efficient diffusion and adoption;

(4) by helping to train national FSR scientific research personnel and technical staff;

(5) by providing technical advisory services to the national research in general and FSR in particular.

COLLABORATIVE LINKAGES

Different versions of collaborative linkages necesary for an efficient FSR program have been documented over the years. The version summarized below has beeen widely used in other countries in the Sahel Region.

The collaborative links may be described as shown in Figure 1.

Besides the farmers with whom the FSR team is expected to work, the team is also expected to establish close working relationships with two other types of partners. These are research partners and the development partners working in the area. The research partners include all thematic researchers of national research centers and institutes, the Faculty of Agriculture of the Institute of Rural Production at Katibougou and

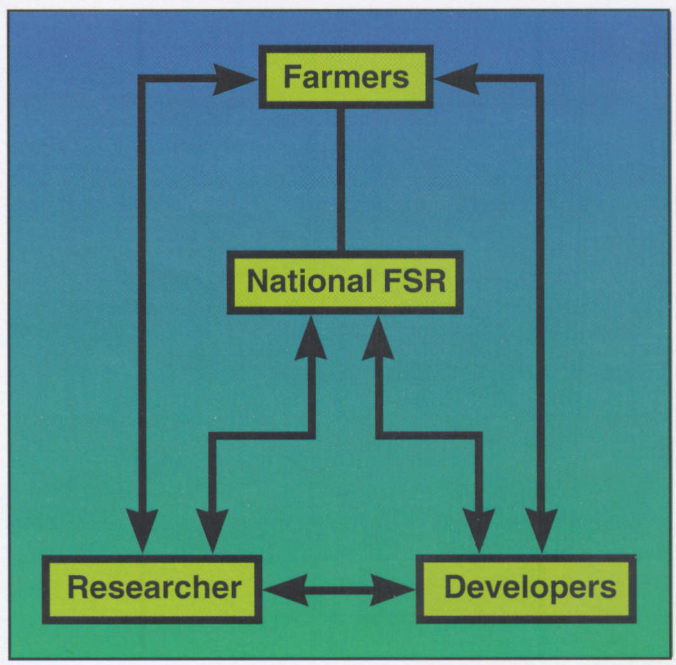


Fig. 1. Farming system research collaborative linkages.

local branches of international agricultural research centers. The collaborative links with the regional development agencies are established through formal documents of cooperation.

THE USAID/IER FARMING SYSTEM RESEARCH METHODOLOGY IN MALI

The methodology used for FSR is as shown in Figure 2 and may be described by the following principles:

(1) FSR is viewed as a research approach promoted and supported by an FSR department.

(2) The FSR department provides on station scientists with information on farmers conditions, own solutions and technical needs, so as to enable each scientist or discipline to address a relevant problem and to find for a given problem, a feasible solution which does not aggravate any other problem faced by the farmer.

(3) The FSR department tests and evaluates proposed technologies on farm with farmers' active participation and it feeds back to station based scientists and to agricultural development agencies information on performances to be tackled.

(4) The FSR department selects, designs, and tests combinations of technologies in collaboration with researchers.

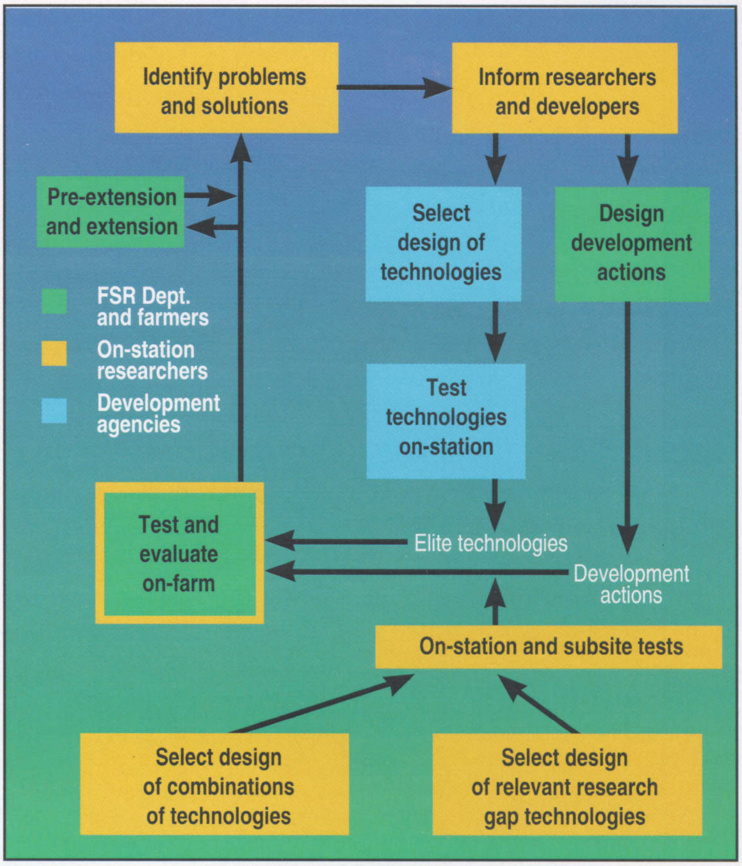


Fig. 2. The IER/USAID FSR methodology in Mali.

PROJECT SITE AND RATIONALE FOR CHOICE

OHV Volet

The governmental agricultural development parastatal, Opération Haute Vallée, in July, 1983, divided its zone of operation into six administrative sectors: Kangaba, Ouelessebougou, Bancoumana, Koulikoro, Kati, and Banamba. These sectors were subdived into 30 zones, "Zones d'Expansion Rurale," (ZER), and the ZER were further subdivided into 150 sectors "Secteurs de Base," approximately 939 villages and settlements in the area, Figure 3.

The population of the OHV zone (390,790 people in the last census in 1976) is predominantly rural, deriving the majority of revenues from agricultural activities. The main ethnic groups found in the area are the Malinke, the Bambara, the Sarakholle, the Peul, and the Bozo.

The OHV zone encompasses an area of 31,530 square kilometers which represents 2.5% of the Malian territory and 11% of the cultivated rain-fed area. It covers the area immediately surrounding the capital city, Bamako, and hence has access to the largest market in Mali. The climate varies from Sahelian (600 mm rainfall) in the northern sectors of Banamba and North Koulikoro, to Sudano-Sahelian (1,200 mm rainfall) in the South in Ouelessebougou, Bancoumana and Kangaba. From 1981 to 1985 rainfall was low, but in 1986 the drought appeared to diminish and the pattern approached the 50-year

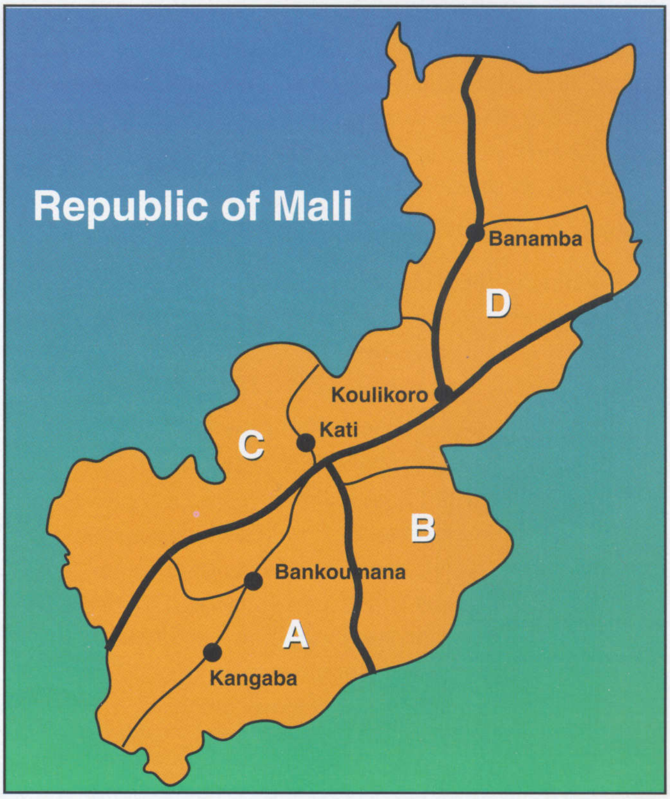


Fig. 3. Zones of OHV Volet.

average. However, 1988 experienced a higher-than-normal rainfall while that of 1989 and 1990 were below the long term average. The rainfall average for last year was also above normal. The mean temperature varies seasonally from 26 to 36 degrees Celsius.

The plains are soils of fine silt, clay materials, or sand, laying over lateritic hardpans. The topography which directly affects the climate of the region, is dominated by the Mandigue mountains in the Sectors of Kati, Bancoumana, Kangaba, and Koulikoro, and the Niger River, which crosses the region from Southwest to Northeast. Lands of variable topography lay between the Niger and the mountain chains. Mountain and cliff areas have predominantly rock outcroppings and wash areas.

The broad alluvial plains of the Niger are the agricultural heartland of the region. Rice, millet, sorghum, vegetables, and cash crops grow in this area. Rice is also grown in the lowlands around the villages. In the sectors of Kangaba, Bancoumana, Ouelessebougou, Kati and South Koulikoro, millet and sorghum are grown in gravelly sandy soils, generally clay-silt or silt-clay mixtures. In the dominantly agropastoral sectors of Banamba and North Koulikoro, souna millet is the principal crop. Tree crops (mangoes, Karite, and etc.) are also important throughout the region.

The road system in the OHV zone comprises four main hubs, starting at Bamako in the directions of Kati, Banamba, Kangaba, and Ouelessebougou. In addition, the area is served by a network of secondary roads, many of which become impassable during the rainy season. Health and education centers are located mainly in the larger urban centers and in the main villages in some sectors. These centers appear to be more developed in the Sectors of Kati and Kangaba than in Banamba, where they are rare.

Mopti Volet

Zoning in the fifth region has been attempted by several studies, however in a general manner, three principal natural zones can be identified: the Delta, Plateau, and the plains (Henry de Frahan et al., 1989; PIRT, 1986).

The Delta covers about 46% of the total area of the region and contains about 48% of the population with a density of about 18 inhabitants per square kilometer. The main crops are rice, millet, sorghum, and cowpeas. Fishing, craftmanship and migration are important sources of income. The importance of livestock lies not only with its income generation, but also with the way it affects natural resource management. The Delta serves as the main source of forage pasture during the dry season for all of the region.

The Dogon Plateau which covers 11% of the region's area and 15% of its population is characterized by a higher population density (22 inhabitants per square kilometer). The important crops are millet and vegetables. Small ruminant production and migration are important income sources.

The Séno Plain and South Gourma are characterized by pure millet stands (South Gourma) or in association with cowpeas and dah (Séno Mango and Séno Gondo).

The initial zone of intervention consists of the Delta (Delta South and the southern portion of Delta Central and the Séno Gondo (Séno Koro and Séno Bankass). The agricultural diversity of the Delta is very well represented by the southern and central portions. Séno Mango and south of Gourma are dominated by livestock production activities. Dryland crops such as millet, cowpeas, and dah are found mainly in Séno Gondo. The pressure on agricultural land is more pronounced in the Dogon Plateau than in the Delta and Séno.

Due to the present size of the team, a limited area of intervention is chosen with a view of progressive expansion over the years as more resources become available and as acquired experience is made use of in future interventions. Thus the Dogon Plateau is not included in the initial zone of intervention.

The pertinent criteria used in the choice included the following (see Table 1):

...the importance of the zone in the context of the overall development of the fifth region;

...how representative the zone is from the point of view of the existing rural production systems;

...the potential of the zone in terms of human and natural resources;

...accessibility to the zone all year round; and

...the presence of research and development institutions to collaborate in the interdisciplinary approach to research used by the farming systems research.

Based on these factors, initially two research villages were

Table 1. Some Important Characteristics of the Zones of Intervention

Zone	Rainfall mm	Production system	Structures
Delta South	350-600	crop-fishing-livestock crop-livestock (mainly irrigated rice)	ORM OPM ODEM DRA CMDT BNDA GTZ CARE-MALI
Delta Central	350-400	crop-fishing-livestock crop-livestock (mainy irrigated rice)	ORM OPM ODEM BNDA DRA
Seno Koro	350-450	crop-livestock (mainly millet based)	DRA ODEM BNDA
Seno Bankass	450-600	crop-livestock (mainly millet based)	DRA ODEM

Source: Rapid Reconnaissance Survey, DRSPR/Volet Mopti 1992 selected in Séno Koro and a village each was chosen from the other three zones (Figure 4). However, due to the limited size of the team, one village was dropped from among the two chosen in Séno Koro.

AVAILABLE RESOURCES FOR PROGRAM IMPLEMENTATION

Over the life of the project there has been a progressive evolution in the resource available for implementing the program. The section below gives an overview of the situation as it existed during the final year of technical assistance to the project.

Personnel: The national FSR programs both at Bamako (OHV Volet) and at Mopti still benefit from the financial and technical support of USAID and the Government of Mali. Two technical assistants currently constitute part of the national farming system research program. They include an agricultural economist, who also serves as the chief of party, and an agronomist, based in Mopti. The national counterparts at Bamako consist of two agricultural economists, two livestock scientists, two agronomists, and a technician. Those for Mopti include an agronomist, an agricultural economist, two livestock scientists, a sociologist, a research assistant, and a technician. Both regional teams are supported by computer technicians, accountants, secretaries, and drivers. The overall NFSR is headed by an agricultural economist. The list of personnel for the program in each region is shown in the appendix.

Computer equipment: There are currently 21 micro-computers, one laptop, and 12 printers at the OHV volet and six micro-computers, one laptop, and two printers at Mopti.

Vehicles: The OHV volet has currently four Toyota Land Cruisers, a Toyota 4x4 pick-up, one Jeep Cherokee, two Peugeot 504s, and two Peugeot 505s. The purchase of four more Jeep Cherokees has been budgeted as part of the commodity renewal process. The Mopti volet has three Jeep Cherokees.

Office Space and Housing: The OHV volet has been occupying the new office building at Sotuba since January, 1990. The construction at Koporo has been completed and that at Mopti is to begin soon. The Mopti volet is currently sharing office space with the rice research station (formerly WARDA) at Mopti and is using some of their residential facilities at Sévaré.

Others: Various office equipment, furniture and some experimental equipment (soil sampling tools, animal weighing scale, and field equipment) have been purchased for both volets. However, further purchases are expected, especially for the Mopti volet.

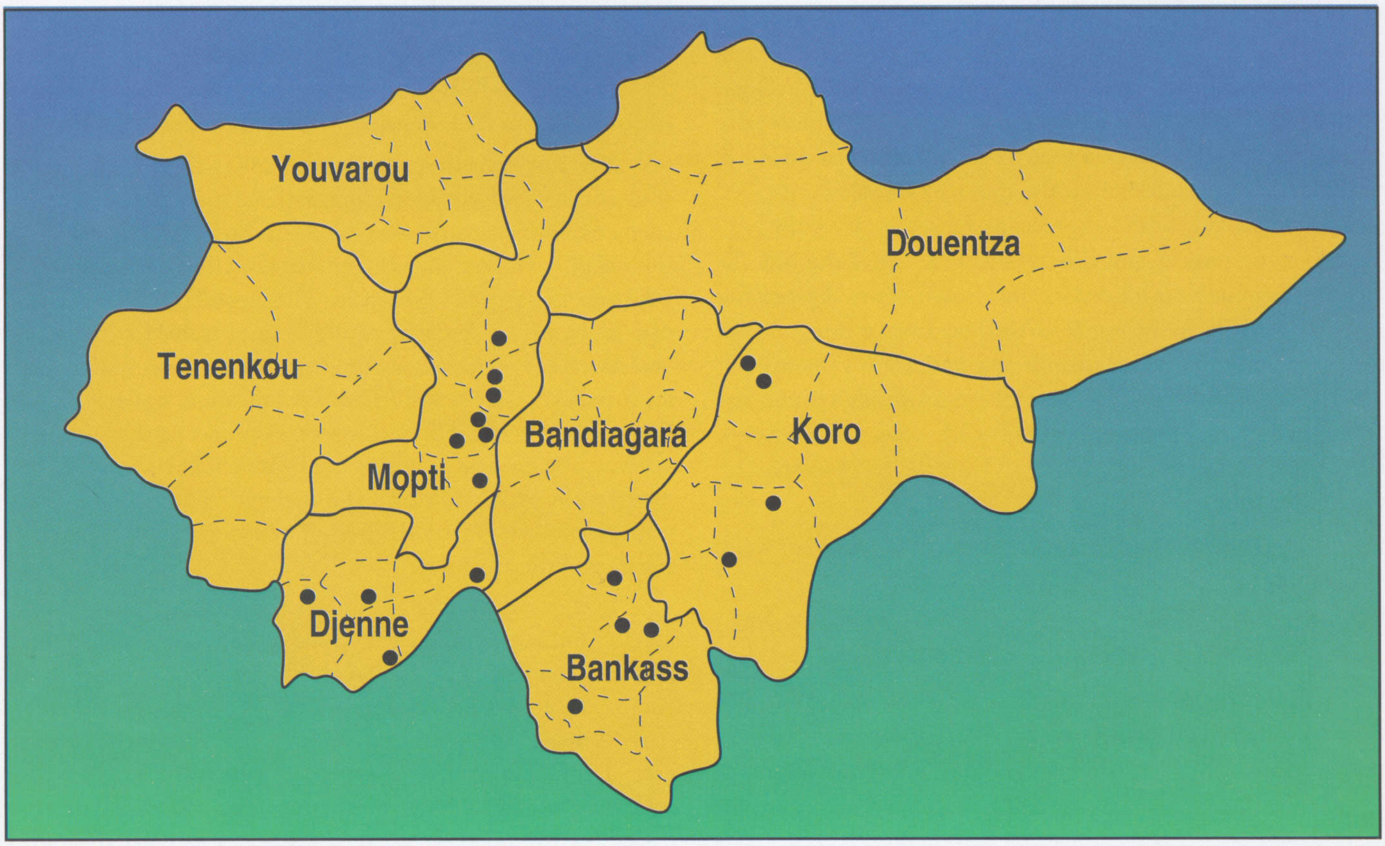


Fig. 4. General reconnaissance survey villages (DRSPR/Mopti Volet).

IMPLEMENTATION STRATEGY

The implementation strategy proposed by the project paper (see Executive Summary) consisted of the following:

(1) Extension of the Farming Systems Research and Extension work from the then single zone to the two other principal food production areas of the country.

(2) Improvement of Research-Extension-Farmer Linkages, as well as those within the agricultural research, training, and policy-making institutions.

(3) Training and Staff Development of 19 personnel with advanced degrees, the transfer of field methodology and analysis skills at all levels, and the facilitation of further professional development.

During the first phase of the project, a FSR team was established in the OHV zone, based in Bamako. A second team has been established, during the second phase, in the fifth region, based at Mopti.

The Research-Extension-Farmer linkages have been well established. A formal document of collaboration exists between the extension service in the OHV zone (Opération Haute Vallée) and a similar one is being developed between the Mopti team and ORDs and research units in the area. Research propositions are developed in close collaboration with both the extension service and farmers in the research villages. Research activities during the implementation phase are also coordinated by both units with specific tasks assigned to each, coupled with periodic meetings. This is especially the case with technologies at the pre-extension stage. Finally, research results are discussed by both units before being submitted to USAID and the Government of Mali for approval through the mechanism of technical commisions. The results and research proposals for the 1992-93 season were first reviewed and discussed at a regional technical commission from March 24-28. This was followed by a review and discussion before a national technical commission from April 25-28. The two documents were then approved.

All the 19 personnel were trained successfully, with about six of the participants already back in the country and working with the various research units and institutions and two others on the way. Most of the other participants are expected back at the end of this year. Continuing staff development is achieved through short-term training both in and out of the country.

Thus the implementation strategy previewed by the project paper has been followed closely.

THE SECID FARMING SYSTEMS RESEARCH AND EXTENSION UNIT

The South-East Consortium for International Development (SECID), which is comprised of over 20 U.S. universities and other institutions for higher education, was awarded the contract to provide technical assistance (TA) for the project and also to provide both long-term and short-term for the personnel of the project and IER as a whole. Thus the SECID Farming System Unit funded by the United States Agency for International Development (USAID) became an integral part of the Farming Systems Research and Extension Department in May, 1986, with the task of conducting farming systems research in the OHV zone in Region II with expected extension to the fifth region in the fifth year. The specific objectives of SECID FSU were as follows:

(1) to identify the principal constraints of increased food production,

(2) to identify technologies appropriate for farmers which could overcome the production constraints,

(3) to develop and implement a multidisciplinary research method which could guide production technology and production research to directly address these production constraints,

(4) to identify the elements of that method which could be implemented in national farming systems research programs, and

(5) to train host-country personnel to assume increasing responsibility in their contribution to research.

The initial technical assistance called for three TA positions at the headquarters in Bamako. One was a Research Management Specialist who would serve as the research advisor to the DRSPR Project Director, and as the Chief of Party of the TA team for a period of six years. The second position was that of a financial manager who would be responsible for the set-up and operation of the accounting and procurement systems also for a period of six years. The third position was for a Data Processing/Statistical Specialist who would set up the computer systems, the formats in which field data could be entered, the programs by which they could be analyzed. Three person-years were proposed to train DRSPR staff in the operation and maintenance of the system.

In the field, two long-term advisors (one agronomist, one agricultural economist) were posted to help develop, test, and apply field methodologies in the OHV zone. Along with their senior Malian colleagues, these adivors had the responsibility for transferring skills to more junior researchers. The expansion to the fifth region was to take place following an evaluation after four years. The expansion called for the posting of two more advisors with the same skills for a period of four years each.

Structure, Rationale, and Benefits of FSR Program (OHV and Mopti Volets)

COMPLEMENTARITY OF FSR COMPONENTS

Rationale for component choice

The disciplines of Agronomy and Soil Science and Animal Production and Economics have been identified as necessary components to a NFSR program. These choices have been used widely in the Sahel countries of Burkina Faso and Senegal. The discipline of agro-forestry was added to the components to take into consideration the deteriorating vegetative cover of the area and the national priority on environmental conservation.

The socio-economic studies provide the research program with an understanding of the social and economic factors that determine the feasibility of the existing technologies and of those to be introduced.

The soil study is to search for technologies that would block the degradation of soil resources and build up the state of knowledge of the soil management at the farm level by using resources locally available. The agronomic research aims to study the major crop management practices in the area and introduce improved practices tested by thematic researchers to the farming community.

The animal production component is aimed at the integration of animal production with crop production so as to promote stable and efficient agricultural practices by stimulating the complementary value of the crop and animal enterprises.

The agro-forestry component introduces practices of integrating multi-purpose vegetation on the farm so as to increase feed and energy supply of the farmer from a given space while at the same time promoting natural resource conservation.

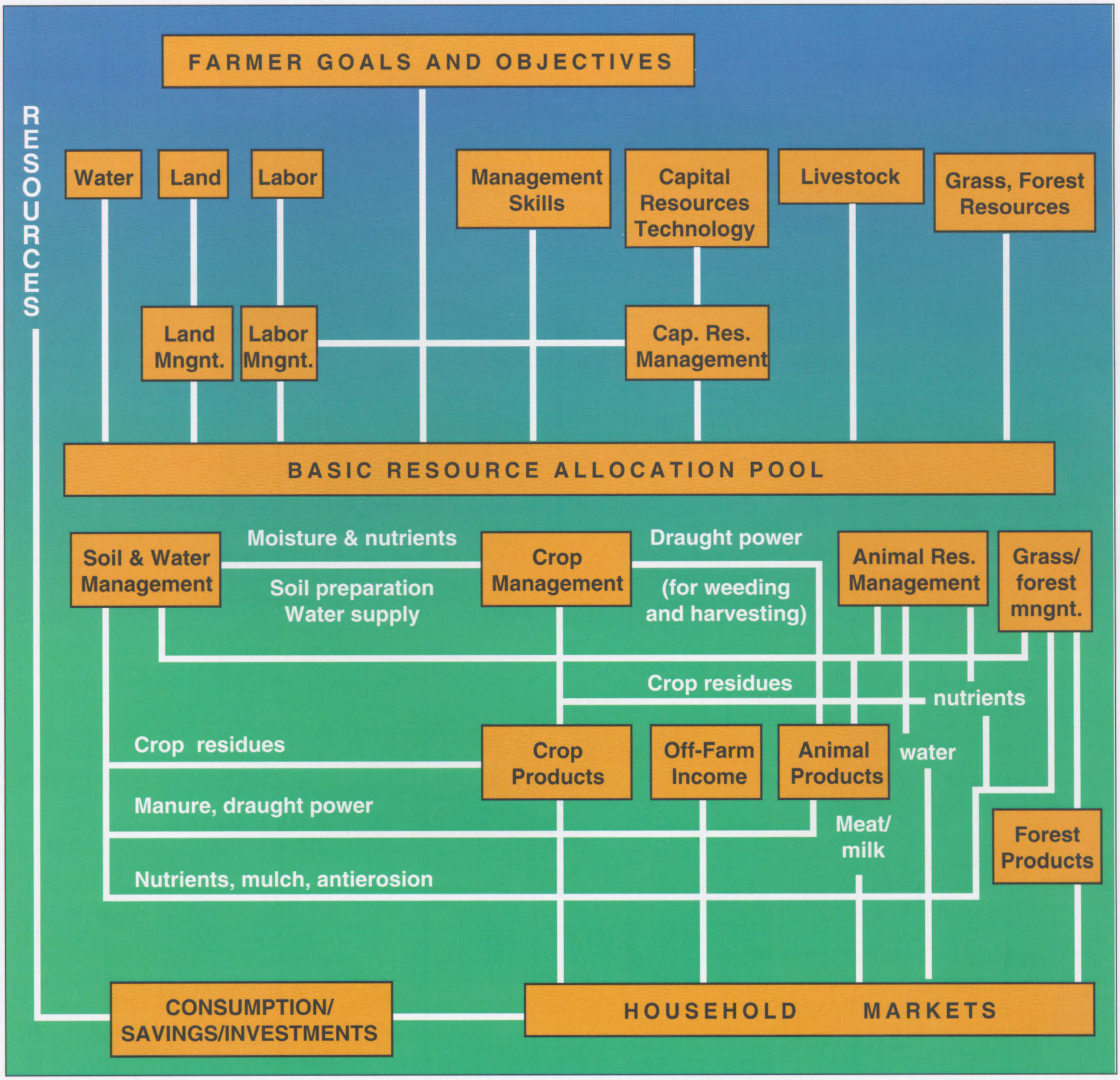


Figure. 5. Linkages of FSR Components.

Linkages of FSR components

The linkages of the FSR components are illustrated in Figure 5.

The socio-economic studies provide the program with an understanding of the constraints for improving the traditional farming sytems by identifying the following:

...farmers' goals and objectives,

...levels of available resources,

...resource management alternatives, and

...resource allocation to the different enterprises on the farm.

Given this condition, the crop and animal production components design mediations that would optimize farm production with respect to the given resources. The agro-forestry component tries to increase the energy and feed harvest from the farm for a given typology of farmers as well as preserve resources so as to sustain yield. Similarly, the soils aspect of the program works out strategies and mediations so that the resource base will be improved which in the long run determines the welfare of the farm community.

As an illustration, an improvement in the soil and water resources of the area would lead to increases in crop and forage production, other factors remaining unchanged. This, in turn, would lead to a higher crop yield per area and/or forage production. The higher grain yield would lead to less land to be cultivated once farmers' goals have been achieved, which would give opportunity for natural vegetation regeneration and ultimately ecological stability. The higher vegetative production would increase the animal feed source, therefore, higher animal productivity as a by-product of which manure availability and traction power, could improve. If prices are favorable the increase in income would be expected to encourage farmers to pay for the investment in soil and water management.

This program assumes several conditions. One of the main tasks of the FSR program is then to clarify these assumptions, identify the conditions under which the different components may be complemented, and work out alternatives for the socio-economic and bio-physical environments. Simultaneously, the findings have to be conveyed to the different development and research partners for concerted action. At all phases, the farmers' roles in the whole program can never be overemphasized.

Thus the FSR program's role can be summarized as an approach in which the farmers' key roles in the research are underlined in an attempt to work out a research strategy to encourage the different enterprises to be complementary in a given environment (social, economic, as well as physical).

Phasing in of components

Even though for discussion purposes the components are presented separately, in practice all the activities are conducted simultaneously with various components phasing into each other in time depending on gestation period.

EXPECTED SOCIO-ECONOMIC BENEFITS OF THE PROGRAM

The major goal of Malian agricultural policy, like those of other countries in the Sahel region, is to achieve self-sufficiency in food crop production as soon as possible.

The government plans to achieve such a goal through:

...farmers organizing and training,

...increasing in productivity in the agricultural sector,

...enhancing and improving crop livestock integration, and

...conserving natural resources and protecting the environment.

The Malian National Farming Systems Research program aims at identifying technological needs and the most promising and relevant agricultural technologies available in Mali and elsewhere within the semi-arid zone, at satisfying such technological needs, and finally at adapting such technologies to the environmental, resource, and management conditions of small farmers.

Through interdisciplinary research on the farm, the program will first adapt technologies to improve the resource base of the farming systems. This will be achieved through soil fertility improvement, soil and water management techniques, livestock management and agro-forestry development within an integrated system of production.

The identification of most adapted improved varieties of crops, forages, trees, and shrubs would then help to further increase the productivity of farming systems in the region.

Thus the program's objectives are well in line with the national goals, objectives, and strategies and can substantially contribute toward their successful achievement.

The FSR program expects to yield tangible results within a five-year period and to be able to propose extension, technologies, and resource management systems that are profitable and accessible to small farmers.

Useful and directly applicable research results should then be available within a five-year period for adoption.

Other impacts expected from the adoption and application of the program's research results are:

...A reduction in rural emigration by making more and better production alternatives available to young farmers, which may also lead to a reduction in urban unemployment..

...Livestock being an important source of protein and an important export commodity of Mali, the program's research results by increasing productivity in the livestock sector through improved livestock feeding and management is expected to have significant positive effects on human nutrition, on the country's balance of trade, and on investments in the agricultural sector of the economy.

It should be noted that the methodology, linkages and rationalizations reviewed in this chapter have been applied by the FSR program in the OHV volet since its beginning in 1986. Thus being in its sixth year, those tangible results alluded to in the above paragraph should be available. A document of synthesis of these results is expected this fall. In addition, an evaluation program is underway to measure the impact of the research program on rural households. Preliminary results of the first phase of this evaluation have already been presented to USAID/Bamako. The second phase is in progress and results are due to be submitted soon.

On the other hand the Mopti Volet is just beginning its first full year of implementation, and thus, valuable results for extension should not be expected until about 1995.

Diagnosis and Characterization of the Production System

The development of technologies suitable for farmers required certain specific information that would provide knowledge about the project area (agro-climatic differences) and the farmers (e.g production constraints). Such information served to develop the design and implementation of research and development programs. Thus before designing an on-farm research program for the OHV and the Mopti zones, an overview of the agro-climatic, socio-economic environment, animal husbandry practices and agronomic practices was required. To obtain background information about the zones, secondary sources were exploited. The results of these studies are summarized in this section.

RAPID RECONNAISSANCE SURVEY

This was conducted in May, 1986, (Isabelle Valencia, 1986) in the OHV zone and in January, 1992, (DRSPR/Volet Mopti March, 1992; Yeboah A.K. Amadou Diarra, May, 1992), for the Mopti volet and the results served, in part, in the delineation of the agro-climatic zones of research as described earlier in the introduction and also in providing basic information about households. For details of production systems and constraints, consult the above cited references.

CHARACTERIZATION OF THE PRODUCTION SYSTEM

As opposed to the "top down" approach that characterized most agricultural research and development projects until the early 1970's Farming Systems Research and Development is characterized by a "bottom up" approach to agricultural research and development. As such, it first attempts to identify and clearly define the problems/constraints and conditions of agricultural production at the farm level before designing final solutions to resolve or alleviate such problems or constraints. The resulting iterative process of diagnosis-design and test results in more "appropriate" solutions to solve the identified problems.

Baseline studies at the farm and village levels are an indispensable instrument to complete the first diagnosis phase of FSR and to identify opportunities for technology development.

The specific objectives for the collection of this kind of data include:

...To study the current agricultural production systems so as to acquire more data and knowledge on small farmers' socio-economic, institutional and technical agricultural problems/constraints, with a particular emphasis on the constraints to technology adoption.

...To identify the adjustment mechanism (strategies, technological innovations and others) utilized by farmers as solutions to cope with their agricultural problems.

...To identify and define the technological needs of farmers ("appropriate technologies") and the appropriate types of development actions needed to resolve the existing problems and satisfy farmers' and national goals and objectives in the agricultural sector.

These objectives are attained by monitoring economic activities of farmers in the primary research sites and by reviewing the results of previous studies.

In order to determine the economic feasibility costs and benefits of promising technologies, the socio-economic baseline studies encompassed economic activities of farmers including crop production, livestock production, crop and livestock transaction and marketing, input purchases, financial transactions (including credit), off-farm income generation, fuel energy production, and consumption and general expenditures.

This data collection began in May 1988 and continue until April 1990 for the OHV volet; and for Mopti, data collection begun during the 1992-93 agricultural season and is expected to continue for another season. A brief summary is provided below:

OHV Volet

Data covered rainfall monitoring and resource use and management by the farmers.

Rainfall

Rainfall levels in the principal research villages were measured twice daily and the results show remarkable annual and location variation as indicated in Tables 2, 3, 4 and 5.

Figures in Tables 2, 3 and 4 indicate a wide variability in rainfall levels across the four zones. In 1988-89, the South experienced the earliest rainfall, in April, while the rest had their first rains in May. For the zone as a whole, much of the rainfall occurred from June to September. The figures also show that the average annual rainfalls are sufficient for cereal production and that the problem of soil moisture is closely related to rainfall distribution and farmer water management practices. The availability of soil moisture during certain points of plant development, such as flowering, is crucial for good crop performance. This had serious implication for research into early-planting, drought-resistant, and early maturing crop varieties. It also has implications for livestock production in terms of water and forage availability.

Resource use and crop and livestock production

What resources are available to a farm family and how they choose to use those resources provide major constraints as to what type and quantity of technology will be feasible and acceptable in an area. Thus the identification of resources and

Table 2. Monthly Average Rainfall (mm) in the OHV Zone (1988-89)

Month	North of OHV		South of OHV		East of OHV		West of OHV	
	Kanika	Doré.	Landé	Balan.	Gouani	Mount.	Komin.	Yéké.
April	—	—	—	22.30	—	—	—	—
May	10.40	5.00	44.50	28.30	18.70	12.00	25.00	14.40
June	56.60	68.50	182.50	157.60	226.80	46.50	122.20	102.30
July	296.50	237.50	312.50	272.50	336.20	385.00	321.30	224.00
Aug.	237.40	267.10	306.50	238.00	348.75	336.00	300.40	337.20
Sept.	73.70	131.00	242.50	245.10	145.50	133.50	168.00	171.20
Oct.	35.60	39.50	29.00	82.50	21.00	54.30	19.50	64.00
Nov.	—	20.00	—	—	—	—	—	3.00
Total	710.20	768.60	1,117.50	1,046.30	1,097.0	967.30	956.40	916.10
Av. total	739		1,082		1,032		936	

Table 3. Monthly Average Rainfall in the OHV Zone (1989-90)

Month	North of OHV		South of OHV		East of OHV		West of OHV	
	Kanika	Doréb.	Landé	Balan.	Gouani	Mount.	Komin.	Yéké.
Feb.	—	—	—	18.80	—	—	—	—
March	—	—	—	28.00	—	—	—	—
April	—	—	—	5.50	—	—	—	—
May	—	16.00	2.50	45.70	27.30	38.00	22.45	26.90
June	29.35	74.70	109.70	153.60	143.10	161.60	75.00	88.70
July	131.50	158.00	155.00	131.30	142.40	165.80	179.75	186.27
Aug.	371.70	163.00	324.50	281.60	288.30	334.50	246.50	275.50
Sept.	71.30	92.00	142.50	145.40	161.10	75.80	109.25	169.50
Oct.	7.90	94.50	74.00	—	36.80	39.00	111.75	94.50
Nov.	—	—	—	—	—	—	—	—
Total	611.75	598.20	808.20	809.90	799.00	814.70	744.70	841.37
Av. total	605		809		807		793	

Table 4. Monthly Average Rainfall in the OHV Zone (1990-91)

Month	North of OHV	South of OHV		West of OHV	East of OHV
	Kanika	Balan.	Déguéla	Kominta	Tinguélé
February	—	—	—	—	—
March	—	—	—	—	—
April	—	—	—	—	—
May	—	—	—	4.00	1.80
June	19.70	145.00	95.40	50.50	97.50
July	235.60	248.50	295.60	142.60	365.90
August	—	216.50	152.50	258.00	157.80
September	130.20	348.00	333.50	158.00	234.40
October	4.50	—	51.90	—	28.50
November	2.00	—	—	—	—
Total	392.00	958.00	928.90	605.10	885.90
Av. total		943.45			

their use by farm families was a major focus of FSR/E. Data were collected on household family structure hence family labor availability, land availability, crop areas cultivated, and crop yields. Only a brief summary is provided in this section. Details of data and analyses are available in annual reports of the project (DRSPR/Volet OHV 1988, 1989, and 1990).

Family structure and labor use

In 1989, ten households each from eight villages were surveyed. The information collected included demography, participation in agricultural activities and time allocated to diffferent cropping activites. The results are summarized in tables 6 and 7. For the zone OHV as a whole, an average household has about 26 members roughly equally divided between the two sexes and children. Out of this total only about 46% participate in some form of agricultural production activity indicating a shortage of family labor. The households in the east of the zone (Gouani and Mountougoula) are smaller in size as compared to those in the other regions. However, the percentage of members that participate in agricultural production is equal to the zone average. Participation in agricultural activity is about the same for the two sexes 56% each, but only 25% of the children work in the fields (Table 6).

Table 7 does not give information on post-harvest activities. Labor needs for the different activities are highly variable, with weeding and harvesting activities appearing to require the most labor, 27% and 20%, respectively. The weeding period extends from the end of June until mid-September; is followed by harvesting from the end of October to mid-January. Thus these are the peak labor demand periods which explain the acute labor shortage during these periods. Several fields cultivated and planted to crops often go unweeded or totally abandoned, a situation exacerbated by both long-term and short-term migration of family members.

The data in Table 7 show that about 200 person days of labor are required per hectare to perform the field operations for agricultural production and its distribution indicates the participation of both men and women and also children in all of these activities albeit with different intensities. However, the amount of time allocated to sowing and weeding by women is relatively higher than that by the men. Harvesting time is equally shared by men and women while men's labor is more important than the women's labor for plowing and other land preparation activities.

Table 5. Number of Days of Rainfall in the OHV Zone (1990-91)

Month	North	South		West	East
	Kanika	Balanzan	Déguéla	Kominta	Tinguélé
February	—	—	—	—	—
March	—	—	—	—	—
April	—	—	—	—	1
May	—	—	—	1	3
June	5	8	4	6	12
July	15	11	16	15	20
August	—	11	17	11	missing
September	13	14	15	15	15
October	2	—	5	3	missing
November	1	—	1	—	—
Total	36	44	58	51	51
Av. total		51			

Table 6. Family Structure, Number of Persons Per Household and Percent Participating in Farm Operations in the OHV Zone (1989-90)

Village	Total number per household				Participating in field operations			
	Men	Women	Children	Total	Men	Women	Children	Total
Kanika	11	12	12	35	55	50	33	46
Doréb.	7	10	9	26	57	50	22	42
Landé	9	8	9	26	67	38	22	42
Balanz.	11	11	8	30	64	73	38	60
Gouani	4	4	4	12	50	25	25	33
Mount.	6	6	5	17	67	67	40	59
Kominta	10	10	10	30	60	60	30	50
Yékeb.	10	10	9	29	60	60	22	48
OHV	9	9	8	26	56	56	25	46

Labor use also varies with the crop in question (Table 8). A hectare of maize requires more labor than the other cereals. In association, the production of these two crops is more labor intensive than the production of any other cereal association. Thus a labor-saving technology was perceived to be more profitable for these two crops.

Two conclusions were derived to orient FSR/E research in this domain. First, labor shortage is more severe for sowing, weeding and harvesting. Research in these areas were reinforced. Secondly, the production of sorghum and maize was the most labor-demanding, hence research into labor-saving technology had these crops in focus.

Table 7. Total Number and Percentage of Person Days Required by Different Cropping Activities (1989-90)

Activity	Total		Men		Women		Children	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Plowing	22	11	11	12	6	9	5	9
Sowing	20	10	8	9	10	15	2	4
Plowing/sowing	32	15	12	14	10	15	10	18
Weeding	57	27	28	31	23	35	6	11
Harvesting	42	20	20	22	15	23	7	13
Cleaning	7	3	5	6	2	0	1	2
Others	29	14	5	6	0	0	24	44
Total	209	100	89	43	66	31	55	26

Table 8. Total Number of Person Days (PD) Required Per Hectare and its Distribution (Percentage of Total) for Different Crop Activities in the OHV Zone (1988-89)

Crop	Farm operation				
	Total PD	Sowing Pct.	Weeding Pct.	Harvesting Pct.	Others Pct.
Millet	102.4	9.8	49.0	36.6	4.6
Sorghum	108.4	12.5	48.0	39.0	0.5
Rice	95.4	4.7	76.5	18.8	—
Maize	220.2	10.2	26.5	40.1	23.2
Cowpea	101.2	7.4	31.8	60.8	—
Cotton	139.5	6.2	47.0	43.3	3.5
Peanut	120.3	20.4	39.8	39.8	—
Dah	14.2	50.0	50.0	—	—
Millet/Sorghum	93.7	7.7	64.6	27.7	—
Millet/Maize	107.2	8.5	42.2	24.8	24.5
Sorghum/Maize	125.4	11.6	42.5	34.3	11.6
Millet/Cowpea	77.2	16.5	52.3	31.2	—
Sorghum/Cowpea	96.0	12.9	56.4	29.9	0.8
Cowpea/Peanut	187.9	8.8	34.1	39.0	18.1
Peanut/Dah	260.1	14.9	48.5	36.6	—
Millet/Sorghum/Cowpea	107.9	12.3	57.3	30.4	—
Millet/Cowpea/Dah	80.6	14.9	67.1	18.0	—
Sorghum/Cowpea/Dah	80.7	13.1	46.0	40.9	—

Use of Equipment and Animal Traction

The most important agricultural materials are equipment and draft animals. A survey of 60 farmers conducted in 1988-89 indicated that more than 40% of the farmers did some shallow plowing with the traditional implement known as "daba." However, a greater percentage, around 66%, plowed with animal traction while close to 17% of the total area cultivated was not plowed (Table 9). Tractors were used on only about 1% of the total area cultivated. Also, fields selected to be plowed depended on the crop planted, availability of labor and equipment.

Another survey of 263 farmers across five villages showed that the draft animals used included oxen, horses, and donkeys (Table 10) with the most important being oxen (used by 65% of the farmers), followed by donkeys (used by about 34% of the farmers). The use of horses and donkeys is more prevalent in the northern part of the zone whereas oxen are more popular in the southern section. Tractors were used by only 10 % of the farmers surveyed, mostly in the South.

Another finding of the survey was that the use of equipment or draft animals did not imply ownership as shown in Tables 10, 11, 12, and 13. An average household owned less than a pair of oxen and less than one of the other draft animals.

Table 9. Soil Preparation Method Used by the Farmers (A Sample of 60 Farmers) of OHV Zone (1988-89)

Method	No. of farmers	Percent of farmers	Total area in hectares	Percent of area
No plowing	25	42	76.7	17
Plowing with daba	24	40	73.3	16
Plowing with animal traction	49	82	293.2	66
Plowing with tractor	3	5	4.4	1

Table 10. Use of Draft Animals and Equipment by the Farmers (Number and Percent of Farmers) in the OHV Zone (1989-90)

Village	Sample size	Oxen		Horses		Donkeys		Tractors	
		No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Kanika	31	22	65	27	87	29	94	0	0
Balanzan	37	36	71	0	0	18	49	5	14
Déguéla	53	37	97	0	0	15	28	22	42
Kominta	48	24	70	0	0	15	31	0	0
Tinguélé	93	50	50	0	0	12	13	0	0
Total	262	169	54	27	10	89	34	27	10

Table 11. Average Number of Draft Animals and Equipment Owned by Farmers in the OHV Zone (1989-90)

Village	Sample size	Oxen	Horses	Donkeys	Tractors
Kanika	31	2.03	0.9	1.39	0.0
Balanzan	37	2.14	0.0	0.46	0.0
Déguéla	53	1.96	0.0	0.32	0.0
Kominta	48	1.10	0.0	0.28	0.0
Tinguélé	93	1.30	0.0	0.17	0.0
Total	262	1.70	0.2	0.52	0.0

Table 12. Use of Other Equipment by the Farmers (Number and Percent of Farmers) in the OHV Zone (1989-90)

Village	Sample size	Cultivators		Seeders		Harrow		Plows	
		No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Kanika	31	4	13	3	10	0	0	30	97
Balanzan	37	6	16	5	14	23	62	37	100
Déguéla	53	12	23	20	38	19	36	34	64
Kominta	48	9	18	12	24	0	0	21	43
Tinguélé	93	13	14	9	10	2	2	47	51
Total	262	44	17	49	19	44	17	169	65

Table 13. Average Number of Other Equipment Owned by Farmers in the OHV Zone (1989-90)

Village	Sample size	Cultivators	Seeders	Harrows	Plows
Kanika	31	0.13	0.10	0.0	1.96
Balanzan	37	0.14	0.14	0.5	0.95
Déguéla	53	0.25	0.34	0.4	0.87
Kominta	48	0.18	0.24	0.0	0.42
Tinguélé	93	0.14	0.10	0.0	0.66
Total	262	0.17	0.18	0.2	1.0

No farmer owned a tractor even though 10% of them used one. This implies a high degree of borrowing and renting.

Other agricultural equipment used include cultivators, seeders, harrows, and plows (Table 13); again the level of ownership is far below the rate of use. This low level of equipment ownership inhibits the timely performance of field operation which is especially important in a region, such as this, where rainfall is limited in quantity and it is of short duration.

Crop production

Sorghum, millet, and maize form the staple diet and hence are the most important crops in the zone. A fourth cereal, rice, is also widely consumed but is grown mainly in the southern portion of the zone. In 1988, all farmers surveyed cultivated sorghum and 33% planted rice while 53% planted millet. Only 11% of them grew rice. Correponding figures for 1989 were 79%, 49%, 47% and 23% for sorghum, maize, millet, and rice respectively (Table 14).

Besides cereals, other crops planted are peanuts, cowpeas, dah, and vouandzou. Sorghum and maize together were planted on over 70% of the total area cultivated for each of the three years (Table 15).

Yields also vary with the type of association and the climatic conditions in place during the year. The "Land Equivalent Ratio" of crop associations for pure crops is about 1.62, thereby supporting the predominace of associations over pure stands.

However, it appears that there are significant cereal yield losses when they are grown in association with legumes. For example, millet, in a good rainfall year like 1988, produces over

Table 14. Crops Planted by Farming Households in the OHV Zone, Number and Percentage of Farmers (1988-89,1989-90 and 1990-91)

Crop	1988-89		1989-90		1990-91	
	No.	Pct.	No.	Pct.	No.	Pct.
Millet	37	53	35	47	26	72
Maize	23	33	37	49	29	81
Sorghum	70	100	59	79	36	100
Rice	8	11	17	23	8	22
Cotton	22	31	9	12	5	14
Peanuts	42	60	61	81	32	89
Cowpeas	54	77	50	67	28	78
Dah	21	30	16	21	20	56
Vouandzou	12	17	10	13	17	47
Tomato	3	4	8	11	12	33
Fonio	2	3	7	9	9	25

Table 15. Crop Areas Cultivted by Farmers in the OHV Zone in Hectares and Percentage of Total Area Cultivated (1988-89, 1989-90, and 1990-91)

Crop	1988-89		1989-90		1990-91	
	Hec.	Pct.	Hec.	Pct.	Hec.	Pct.
Millet	11.1	2	4.1	1	9.8	3
Sorghum	76.4	16	91.6	15	45.4	13
Rice	23.0	5	33.8	6	8.0	2
Maize	20.8	4	22.2	4	7.6	2
Cotton	49.6	10	16.6	3	8.6	2
Peanuts	20.4	4	23.8	4	7.4	2
Tomato	1.1	0	3.6	1	8.4	2
Maize/Cowpea	10.2	2	0.2	0	0.0	0
Millet/Sorghum	8.8	2	19.5	3	25.8	7
Maize/Millet	6.5	1	8.3	1	7.9	2
Millet/Cowpea	46.8	10	29.2	4	8.2	2
Maize/Sorghum	17.1	4	12.9	2	9.4	3
Sorghum/Cowpea	147.6	30	109.2	18	43.0	12
Sorghum/Peanut	2.8	1	12.4	2	10.1	3
Peanut/Cowpea	10.2	2	5.9	1	6.6	2
Peanut/Dah	6.9	1	4.1	1	10.0	3
Millet/Cowpea/ Sorghum	16.6	3	195.8	31	134.7	38
Peanut/Cowpea/ Sorghum	2.0	0	4.3	1	0.3	0
Dah/Cowpea/ Sorghum	7.9	2	9.3	1	0.0	0
Peanut/Dah/ Sorghum	2.7	1	5.3	1	2.4	1

Table 16. Crop Yields (kg/ha) in the OHV Zone (1988-89, 1989-90, and 1990-91)

Crop	1988-89	1989-90	1990-91
Millet	878	499	377
Maize	1,114	783	731
Sorghum	699	484	404
Rice	450	442	1281
Cotton	702	1,117	766
Peanut	580	483	351
Sorghum/Cowpea	503/51	609/68	444/67
Millet/Sorghum	139/876	117/193	127/277
Millet/Cowpea	336/14	192/33	593/39
Sorghum/Peanut	417/486	108/239	98/388
Peanut/Cowpea	483/94	402/52	300/48
Maize/Sorghum	296/493	645/347	441/308
Maize/Millet	392/180	966/193	138/319
Millet/Cowpea/Sorghum	417/24/327	131/48/405	97/177/321

850 kg/ha but in association with cowpeas, the yield is only 336 kg/ha. Sorghum, in pure stands, yielded close to 700 kg/ha but only 503 in association with cowpeas (Table 16). However in years of less than adequate rainfall, (1990-91) cereals tend to perform better in association with legumes than in pure stands. Pure millet stands in 1990 yielded only 377 kg/ha but in association with cowpeas, a yield of close to 600 kg/ha was obtained. Despite the above hypotheses, no definite conclusions could be drawn since, for example, sorghum fared better in pure stands than it did in association with peanuts in 1990.

Livestock production and management practices

Livestock and poultry are an important part of the agricultural system of the households in the OHV zone. Livestock, especially cattle, is a source of permanent wealth while small ruminants and poultry are used as transitory sources of cash income. An inventory study conducted on 263 farmers from five villages in 1990 showed that an average household owned seven head of cattle, three head of sheep and three goats (Table 17). The farm-family ownership of cattle is higher in the South than in the North of OHV where small ruminants are relatively large in number. The introduction of small ruminants into the western and eastern parts of the zone were considered in the FSR/E research program.

Livestock and poultry management practices used by farmers were analyzed in a separate study and results are provided in Table 18.

Table 17. Ownership of Livestock in the OHV Zone (Average Number Per Household) (1990-91)

Village	Cattle	Sheep	Goats
Kanika	5	8	7
Balanzan	9	2	1
Déguéla	9	3	1
Kominta	3	1	1
Tinguélé	7	1	3
OHV average	7	3	3

Over 71% of the farmers added salt to cattle feed during the rainy season as compared to 61% in the dry season. Cattle feed supplements, such as bonemeal and calcium phosphate, were used by only 16% during the rainy season as compared to 52% in the dry season. The correponding figures for small ruminants were 10% and 42% respectively. Thus abundance of forage and other vegetative matter during the rainy season is seen as being sufficient to meet the nutrient requirement of livestock. Most farmers (between 85% and 90%) vaccinated their cattle and also treated them for diseases whereas only 42% of small ruminant owners performed these practices. Ponds were the major watering sources for all livestock during the dry season. Streams and rivers were used mainly during the dry season due to the unavailability of standing water. Castration of cattle was done by up to 45% of the owners, but only 26% of small ruminant owners practiced it.

Poultry was owned by about 98% of the farmers but only 38% of them reported having consumed poultry meat. Also less than 15% sold any bird (less than 5) during the entire year. Out of the 77% of farmers that owned small ruminants, 52% reported rarely slaughtering for consumption and over 94% sold less than five head of animal. For cattle, out of the 77% who possessed cattle, 71% rarely slaughtered their animals for meat and about 70% reported no sale of animals during the year of the survey.

Table 18. Livestock and Poultry Management Practices in the OHV Zone (Number and Percentage of Farmers Following Practices) (1989-90)

Management practice	Poultry	Sheep/goats	Cattle
Ownership			
No. of farmers owning cattle	39	31	31
No. of farmers with at least 10 head	85	38	25
Meat Consumption			
Pct. of farmers rarely consuming	38	52	68
Pct. of farmers frequently consuming	62	48	32
Sales			
Pct. of farmers with no sales in 1989	1	39	71
Pct. with sales of < 5 heads/year	15	94	100
Pct. of farmers castrating	—	26	45
Pct. of farmers vaccinating	—	42	94
Pct. of farmers treating diseases	—	42	87
Dry season watering source			
Lakes and ponds	—	61	65
Rivers and streams	—	10	26
Wells	—	32	10
Other sources	—	23	29
Rainy season watering source			
Lakes and ponds	—	16	48
Rivers and streams	—	42	13
Wells	—	3	3
Other sources	—	23	29
Dry season feeding			
Pct. of farmers adding salt to feed	—	29	61
Pct. of farmers adding supplement	—	42	52
Rainy season feeding			
Pct. of farmers adding salt to feed	—	35	71
Pct. of farmers adding supplement	—	10	16
Dry season livestock watch			
Pct. of farmers using salaried watch	—	<1	26
Pct. of farmers using family watch	—	58	39
Pct. of farmers using both of above	—	0	<1
Pct. of farmers using other sources	—	42	32
Rainy season livestock watch			
Pct. of farmers using salaried watch	—	29	71
Pct. of farmers using family watch	—	68	26
Pct. of farmers using both of above	—	<1	<1
Pct. of farmers using other sources	—	0	<1
Miscellaneous			
Pct. of farmers in possession of reproductive females	—	100	94
Mortality rate among animals of less than 6 months old	—	45	16

The low sale of livestock has implications for developers since one hypothesis for technology adoption assumes that livestock owners would be willing to sell animals to invest in yield improving technologies.

Mopti volet

The Mopti volet was in its first full year of research and the baseline data available from the 1992-93 season are summarized below.

Family structure

The average number of persons for the two villages covered in the study (Youré and Léré) was 20, with Léré in the Séno region having the higher average of 24, compared to 16 for Youré in the Delta (Table 19). However, there is no significant difference between the two villages in terms of the ratio of average number of persons to the average number of farm workers (1.4 versus 1.3). Thus, in terms of number of persons to be fed by the household and the available family labor, there was no significant difference.

The average household in Léré appears to have a higher percentage of males than that of Youré, 54.7% versus 48.2% (Tables 20 and 21). This will affect the relative availability of family labor for different types of field work. However, if the age range of 15 to 55 is considered as the range for effective field work capability, then one can conclude that there are more male field workers than there are of female ones at Léré. The percentage is about the same for Youré.

On the question of migration, it appears that there is virtually no migration among the women in Léré. However, close to 75% of the households have male migration that lasts more than six months. In Youré, there is migration among both men and women at about 89.9% and 11.1% of the households, respectively.

Table 19. Total Number of Persons and of Farm Worker Per Household in Two Villages in the Area of Intervention (1992-93)

Village	Number of persons			Number of farm workers		
	Average no. (a)	Minimum no.	Maximum no.	Average no. (b)	Total no.	Ratio of of (a) to (b)
Léré	24	7	87	17	174	1.4
Youré	16	3	39	12	141	1.3

Table 20. Distribution of the Population Per Household at Léré by Age and Sex

Class in years	Sex				Total per class	
	Male		Female			
	No.	Pct.	No.	Pct.	Total	Pct.
0 - 7	31	12.7	23	9.4	54	22.0
7 - 15	25	10.2	28	11.4	53	21.6
15 - 55	69	28.2	52	21.2	12	49.4
> 55	9	3.7	8	3.3	17	7.0
Total	134	54.7	111	45.3	245	100.0

Crops and crop areas

Table 21 gives information on the crop areas and number of farm workers per unit area by type of ownership.

The average farm size and area cultivated per farm worker are bigger in Léré than they are in Youré (Table 22). This may be explained by the proximity of the latter village to the urban centers of Sevaré and Mopti.

Tables 23 and 24 present three important features: (1) the

Table 21. Distribution of the Population Per Household at Youré by Age and Sex

Class in years	Sex					
	Male		Female		Total per class	
	No.	Pct.	No.	Pct.	Total	Pct.
0 - 7	16	8.0	22	11.1	38	19.1
7 - 15	21	10.6	19	9.5	40	20.1
15 - 55	50	25.1	51	25.6	101	50.7
> 55	9	4.5	11	5.5	20	10.1
Total	96	48.2	103	51.8	199	100.0

Table 22. Crop Areas, Area Per Worker by Ownership Type

Type of ownership	Village					
	Léré			Youré		
	Total area	Avg.	Area per worker	Total	Avg.	Area per worker
Household fields	135.31	2.02	0.55	54.63	1.27	0.39
Male owned fields	14.31	0.75	0.001	—	—	—
Female owned fields	3.33	0.1	0.01	4.52	0.4	0.032

Table 23. Area Cultivated by Farmers in Léré by Type of Crop (1992-93)

Crop	Crop area			
	Average	Minimum	Maximum	Std. dev.
Millet	1.38	1.01	1.75	0.52
Sorghum	1.53	—	—	—
Vouandzou	0.76	—	—	—
Peanuts	0.10	0.06	0.12	0.03
Millet/Cowpeas	1.47	0.61	3.85	1.18
Millet/Sorghum/Cowpea	1.61	—	—	—
Peanut/Oseille	0.15	0.06	0.34	0.12
Vouandzou/Oseille	0.36	0.04	0.74	0.29
Vouandzou/Peanut	0.30	0.16	0.44	0.20
Millet/Cowpea/Oseille	1.76	0.07	5.02	1.48
Fonio/Cowpea/Oseille	1.36	—	—	—
Sorghum/Cowpea/Oseille	0.49	—	—	—

Table 24. Area Cultivated by Farmers in Youré by Type of Crop (1992-93)

Crop	Crop area			
	Avgerage	Minimum	Maximum	Std. dev.
Millet	0.42	0.39	0.46	0.04
Sorghum	2.21	—	—	—
Rain-fed rice	0.39	0.29	0.49	0.14
Peanuts	0.51	0.29	0.73	0.31
Millet/Cowpeas	1.31	0.31	3.43	0.93
Sorghum/Cowpeas/Oseille	1.47	0.46	2.86	1.07
Millet/Sorghum/Cowpeas	0.72	0.59	0.85	0.18
Vouandzou/Oseille	0.17	—	—	—
Rain-fed rice/Sorghum	0.76	—	—	—
Millet/Oseille	0.38	0.26	0.59	0.18
Sorghum/Cowpeas	1.38	0.31	3.16	1.04
Sorghum/Millet/Oseille	2.06	0.21	3.91	2.62
Sorghum/Millet/Cowpeas	1.62	1.07	2.31	0.63
Sorghum/Millet/Oseille	0.38	0.10	0.65	0.39
Millet/Cowpeas	0.95	0.17	2.10	0.69

smallness of farmers' fields, (2) the absence of fonio in Youré, and (3) the absence of rice in Léré. The most important crops and crop associations in Léré, in terms of areas cultivated, are millet/cowpea/oseille associations followed by associations of millet/sorghum/cowpeas and those of millet/cowpeas. The important pure stand crops are sorghum, millet, and vouandzou, in order of importance. But in terms of number of farmers growing the crop, the most important association is millet/cowpeas/oseille, produced by 100% of the farmers surveyed.

In Youré, on the other hand, the most important crops in terms of area under cultivation are sorghum/cowpeas/oseille associations (2.06 ha) followed by sorghum/millet/cowpeas. In pure stands, again, sorghum is the most widely cultivated with a per farmer average of 2.21 hectares. However, in terms of number of farmers engaged in production, the most important crops are millet/cowpeas associations followed by sorghum/cowpeas and millet/cowpeas/oseille.

Crop yields

Tables 25 and 26 give the yield figures for the different crops for the 1992-93 season.

The figures in the two tables show yields that generally average less than one ton per hectare except for vouandzou at Léré and rain-fed rice at Youré; this leads to the absence of self-sufficiency in cereal production.

Equipment, draft animals and other agricultural tools

Different types of agricultural implements are owned by the farmers as shown in Table 27. The average numbers of units owned of cultivators and seeders are the lowest among the lists presented.

From the above discussions, the following conclusions were made:

...rate of migration is low in the two villages;

...the majority of farms are community-operated;

...the ratio of farm workers to total household size is relatively higher than for the OHV zone, thus there is higher labor availability;

...crop yields are very low; and

...there are village associations which will make it possible to extend credit and other development services.

In addition to the above characterizations, information was also obtained on the agronimic, cultural, and livestock pratices of the farmers in the zone (see Mopti Volet "Results for the 1992-93 season").

Two specific studies on agroforestry were conducted in collaboration with the Agroforestry Department. These were: (1) Some aspects of agroforestry developement within the cropping systems of farmers, and (2) Lessons of soil and water conservation obtained from farmer practices. Details of these studies are provided in the document for the Technical Commission in Mopti.

Table 25. Yields for Crops at Léré Based on Type of Association

Crop association	No. of cases	Crop yields in kg/ha		
		Avg. yield	Minimum Yield	Maximum yield
Millet				
Principal crop	10	343.60	1765.67	506.33
Secondary crop	1	367.00	—	—
Pure stand	1	508.00	—	—
Sorghum				
Principal crop	1	553.00	—	—
Secondary crop	1	620.00	—	—
Cowpeas				
Secondary crop	9	52.45	3.00	110.00
Vouandzou				
Principal crop	3	1,073.83	800.00	1,473.00
Pure stands	1	912.00	—	—
Peanuts				
Principal crop	2	472.50	345.00	600.00
Oseille				
Secondary crop	5	337.45	31.00	1,193.50
Tertiary crop	9	320.92	80.00	592.00

Table 26. Yields for Crops at Youré Based on Type of Association

Crop association	No. of cases	Crop yields in kg/ha		
		Avg. yield	Minimum Yield	Maximum yield
Millet				
Principal crop	11	6589.64	368.00	1,204.00
Secondary crop	6	94.67	—	—
Sorghum				
Principal crop	11	558.82	208.00	1,376.00
Secondary crop	4	82.00	44.00	96.00
Rain-fed rice				
Principal crop	1	872.00	—	—
Pure stands	2	1,086.00	352.00	1,820.00
Vouandzou				
Pure stand	1	600.00	—	—
Peanuts				
Pure stand	2	434.00	348.00	520.00

Table 27. Number of Equipment and Draft Animals Owned by Farmers in Léré and Youré

Equipment, tools and draft animals (avg. per farmer)	Léré	Youré
Plow	1.43	1.82
Cart	1.40	1.10
Cultivator	1.00	0
Seeder	1.00	0
Hoe	1.29	1.0
Daba	14.90	12.75
Cutlass	10.80	5.75
Draft cattle	2.50	3.83
Donkeys	1.9	1.67
Camels	2.0	5.40

Goals of and Constraints to Agricultural Production

National Goals

National and farmers' goals are the major determinants of farming systems research activities.

The national goals for the agricultural sector can be summarized as follows:

...food self-sufficiency

...improved income and standard of living of farmers; and

...restoration and conservation of agricultural potentials.

Farmers' Goals

The farmers' goals are variable depending on the level of decision. The results of a survey conducted by FSR/E (Volet OHV 1989a) show that food security remains the principal goal of farmers (Table 28) in reference to crop production, while the acquisition of money for daily living expenses is the main goal for livestock production.

Thus, overall at national and farmer levels, the main goal appears to be to maximize food security.

Food security is achieved through:

...Crop production;

...Livestock production; and

...Off-farm income generating activities.

Surpluses generated in crop production and off-farm activities are saved in the form of livestock and are cashed when necessary for a transaction (purchase of grains and other items). Livestock is an important component of the farmer's portfolio. Social security is achieved by fulfilling social obligations: paying premiums in the form of gifts, ceremonies, labor, and etc. The maintenance and improvement of social status is achieved through:

...timely fulfillment of social obligations; and

...wealth accumulation in the form of livestock, and grains to acquire more economic security and political power.

Table 28. Number and Percentage of Farmers Indicating a Specific Goal for an Agricultural Activity Out of a Total of 263 (OHV Zone 1990)

Goal	Crop Production		Livestock Production	
	No.	Pct.	No.	Pct.
Wealth	0	0.0	19	7.2
Income for living expenses	43	16.0	155	59.0
Food security	208	79.0	6	2.3
Animal traction only	—	—	29	11.0

Constraints

The principal constraints are similar for OHV and Mopti except for the variation in intensity which affects the priorities to be given to individual constraints for research intervention.

Inadequate Moisture

The insufficient quantity and poor distribution of rainfall have been cited as a major constraint to crop production by the farmers in both FSR/E zones of intervention (OHV and Mopti).

The rainfall varies greatly both across zones and over the years (Table 29). The start and end of the rainy season is also highly variable. A high proportion of seasonal rainfall occurs in a few showers, while a large number of showers contribute to ineffective quantities of moisture. Such rainfall characteristics make scheduling of agricultural activities problematic and lead to severe crop moisture stress at critical stages of growth (i.e. germination, flower setting, and grain formation).

Table 29. Average Annual Rainfall for OHV (1988-89 and 1989-90)

Zone	Annual rainfall	
	1988-89 mm	1989-90 mm
North	739	605
South	1,082	809
East	1032	807
West	936	793
OHV avg.	947	754

Effect on crop production systems: The consequence at the village level is a reduction of up to 25% in crop yields.

Effect on animal production systems: Both quantity and quality of feed are affected by the inadequate moisture supply. Ruminant animals are the first victims of drought. This is the basic reason for transhumance or seasonal movement of livestock. The animals cover long distances to get water. This coupled with the inadequate level of nutrition for cows, ewes, and does and high expenditure of energy by the growing offspring to follow their dams, could lead to high losses at a younger age.

The productivity of animals exposed to low-nitrogen cellulosic pasture, as seen during the dry season, is frequently further depressed by low voluntary intake. Loss of live weight and poor reproductive performance are common phenomena under such conditions.

Farmers' Strategies

Farmers' strategies include the following:

...risk minimization through crop diversification and maximum exploitation of potentials of different crops with different soil moisture requirements and growth cycles (maize, sorghum, millet, cowpea and peanuts);

...a dynamic planting strategy to escape drought with efficient use of local soil moisture retention capacities;

...varietal search and selection of shorter cycle varieties;

...differential field management (i.e. better management of some fields with more manure and timely labor uses to increase chances of crop success);

...crop substitutions;

...grain stock and marketing strategies (e.g. grain purchase and stock at the end of unfavorable rainy season); and

...seasonal and long term migrations.

Technological Needs

Technological needs include:

water management technologies (i.e small irrigation dams);

shorter cycle varieties to escape drought or drought-tolerant crops and varieties;

soil-water management technologies, particularly the improvement of the efficiency of traditional soil-water management techniques;

mechanical labor-saving technologies for timely soil preparation and planting;

technologies that will improve the animal feed supply; and

credit to acquire animal traction implements.

Available Agricultural Research Solutions

Two main research solutions are:

varietal selection, and

soil/water management.

Some elite technologies are listed below:

In the area of varietal selection:

Crop variety improvement is a major research undertaking of the national and international research institutions. The main focus of the research being:

...identification and improvement of varieties with respect to yield potential, drought tolerance and disease resistance;

...specification of ecological zones and management requirements of recommended varieties; and

...evaluation of introduced varieties under farm conditions.

Among the promising varieties are:

Sorghum: Tiemarifing, S-34, ICSV-1063, CSM-388, Sako6ka, Malisor 84-1, Malisor 84-7, Bimbiriba.

Millet: Souna, Sanio, Boboni, NKK, Synthétique 11, Synthétique 16, PN 4, 81 BHT.

Maize: Tiémantié de Zamblara.

Arachide: 47-10, 28-206, 55-437.

Cowpea: TVU 76-07, Amary sho, KNI, KVX 30-305-3G, Shotely, TN 88-63.

In the area of soil management techniques:

Tied ridges: these have been shown to significantly increase yields (Rodriguez 1982, Nicou and Charreau 1985). On-farm researcher managed trials have shown significant yield increase and economic returns to the additional labor required to do the tied ridging (TR) on maize, sorghum, and millet. The technology has the advantage that no cash outlay is required if family labor is utilized. Availability of labor has been the limitation to the adoption of the technology. FSR/E could conduct more research in order to refine this technology to make it less labor intensive. Another limitation of the TR technology is that, it does not work well on sandy soils because the ties tend to break in heavy rain. The soils in the southern part of OHV appear to be suitable for this technology.

Diguettes/dikes: the construction of diguettes, although not as effective in retaining water as tied ridges, is a water conservation method that has been investigated elsewhere in the Sahel region. Diguettes are barriers 10 to 15 cm high mainly made of rocks and placed on field contour lines 10 to 50 meters apart. The barriers, although permeable, slow runoff to allow increased infiltration. The technology has increased yields in the northern region of Burkina Faso (Wright 1985). Provided that rocks, the principal material for the construction of diguettes, are available, these barriers can be constructed in off- peak labor periods with family labor and are not as labor intensive as tied ridging.

Mulch: crop residue can reduce rainfall runoff and increase water infiltration. The principal limiting factor is scarcity of mulching material. The crop residue is used for animal feed, fuel and construction materials. However, with improved management, increased biomass yields could lead to increased mulching material for improvement in soil and water management.

Low soil fertility and land quality degradation

Cause and Effects

The soils in Mali are mostly poor in fertility. Chemical properties indicate low organic matter content, low clay content, low phosphorus content and consequently low nitrogen content and low cation exchange capacity. Analyses of physical properties show mostly sandy and gravelly textures, low moisture retention capacity and high susceptibility to erosion. These properties lead to poor soil fertility resulting in low crop yields.

Farmers' Strategies

The farmers' strategies for dealing with the poor fertility problem are based on preferential application of nutrient materials to the different fields. Soil fertility is, in general, better managed in the fields closest to the household compound than in the fields far away from the compound. Farmyard manure constitutes the main source of fertility for the fields closest to the compound and these are often planted to maize (in villages where this crop is cultivated). On further fields, moderate amounts of both organic and mineral fertilizers are used to restore fertility with cereals-legume intercropping or rotation. Fertility on fields farthest from the compound is maintained mostly with fallows and cereal-legume intercropping or rotation. Thus soil fertility is generally higher on fields closest to the compound with gradual reduction the farther the fields are from the compound. Consequently, grain yields also vary accordingly. Farmers also make efforts to maintain the physical status of the soil to stop erosion and conserve both soil and moisture. The major traditional soil and water conservation techniques used include earthen diguettes around maize fields, stone bunds, mulching, and grass strips.

Technological Needs

The main constraints related to the soil quality deterioration problem include:

shortage of organic manure,

manure transportation problems,

unavailability and high price of mineral fertilizers,

high financial risk of mineral fertilizer application in semi-arid conditions,

lack of credit facilities to buy fertilizers for food crops,

high labor costs of installation of soil conservation devices,

lack of collective or coordinated actions for soil conservation, and

poor technical efficiency of traditional soil and water conservation techniques as presently used.

Development Solutions

Development solutions by governmental and nongovernmental organizations to tackle the problem include:

diguette construction,

fertilizer subsidies (stopped since 1985), and

the Rock Phosphate project which supplies phosphate at a lower price, 47 CFA/kg.

Available Agricultural Research Solutions

Solutions offered by agricultural research (IER) include:

a widely recommended rate of cotton fertilizer: 100 kg of NPK (cotton complex) + 50 kg of urea, and

PNT dose: 300 kg/ha over a 3-year period as a substitute for imported phosphate.

Several institutions are working on soil fertility amelioration. Major emphasis is on finding appropriate economic doses for different agroclimatic conditions and crop combinations.

Recently attention has been drawn to the role of organic matter in soil fertility. Where mineral fertilization alone is applied, it can lead to soil-acidification. A brief overview of these technological options follows:

Animal manure and composting: This technology, as mentioned earlier, is already in application in several areas of both zones of intervention. Insufficient quantity of materials is the main limiting factor. The animal production component of the FSR/E is currently working on improving fallow and cropping lands by integrating forage legumes and the raising of animals, particularly cattle in enclosures for effective manure collection. This improved system of manure collection has already received positive response from farmers. However, continued improvement in the natural pasture and proper management of crop residue is necessary in order to increase manure and compost availability since animals could then be coraled to make collection possible. Forage legumes and trees are known to restore the fertility of the soil. This innovation has been introduced in the northern part (Kanika) of the zone OHV.

Green manuring and plowing: Deep plowing, green manuring, and other tillage practices have been observed to increase yield, due to change in soil structure, which allows for better root establishment and improved water infiltration and storage. About 60% of the farmers in OHV zone practice some form of tillage, either manual or with animal traction. Green manuring can also increase the fertility of the soil and add to water retention capacity of the soil. This technology also requires deep plowing to incorporate the crops into the soil.

Chemical fertilizers: The usefulness of fertilizer usage is dependent often on adequate rainfall. Trials by the agronomic component of FSR/E have shown yield response to fertilizer to be highly variable between sites, crop kind and years. There is, however, considerable risk of financial loss when fertilizer is used alone.The following research is ongoing:

specification of fertilizer rates for food crops in different agro-ecological zones,

increasing the solubility of PNT,

composting and manure application, and

cereal/legume rotations.

Labor Shortage

Cause and Effects

The main cause of labor shortage is migration during the agricultural season.

This labor shortage results in reduced farm sizes, poor tillage, poor crop maintenace, and abandoned fields.

Farmers' strategies to deal with the problem

Some of the farmers' strategies include the use of agricultural equipment, the preferential maintenance of fields based on the crops planted on them, and the use of hired labor for certain activities such as weeding and harvesting.

Technological Needs

Two technological needs of the farmers are labor-saving equipment and implements, and more efficient (agronomically and economically) herbicides.

Available Agricultural Research Solutions

Some of the available solutions include the introduction of herbicides, increasing animal draft power through the use of new materials and different types of animals (donkeys and horses), and diversification in the equipment used for mechanical weeding (DMA).

Inadequate Quantity and Poor Quality of Feed Resources

Inadequate quantity and quality of feed is the major constraint to animal production. Where nutrition is adequate qualitatively, particulary in protein content, parasites and diseases have a minor effect on the productivity of the animals. When amino acid availability from a diet is low, however, parasites and diseases could manifest as the dominant constraint to production.

The nutritive value of feedstuffs is essentially a function of the availability of energy and nitrogen. Research has shown that cereal crop residues and mature natural pasture have abundant sources of energy as cellulose but are poor in the content of nitrogen. Such materials will remain to be a basic diet from which animal protein will be derived. Thereby, creating the conditions through forage legumes that will allow the efficient utilization of the materials is of prime importance for the effective integration of animals, particularly cattle, in the farming system.

Farmers' Strategies

Over 90% of the farmers in OHV raise either poultry, cattle, or small ruminants (Volet OHV 1990). The percentage is expected to be higher for the Mopti zone even though such information is not currently available. The number of livestock raised in the OHV ranges from zero to about 68 with an average of about six animals, the highest concentration being in the southern region of the zone (Volet OHV 1990).

Livestock production is a family enterprise sometimes guarded by children, however, most cattle are entrusted to the Fulani herdsmen. Draft oxen are kept on the farm in addition to a very limited number of non-draft animals. The use of horses and donkeys is more prevalent in the West and North of OHV respectively.

The feeding of small ruminants is sedentary/extensive with:

grazing natural pasture as the basis of feeding with some provision of supplements consisting of the irregular addition of crop residues (straws), and

the animals are guarded during the rainy season and left to stray in the dry season. All year round, they are watered and housed by the farmers.

The feeding of large ruminants is also sedentary/extensive with natural pasture as the major feeding source with some supplementary feeding in the dry season.

The cattle entrusted to the Fulani herdsmen are fed through transhumance during the dry season. During the rainy season, they are fed on natural pastureland around the villages.

Fallows around the villages are the main natural pasturelands. The feed supplements are salt, special varieties of cereals (mainly for draught animals), and crop residues. The latter consists of crop residues of cereals and legumes. The cereal crop residues used are the most green and tender stems obtained during the harvest. The legume supplements are cowpea and peanut residues. Cowpeas are mainly grown as intercrop. The amount of cowpea residues produced on the farm is very low compared to cereal residues. The former serving as a source of nitrogen supplement, the quantity produced cannot offset the deficiency of nitrogen to improve the utilization of the latter by the animals.

Technological Needs

Technological needs include:

increase the quality and quantity of feed resources, and

promote forage conservation techniques.

Such technologies are particularly needed for the dry season feeding.

Development Solutions

The emphasis nationally is on vaccination programs against killer diseases. Grazing of natural pasture is the dominant form of feeding. Natural pasture harvest at the right stage and production of forage legumes accompanied with conservation will undoubtedly increase the feed budget both quantitatively and qualitatively. This will open the way for the long-term genetic improvement of the animals for milk, meat, and draft power.

Low productivity inputs and limited cash resource and credit

Most farmers are still using low productivity hand-tool implements to perform most crop production activities. Lack of sufficient cash resources and limited acces to credit prevent many farmers from acquiring higher productivity inputs such as animal traction implements, fertilizers, etc. to relax the labor bottlenecks and increase output.

Insufficient input supply and extension services

Overall, cash crop producers traditionally benefit more from input supply and extension services than from food crop producers. The situation has improved in recent years due to the presence of several non-governmental organizations and improved OHV actions.

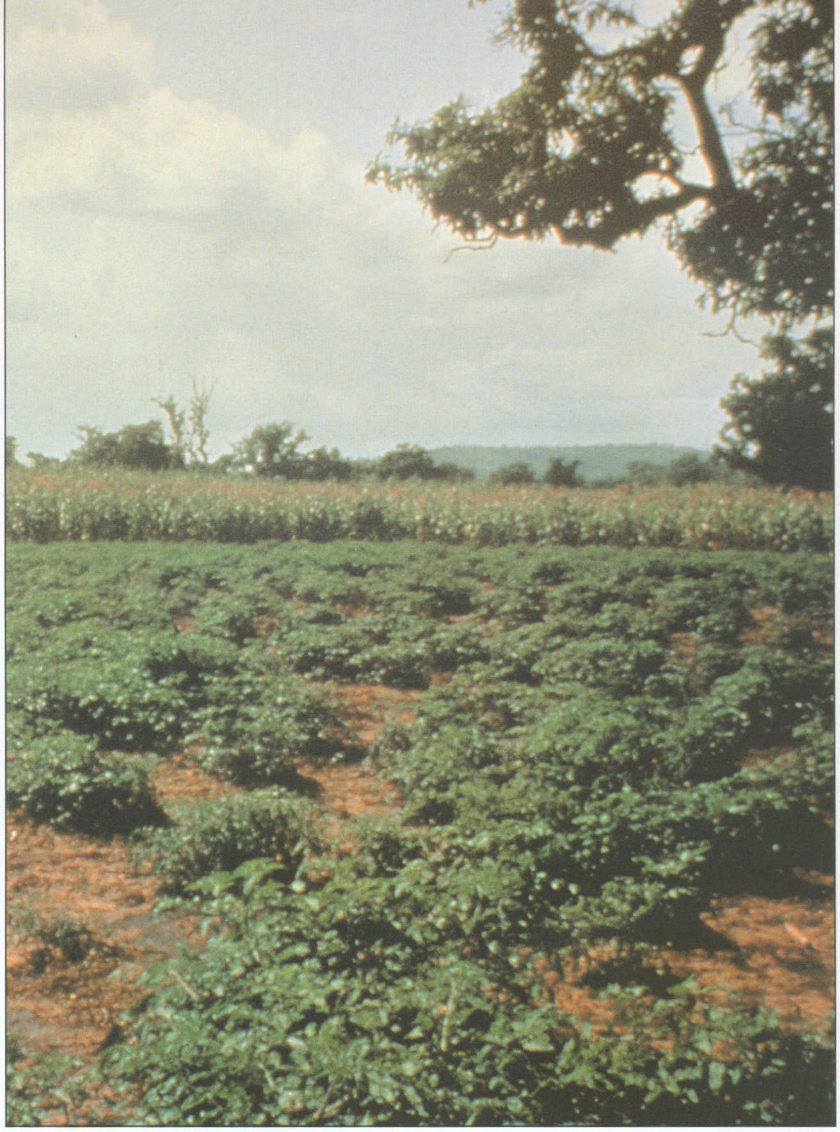
Other agronomic constraints include crop pests and diseases, low effective off-farm demand of food grains, inadequate or poorly implemented pricing, marketing, and grain stocks management policies.

Animal diseases

The major diseases of sheep and goats are muzzle scab and foot rot; and the major diseases of cattle are pasteurellosis, trypanosomiasis, and tick-borne diseases.

Agro-forestry constraints

The main difficulty farmers confront in the tree planting activities is the lack of water. Natural rainfall is insufficient to ensure plant establishment. Furthermore, there is no water source (bore-hole, well, reservoir) for watering seedlings during the dry season. Other difficulties such as the straying of cattle, the unavailability of seedlings and termites are somewhat negligible in comparison with the problem of lack of water.



Development of Technologies for Increased Crop and Livestock Production

TECHNOLOGY DEVELOPMENT IN THE OHV ZONE

Evaluating the impact of an agricultural research project has always been a difficult task on which very little in terms of literature exists. This section of the document begins with a review of the different diagnostic and thematic studies that were undertaken and the technologies proposed to alleviate the production constraints identified in the OHV zone. The review uses research data and agronomic and socio-economic information from FSR/E and other research organizations in the zone. FSR/E has been conducting research in the zone since 1986 and the research results, review of technologies, and recommendations reflect this orientation. The section begins with a discussion of each technology in terms of its usefulness and feasibility to the farmers in the short term, medium term, and long term. The modality of adoption is presented together with the evaluation criteria.

Socio-economic research has shown that farmers do not necessarily adopt technologies in the form of packets but rather take a one-at-a-time approach to adoption (Byerlee et Hesse de Polancio, 1986; Mann, 1987). This mode of adoption prevails despite the fact that the greatest impact on crop yield is obtained when technologies are used in combination. Farmers' strategies for technology adoption is based on availability of technology, technical feasibility, economic profitability, and considerations for risk and resource endowment in the cropping system. Technologies that are favored by the above factors are adopted first and the others are considered later based on farmers initial experience with adopted technologies. Thus, even if a technological package exists, there is a logical sequence for adoption from both agronomic and economic view points. This information on adoption modality is important in orienting research and extension programs. With this in view, this section uses the available results from agronomic, technical, and socio-economic research to assess or confirm the compatibility of the technologies and cultural practices proposed to the farmers of the OHV zone. Results from agronomic research stations and those from on-farm trials are used to evaluate the proposed technologies. Partial budgets and benefit-cost ratios are used to determine economic profitability. Risk and variability analyses are performed on test results to assess potential financial losses.

After the review of the proposed technologies, the section proceeds to identify the available technologies for the present production system and those that have potential for a more intensive system.

SOME DIAGNOSTIC AND SPECIFIC STUDIES

LAND TENURE SYSTEM

This study was conducted in 1988 to describe the system of land ownership in the research villages. Four principal ownership modes were identified: ownership by the largest and oldest families existed in over 75% of the villages, ownership by village chief existed in about 38% of the villages while collective ownership and individual titles to land existed in only about 12.5% of the villages in both cases. Allocation of land to individuals is then made by the respective authorized owners as the case may be. All land litigations are resolved locally with the government rarely intervening. Livestock have acess to fallow and pasture land without reference to ownership; however, animals of the land owner have the first right to the use after-harvest crop residue. The systematic reduction in natural pasture has created conflict between the crop production and livestock production systems.

AN ANALYSIS OF WOMEN'S TIME ALLOCATION TO AGRICULTURAL ACTIVITIES

This study was conducted in 1988 and its results showed that women participate fully in all agricultural activities over and above their traditional domestic and socio-eonomic responsibilities. In certain areas of the zone, women are reponsible for providing condiments for the household's consumption. To meet this need, the women cultivate their individual farms beside those owned by the household. Yields from these fields are very low since the land apportioned to the women is usually poor in fertility. In addition, the women do not have access to good agricultural implements nor to credit. These findings helped shape FSR/E research into potential alternative income sources for women, improvement in soil fertility of women's fields, and infant-nutrition improvement through local resources.

TABLE 30. PRINCIPAL CROP VARIETIES IN TWO OHV ZONES

Crop	Niaganabougou in the south		Bougoula in the east	
	Variety	Type	Variety	Type
Maize	Kabadié	Local	Kabadie	Local
	Kabablé	Local	Tiémantié	Improved
	Mochi	Local		
Sorghum	Kédé	Local	Tiémarifing	Improved
	Bimbiri	Local	Bimbiri	Local
	Drongon	Local	Kédé	Local
Millet	Sanio	Local	Sanio	Local
Tobacco	Paraguay	Improved	-	-
Cotton	-	-	B163	Improved
Rice	Maloble	Local		
	Dis	Local		
	Gambiaka	Improved		

INVENTORY AND COMPARATIVE STUDY OF PRINCIPAL CROP VARIETIES IN THE OHV ZONE: THE CASE OF NIAGANABOUGOU AND BOUGOULA

In 1988, a study was conducted in two villages Niaganabougou in the south and Bougoula in the East of OHV with the aim of identifying the principal crop varieties and the extent of their cultivation by the farmers. Table 30 summarizes the varieties and indicates whether or not it is an improved or local variety.

Improved cereal varieties are practically absent in the southern region of the zone, except for rice which covered 56% of the total area planted to the crop. Improved maize and sorghum varieties are found in the eastern part and they occupied 98% and 6% respectively, of the total area planted to the crops in 1988.

THE SOCIO-ECONOMIC ROLE OF SMALL RUMINANT PRODUCTION BY MALINKÉ WOMEN

This study, initiated in 1989, was to identify the socio-economic use of small ruminants by women. The results indicated that sheep are used for family consumption (33% of households interviewed) and sacrifices (17% of the households). Goats are principally used for family consumption. Small ruminants are sold by the women to pay for cereals and other family needs and sometimes are exchanged for hired labor. The women obtain their animals through purchases with income from agriculture and also through marriages (dowries).

ANALYTIC STUDY OF WOMEN ASSOCIATIONS

This study was conducted in 1989 in the five principal research villages with the objective of identifying the women associations in existence, their structure and form, objectives, activities, and the major constraints to their efficient performance. This was to help in identifying intervention domains together with researchers and developers. The results showed that in almost all cases, the associations were formed with social objectives rather than agricultural ones. Thus despite the presence of these associations, agricultural production was an individual affair. The lack of agricultural equipment was cited as the main constraint of agricultural production. It appeared that the association could be a mechanism of obtaining such equipment.

Food security in the OHV zone

A households's self-sufficiency in food production is measured as the percentage of its food needs covered by its own production. Estimates by FAO in 1988 put the per capita food need for a Malian household at 188 kg. During this year a study was conducted in five representative villages in the OHV zone to assess the levels of food self-sufficiency. The study was repeated a year later and results are summarized in Table 31. They showed that in 1988-89, the level varied between 31% for the East of the zone to 54% for the West. However, in 1989-90, the East had 143% while the South had the lowest level of 56%. For each zone, the level of sufficiency was higher in 1989-90 than in 1988-89 despite the better-than-average rainfall in 1988. Possible explanation might include the higher than usual migration that took place in 1989 thereby reducing the number of persons to be fed per household.

The study also investigated the potential for self-sufficiency based on available land and the level of technology in existence. The results showed that despite the availability of cultivable land, labor was the main bottleneck against increasing food production.

Table 31. Level of Self-Sufficiency in Cereal Production in 1988-89 and 1989-90

Region	Pct. of self-sufficient households Pct.		Level of self-sufficiency Pct.		Per capita food deficit in kg	
	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90
North	10	11	49	60	-98	-74
South	10	10	51	56	-93	-82
East	05	12	54	58	-86	-80
West	00	65	31	143	-131	-76
OVH	56	25	46	79	-102	-40

Experimentation and other studies

Studies on the constraints to the adoption of technologies

A study of village associations

The adoption of new production techniques vary widely between farmers and also between villages across the different agro-climatic zones. The development agencies have an objective of encouraging the formation of village associations to promote economic and social development. In addition, these associations are used as vehicles for technology diffusion since often such diffusion is more successful than if done through individual farmers. However, very little is known about these organizations in terms of their characteristics and the mode of technological transfer across their farmers, hence this study was initiated in 1991.

The main objectives of these associations are very diversified and include the collective performance of field work (40%), general social development and development of cash crops such as cotton (15%). The principal resources used by the associations are labor (40%) and cash resources (42%). Credit is used by only 9% of the associations interviewed. The main constraints included are insufficient cash availability (32%), lack of equipment (27%) and lack of credit (16%).

The main extension activities so far as farmer groups were concerned were tests on crops, the use of simple production techniques and phytosanitary treatment of plants. Agro forestry and environmental protection are at a very limited level.

Transactions and revenue sources of households in OHV zone

This study started in 1991 was designed to describe the structure of the formal and informal agricultural markets for crops, smallstock, chickens, and animal products available to traditional farmers in the OHV zone. The different sources of revenue and expenditures were also identified. Both formal and informal markets exist in the zone. A greater percentage of farmers sold shelled peanuts than any other crop confirming the notion that peanuts are a cash crop. The sale of cereals is very limited since they serve mainly as the staple diets of households. With the exception of rice growers (17.1%), cereals serve very little as a source of income. Cotton provides the highest income, close to 60,000 CFA but grown by only a few farmers. Due to unavailable storage facilities, most farmers sell the output during harvest and post-harvest time leading to lower prices and incomes. Sales of vegetables occur throughout the year due to the ability of garden production during the offseason. Vegetables, together with potatoes and sweet potatoes, are very important income sources. Vegetable sales are more prevalent among farmers in group three and are done mainly in formal markets. Poultry serves as a transitory source of income whereas livestock serves as a source of permanent wealth. Livestock sales are more prevalent among farmers in the first group. More farmers make purchases of sorghum than any other agricultural product and most of the purchases occur during the rainy season just before the first harvest. Higher percentages of farmers in group three make cereal purchases than those in group one. Many of the transactions are made on a cash basis and take place in the formal markets. Very little investment in agricultural inputs takes place. The most common investments are in improved seeds and inorganic manure. The purchase of chemical fertilizers is limited to the application on vegetables, especially in Kominta. Most of the input transactions occur in informal markets (between farmers) except for chemical fertilizers. Wild fruit hunting is the main alternative source of income used by the highest percentage of households followed by remittances from abroad. Significant differences exist between villages in terms of the importance of the different sources of income. The determining factors include distances from urban centers, migration, and the availability of rural industries.

Availability and use of credit and its impact on technology adoption

Despite the technical feasibility and economic viability in terms of profits and risk of new technologies, their adoption is often limited by certain factors such as funds to finance the initial cost of investment. Farmers, in the absence of available personal or family funds, will have to rely on credit to acquire these technologies. The lack of adequate rural financial institutions limits the availability of such credit. A study into the availability and use of credit would help inform the developers about the appropritae measures to take to encourage the adoption of recommended technologies. This study lasted two years. Interviews of 225 households from four villages were conducted across the principal agro-climatic zones. The information collected included the use of credit and sources of income.

Table 32 gives the distribution of the form of credit between the principal FSR/E research villages.

Table 32. Types of Credit by Farmers in the OHV Zone (1992-93)

Village	Credit in-kind		Cash credit	
	No. of farmers	Pct. of farmers	No. of farmers	Pct. of farmers
Kanika	7	23	25	81
Déguéla	26	49	7	13
Kominta	44	92	7	15
Tinguélé	53	57	-	-
Total	130	58	39	17

Source. FSR/E/OHV Volet Survey on the availability and utilization of credit (1992-93).

From the above results, it is clear that the majority of credits (58% of farmers who responded) taken by farmers was in-kind and only 17% of them obtained cash credit. Percentage of in-kind credit was higher in Déguéla, Kominta, and Tinguélé which are villages located in what can be termed as relatively more agriculturally intensive. In these villages, most of the credit was tied to cotton production in the form of fertilizers and insecticides. Contrary, the percentage of cash credit was highest in Kanika, in the northern part of the zone. This could be attributed to the presence of BNDA which gives cash credit for livestock fattening. The results of the two-year study also show a high annual variability in the credit given. However, a lot of caution is needed in drawing conclusions due to several factors such as changes in sample size between the two seasons and changes in the political situation in the country that affected the activities of state financial institutions.

Even though the majority of credit is in-kind, most of it is repaid in cash as shown in the table below. In 1991-92, even though 58% of the credit was in-kind almost all of it was repaid in cash again the following season. Over 70% of the repayments were in cash (Table 33).

It is also apparent that a greater percentage of farmers in group three (according to the farmer typology developed two years ago) obtain loans than those for in group one and group two (Table 34). These two groups are better equipped and possess more livestock than those in group three. It has therefore being hypothesized that farmers in group one and two will be at less risk since they are more likely to be able to survive poor agricultural seasons and repay loans. Thus they are inclined to be more willing to obtain credit. The farmers in group three are assumed to be more at risk hence less willing to take credit. However, the results in Table 34 call these hypotheses into question. It is entirely possible that the poor and less equiped farmers are more willing to take credit in an effort to improve their welfare through investment in equipment and other productivity-increasing technology. In short, they have more need for credit than the other farmers hence if made available to them on favorable terms, they would accept credit. These results also point out the fact that credit as extended by local financial institutions, is less risky than otherwise believed, thus enabling the poorest among the farmers to access it.

Table 33. Credit Repayment Method for the Two Seasons 1991-92 and 1992-93 (Percentage of Farmers)

Village	Repayment in-kind		Repayment in cash	
	1991-92	1992-93	1991-92	1992-93
Kanika	-	1.9	78.3	11.3
Déguéla	0.1	10.8	5.9	4.5
Kominta	-	14.1	9.2	31.5
Tinguélé	-	-	6.5	25.9
Total	0.1	26.8	99.9	73.2

Source. FSR/E /OHV Volet Survey on the availability and utilization of credit (1992-93).

Table 34. Distribution of Credit Obtained Between Farmer Types (Percentage of Farmers)

Village	Group 1		Group 2		Group 3	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Kanika	-	-	22.7	9.5	36.6	2.7
Déguéla	12.4	5.3	1.6	3.4	4.7	6.8
Kominta	-	-	6.4	16.8	3.0	28.7
Tinguélé	8.4	7.2	2.0	9.6	2.2	9.0
Total	20.8	12.5	32.7	39.3	46.5	48.2

Source. FSR/E /OHV Volet Survey on the availability and utilization of credit (1992-93).

However, specific situations deserve mention. The repayment period and the need to repay in cash often force farmers to sell all their produce at the end of harvest to pay the creditors. For example, the majority of livestock-fattening loans extended by BNDA in Kanika were to be repaid in five months at an interest rate of 4.5%. Faced with marketing problems, farmers are forced to travel as far as Bamako to sell their animals, abandoning other agricultural activities in the process.

The different sources of credit include developers and private individuals such as civil servants and farmers. During the 1992-93 season, for example, over 30% of all credits extended in the zone were made by civil servants, followed by individual farmers (28.2%), OHV (22.%) and BNDA (10.2%).

The greatest percentage of the credit obtained is used for the purchase of seeds (97% of farmers) and fertilizer (68% farmers) as shown in Table 35.

Credit is available and even though certain terms and conditions for obtaining it exist, the available credit is offered on reasonable terms. However, more information is needed. The poorest of farmers do use credit and are willing to use more and farmers themselves are an important source of credit.

Table 35. Utilization of Credit by Farmers in the OHV Zone in 1992-93 (Number and Percenatge of Farmers)

Use	Kanika		Déguéla		Kominta		Tinguélé		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Draft animal	8	26	2	4	-	-	-	-	10	4.4
Improved seeds	23	74	9	17	-	-	-	-	32	91
Fertilizer	-	-	2	4	22	46	16	18	40	68
Pesticides	-	-	-	-	8	17	7	8	15	7
Livestock fattening	3	10	-	-	-	-	-	-	3	1.3

Source. FSR/E /OHV Volet Survey on the availability and utilization of credit (1992-93).

Technologies proposed by FSR/E for farmers in OHV

Agronomic technologies

The agronomic research carried out by FSR/E in the OHV zone to alleviate production bottlenecks such as physical, climatological labor constraints can be grouped as follows:

soil fertility improving and soil and water conservation technologies,

labor-saving technologies,

crop variety improvement,

crop association performance improvement, and

diseases, insects and other crop pests.

Soil fertility improving and soil/water conservation technologies include chemical and organic fertilizers, rock phosphates, compost, mulching, plowing techniques, tied ridges, and digue/dikes.

Chemical fertilizers

On-station and on-farm agronomic research results have shown significant yield increases with the application of chemical fertilizers on maize, sorghum, millet, and rice (ICRISAT 1986, 1987,1988; DRSPR/Volet Fonsebougou 1985, 1986, 1987). However, fertilizer response varies strongly with site and year. For example the results from maize/millet fertilization tests in the South of Mali showed that grain yield was significantly higher for farmer practice than for fertilized fields (Kébé Demba 1987). Nevertheless, most agronomic test results indicate that the use of chemical fertilizers is profitable given the necessary climatic and physical conditions (Pieri, 1985). However, continuous use of chemical fertilizers without the incorporation of organic matter into the soil can result in reduced crop yields. FSR/E conducted research on the fertilization of several cereal and leguminous crops both in association and in pure stands.

Fertilization of crops in pure stands

Table 36 gives a summary of results obtained from the fertilization of pure maize stands.

For the average of the three villages, fertilizer application is profitable, yielding a marginal rate of return of 244%. Thus a farmer investing one dollar in chemical fertilizer will recover this amount plus an additional two dollars and forty-four cents. The additional labor for fertilizer application is also profitable since the net benefit per person day of work is over 3480 CFA which is higher than the estimated daily wage rate of 500 CFA for a Malian worker. In Gouani, where agriculture is more intensive in terms of equipment and other input usage, the application of urea togther with that of PNT or cereal complex is more profitable that the application of urea alone. Contrary, in Mountougoula, a village in the same zone as Gouani, but where agriculture is less intensive perhaps due to its proximity to Bamako, the application of urea alone appears to be more beneficial than when combined with PNT or cereal complex. Thus the profitability of fertilizer application does not only vary with site and climatic conditions such as rainfall but also with the resource management practices of the farmer.

FSR/E conducted a test on the effect of fertilization and improved cultural practices on pure sorghum stands on farmers' fields during the 1988-89 season and results are summarized in Table 37. The results showed highly significant village-treatment interaction especially for the users of ammo-

Table 36. Economic Analysis of Fertilization of Pure Maize Stands on Farmers Fields in the OHV Zone (1988-89 and 1989-90)

Item	Fertilization[1]			
	T1	T2	T3	T4
Average of 3 villages		1988-89		
Total yield, kg/ha	1,030	2,220		
Adjusted yield[2]	927	1,998		
Value of production[3]	50,985	109,890		
Total costs	0	17,130		
Net benefit (NB)[4]	50,985	92,760		
Increase in NB	—	41,775		
Marginal rate of return (MRR)[5]	—	244%		
Return/person day of additional labor[6]	3,481			
Pct. of farmers losing money	0			
At Gouani		1989-90		
Total yield	1,490	1,930	1,975	2,390
Adjusted yield	1,341	1,737	1,777	2,151
Value of production	44,253	57,321	58,641	70,983
Total cost	15,180	33,080	19,420	26,680
Net benefits (NB)	29,073	24,241	39,221	44,303
Increase in NB	—	-4,832	10,148	15,230
MRR	—	Domin.	239%	132%
Return/person day of additional labor	-402	1,691	2,538	
Pct. of farmers losing money	0	0		
At Mountougoula		1989-90		
Total yield	1,069	1,400	1,040	
Adjusted yield	962	1,260	936	
Value of production	31,746	41,580	30,888	
Total costs	15,180	33,080	19,420	
Net benefits (NB)	16,566	8,500	11,468	
Increase in NB	-8,066	-5,098		
MRR	—	Domin.	Domin.	
Pct. of farmers losing money	0			

[1] For 1988-89 test, T1 represents the farmer practice without Fertilization. For 1989-90, T1 = 100 kg/ha of urea. T2 in 1988-89 = 100 kg/ha of ammonium phosphate and 50 kg/ha of urea, but for 1989-90, T2 = 100 kg/ha of ammonium phosphate and 100 kg/ha of urea. T3 = 100 kg/ha of urea and 300 kg/ha of PNT and T4 = 100 kg/ha of urea and 100 kg/ha of cereal complex.
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Adjusted yield multiplied by the average maize price which was 55 and 33 CFA/kg in 1988 and 1989 respectively .
[4] Adjusted yield multiplied by the average grain price less fertilizer costs in CFA.
[5] Marginal rate of return.
[6] Net benefits divided by the number of additional person days necessary for fertilizer application. Estimates elsewhere show that additional 48 hours is needed to fertilise an hectare translating to 6 person days of work if one supposes that a person day corresponds to 8 hours of work. Thus, the application of ammonium phosphate or cereal complex followed by an application of urea will use up 12 person days.

nium phosphate and urea (T4) compared with users of PNT only (T2). At Gouani, there was a significant treatment effect with a fertilizer yield increase of 74% or about 830 kg/ha of sorghum. The application of ammonium phosphate and urea produced a yield increase of 49% or 720 kg/ha of sorghum over the application of only PNT with a marginal rate of return of 403.3% which was lower than the return rate for PNT application. However, the return to the additional labor required for fertilization was much higher for the former than for the latter (5679 as against 3073 CFA per person day).

At Mountougoula, the average yield increase due to fertilization was only 69% or 470 kg/ha of sorghum. Even though there was no significant yield difference between PNT application and the application of ammonium phosphate and urea, the former had a return rate of over 687% at the margin and a return to additional labor of 4858 CFA per person/day as compared to 52.8% and 744 CFA, respectively, for the latter treatment.

Table 37. Economic Analysis of Fertilization of Pure Sorghum Stands on Farmers Fields in the OHV Zone (1988-89)

Item	Fertilization[1]			
	T1	T2	T3	T4
At Gouani		1988-89		
Total yield, kg/ha	1,120	1,480	1,910	2,470
Adjusted yield[2]	1,008	1,332	1,719	2,223
Value of production[3]	70,560	93,240	120,330	155,610
Total costs	0	4,240	12,240	16,900
Net benefit (NB)[4]	70,560	89,000	108,090	138,710
Increase in NB	—	18,440	37,530	68,150
Marginal rate of return (MRR)[5]	434.9%	306.6%	403.3%	
Return/person day of additional labor[6]		3073	3128	5679
Pct. of farmers losing money	0	0	0	
At Mountougoula		1988-90		
Total yield	680	1,210	missing	1,090
Adjusted yield	612	1,089	—	981
Value of production	42,840	76,230	—	68,670
Total cost	0	4,240	12,240	16,900
Net benefits (NB)	42,840	71,990	—	51,770
Increase in NB	—	29,150	—	8,930
MRR	687.5%	—	52.8%	
Return/person day of additional labor	—	4,858	—	744
Pct. of farmers losing money	0	0		

[1] T1 represents the farmer practice without Fertilization, T2 represents improved cultural practice and 300 kg/ha of PNT for 3-year period at 42.4 CFA/kg , T3 represents improved cultural practice and300 kg/ha of PNT followed by 50 kg/ha of urea at 160 CFA/kg and T4 represents improved cultural practice and 100 kg/ha of ammonium phosphate at 89 CFA/kg followed by 50 kg/ha of urea
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Adjusted yield multiplied by the average sorghum price which was 70 CFA/kg in 1988 .
[4] Adjusted yield multiplied by the average grain price less fertilizer costs in CFA.
[5] Marginal rate of return.
[6] Net benefits divided by the number of additional person days necessary for fertilizer application. The application of ammonium phosphate or PNT followed by an application of urea will use up 12 person days.

Thus, it is apparent that farmers in Gouani who are relatively more intensive in terms of equipment use can more profitably apply the more expensive but more nutrient enriched combination of ammonium phosphate and urea. The farmers in Mountougoula, who are generally less intensive, will fare better with the local rock phosphate. Yield differences could not be attributed to rainfall since the two villages are in the same agro-ecologic zone.

Fertilization of rain-fed rice was started in 1989 with variety choice and fertilization as the main goals. Initial effort of fertilization was through the use of BG 90-2 planted on flooded fields previously planted to vegetables. This was at the urging of the farmers themselves. However, this variety turned out not to be suited agro-climatically to the zone. Mineral fertilization was thus introduced into the test the previous year and results are summarized in Table 38. The fertilization of farmer varieties proved to be the most profitable with a marginal rate of return of over 100% and a return to additional labor of 2,491 CFA per person day. The production of the improved variety resulted in reduction in net benefits, even if fertilizers were applied.

However, none of the farmers who planted the improved variety without fertilization lost any money as against 40% of those who fertilized.

Table 38. Effect of Variety and Fertilization on Rice Yields in Balanzan (1990-91)

Item	Fertilization and variety[1]			
	T1	T2	T3	T4
Total yield. kg/ha	575	1,103	291	470
Adjusted yield[2]	345	662	175	282
Value of production[3]	61,410	117,836	31,150	50,196
Total costs	0	26,530	0	26,530
Net benefit (NB)[4]	61,410	91,306	31,150	23,666
Increase in NB	—	29,896	-30,260	-37,744
Marginal rate of return (MRR)[5]		113%		
Return/person day of additional labor[6]		2,491	-3,145	
Pct. of farmers losing money	0	0	40	

[1] T1 represents the farmer variety without fertilization, T2 represents farmer variety 100 kg/ha of ammonium phosphate at 182.8 CFA/kg followed by 50 kg/ha of urea at 165 CFA/kg, T3 represents improved variety without Fertilization and T4 represents improved variety and 100 kg/ha of ammonium phosphate at 182.8 CFA/kg followed by 50 kg/ha of urea at 165 CFA/kg

[2] Yield is adjusted by a decrease of 40 % to reflect harvest and processing losses.

[3] Adjusted yield multiplied by the average rice price which was 178 CFA/kg in 1990-91 .

[4] Adjusted yield multiplied by the average grain price less fertilizer costs in CFA.

[5] Marginal rate of return.

[6] Net benefits divided by the number of additional person days necessary for fertilizer application. The application of ammonium phosphate followed by an application of urea will use up 12 person days.

Fertilization of crop associations

Table 39 gives a brief summary of results obtained from fertilization of sorghum/peanut association.

The source of phosphatic fertilizer had no significant effect on the yields of cereal/legume association. Testing this hypothesis on sorghum/peanut association, FSR/E applied local rock phosphate PNT and Simple Super at the recommended rates over a two-year period. No significant yield differences were obtained, even though fertilization was highly significant over the control. Such results make economic considerations extremely important due to cost effectiveness and risk aspects of technology application.

Both sources of phosphate gave economically viable results with marginal rate of return ranging from 452% to close to 1,900%. However, the local rock phosphate, PNT appeared to be relatively more economical for both seasons. The net benefits per hectare were higher than those for Simple Super with lower variability indices for both years. The returns per person day for labor required for fertilizer application were also higher for PNT(an average of 10,298 CFA as against an average of 8,650 CFA). The local production of PNT makes it a better choice since its availability is better assured.

Fertilization of sorghum/millet was conducted at Kominta, in the west of OHV zone. Tests carried out in 1987, 1988, and 1989 using mineral fertilizers did not prove profitable for millet and results for sorghum were not consistent. In 1990-91, the local rock phosphate was introduced as a possible fertility source and the results and analysis are summarized in Table 40.

PNT proved more profitable than mineral fertilizer application with a marginal rate of return exceeding 220% and a return to the additional labor needed for its application close to 1,700 CFA per person day. Further analysis (DRSPR/Volet OHV 1990) indicated that even if the per kilogram price of PNT doubles, the technology is still profitable yielding a net return at the margin of over 60%.

Fertilization of sorghum/cowpea was begun in 1988 and the results of 1989 crop season did not show any significant difference in yield between phosphate sources (PNT versus Ammonium Phosphate). However, the application of phosphate gave a significantly higher yield than the control (Table 41).

Maize/sorghum is an important crop association for the farmers in the southern section of the OHV zone. In years of good rainfall, very high yields are obtained. Farmers owning livestock try to fertilize their sorghum/maize fields with manure obtained from the traditional pens. The introduction of the improved corral system by FSR/E in this zone provided an opportunity for farmers to fertilize their fields with better quality manure in combination with the local rock phosphate. This was the focus of this test initiated in 1989-90 and repeated in 1990-91.

Table 39A. Economic Analysis of Fertilization of Sorghum/ Peanut Association in the OHV Zone (1990-91)

Item	Treatment[1]					
	T1		T2		T3	
Crop	Sorghum	Peanut	Sorghum	Peanut	Sorghum	Peanut
Total yield	267	499	296	653	433	703
Adjusted yield[2]	240	449	266	588	390	633
Value of production	90,194	116,838	128,552			
Total costs	0		4,823		4,700	
Marginal costs	—		4,823		4,700	
Net benefits(NB)[3]	90,194		112,015		123,852	
Increased NB	—		21,821		33,658	
Marginal rate of return (MRR)	—		452%		716%	
Return/added person day	—		3,637		5,610	
Standard deviation	41,727		49,492		51,936	
Index of variability	46.3		45.5		40.8	
Pct. of farmers losing money	0		0		0	

[1] T1 represents the farmer practice without fertilization, T2 represents the application of 65 kg/ha of Simple Super and T3 represents 300 kg/ha of PNT for a 3-yr period.
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Yield multiplied by the average prices for peanuts and sorghum which were 150 and 95 CFA/kg respectively in both 1990 and 1991.
[4] Yield multiplied by the average grain price less fertilizer costs in CFA (SS was 74.2 CFA/kg for both 1990 and 1991 and PNT was 47 and 47.2 CFA/kg in 1990 and 1991 respectively).
[5] Net benefits divided by the number of additional person days necessary for fertilizer application which is estimated at 6 person days. Thus, the application of Simple Super and PNT each uses 6 person days.

Table 39B. Economic Analysis of Fertilization of Sorghum/ Peanut Association in the OHV Zone (1991-92)

Item	Treatment[1]					
	T1		T2		T3	
Crop	Sorghum	Peanut	Sorghum	Peanut	Sorghum	Peanut
Total yield	750	1,352	742	2,000	722	2,070
Adjusted yield	675	1,217	668	1,800	650	1,863
Value of production	246,645		333,441		341,270	
Total costs	0		4,823		4,740	
Marginal cost	—		4,823		4,740	
Net benefits (NB)	246,645		328,618		341,270	
Increased NB	—		81,973		89,922	
MRR	—		1,700%		1,897%	
Return/person day of additional labor	—		13,662		14,987	
Standard deviation	73,723		120,945		68,402	
Index of variability	32.9		36.8%		20.3%	
Pct. of farmers losing money	0		0		0	

[1] T1 represents the farmer practice without fertilization, T2 represents the application of 65 kg/ha of Simple Super and T3 represents 300 kg/ha of PNT for a 3-yr period.
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Yield multiplied by the average prices for peanuts and sorghum which were 150 and 95 CFA/kg respectively in both 1990 and 1991.
[4] Yield multiplied by the average grain price less fertilizer costs in CFA (SS was 74.2 CFA/kg for both 1990 and 1991 and PNT was 47 and 47.2 CFA/kg in 1990 and 1991 respectively).
[5] Net benefits divided by the number of additional person days necessary for fertilizer application which is estimated at 6 person days. Thus, the application of Simple Super and PNT each uses 6 person days.

Farmers were grouped into two: those possessing animal manure in adequate quantites and those without. The animal manure was evaluated as the value of contractual arrangements between farmers and animal herders. The herders pack their cattle on farmers' fields to provide manure to the soil and farmers pay these herders on the basis of pre-arranged modes of payments including cash and cereal (Koné B, Yeboah A.K, and J.S Caldwell 1990).

The application of animal manure has a marginal rate of return over the absolute control of about 37.7% which is less than the minimum 100%. However, the nutrient benefits of manure application accrue over more than one year and together with its positive effect on soil structure and overall production sustainability makes a one-year analysis such as this one an underestimation of the importance of manure application. The results also show that the effect of fertilizer application is much higher when combined with manure than if applied alone. The marginal rates of return for fertilizer application on fields that also received manure are much higher than those from fields without manure. For example the application of urea and ammonium phosphate has a return of over 990% if manure was also applied as against only 62.2% if they were applied alone (Table 42). This combination was the most profitable in the 1989-90 season providing a return to additional required labor of over 3,000 CFA per person day.

Similar conclusions could be drawn from the results from the following year's test with manure application increasing the profitability of fertilizer application. The application of manure increased the marginal rate of return of PNT and ammonium phosphate from losses to 176 and 17% respectively (Table 43). The return to added labor was much lower: 1,376 and 518 CFA respectively if manure was applied, but in the absence of manure the applied fertilizer yielded negative returns (Table 43).

Organic fertilizers and compost

Organic manure and compost are applied to village fields, especially of maize, but at rates well below the recommended levels. The principal constraint to the adoption of this technology is the scarcity of the manure whether of animal or plant sources. Harvest residues are often fed to animals through the system of free browsing. The resulting animal manure is also difficult to collect since the animals are left to roam hence fecal matter is dispersed over a wide area. The technology of improved corralling system tested by FSR/E in which animals are penned and fed in a fenced area is aimed at resolving this problem. This technology is presented in more detail later in the publication.

Table 40. Economic Analysis of the Fertilization of Sorghum/Millet Association in Kominata (1990-91)

Item	Treatment[1]					
	T1		T2		T3	
Crop	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Total yield	299	216	434	274	444	371
Adjusted yield[2]	269	194	390	247	400	334
Value of production	39,474		54,249		62,658	
Total costs	0		4,700		18,280	
Marginal costs	4,700		18,280			
Net benefits(NB)[3]	39,474		49,549		44,378	
Increased NB	10,075		4,904			
Marginal rate of return (MRR)	—		222%		26.8%	
Return/added person day	—		1,679		817	
Standard deviation	10,252		15,936		13,509	
Index of variability	25.9		32.2		30.4	
Pct. of farmers losing money	0		0			

[1] T1 represents the farmer practice without fertilization, T2 represents 300 kg/ha of PNT for a 3-yr period and T3 represents the application of 100 kg/ha of ammonium phosphate during plowing.
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Yield multiplied by the average prices for millet and sorghum which were 87 and 84 CFA/kg respectively in 1991.
[4] Yield multiplied by the average grain price less fertilizer costs in CFA (Ammonium phosphate was 182.8 CFA/kg and PNT was 47 CFA/kg.)
[5] Net benefits divided by the number of additional person days necessary for fertilizer application which is estimated at 6 person days.

Table 41. Effect of Fertilization on the Yields of Sorghum and Cowpea in Association (1989)

Village	Treatments[1] and crop yield, kg/ha							
	T1		T2		T3		T4	
	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea
Dorébougou	584	456	600	616	683	744	813	600
Yékébougou	304	95	424	70	555	105	569	138
Average	444	276	512	343	619	425	691	369
Mountougou	364	242	556	269	637	387	970	699
Gouani	602	115	768	112	1,134	126	1,536	172
Average	483	179	662	191	886	257	1253	435

T1: control (no fertilization)
T2: 50 kg/ha of urea
T3: 300 kg/ha of PNT and 50 kg/ha of urea
T4: 100 kg/ha of ammonium phosphate and 50 kg/ha of urea.

FSR/E also investigated the effect of two different sources of animal manure (from transhumant animals and from improved corrals) on the yield of millet/cowpea association. The study had two components: field with manure and fields without. For the fields without manure the treatments consisted of T1 the absolute control, T2 which received an amount of manure equivalent to the average deposited by transhumant animals (see study below) and T3 received the recommended rate of manure (3.5 tons per hectare). In the second part additional treatments were incorporated: T4 received only manure deposited by the transhumant animals and T5 had manure from corrals added to that deposited by transhumant animals to obtain the recommended rate. The results show that manure from the transhumant animals produced millet yields that were over 10% higher than those for manure from improved corrals. For cowpea yields, fields without manure application had better yields than those receiving organic manure. However, there was a significant difference between the two sources of manure in terms of cowpea yields with manure from improved corrals producing yields that were 97% higher than those from transhumant animals.

A study of the contracting arrangements for animal manure was conducted. This was a study aimed at quantifying the manure deposited by transhumant animals on farmers' fields after a given number of days stay. The method was based on an equation developed by ISRA in Senegal in 1986 (DRSPR/Volet OHV 1990). The results indicated a high correlation between the length of stay during the season, the number of animals in Tropical Livestock Units, and the amount and quality of manure deposited.

The technology of tied ridges has been introduced to West Africa since 1950 (Dagg and McCartney 1968). On-station and on-farm researchers have indicated that tied ridges increase yields (Nicou and Charreau, 1985; Dugue, 1985; Rodriguez, 1982; Ohm and associates 1985a and 1985b). On-farm research has shown significant increase in yield and economic profitability for the additional labor required for using tied ridges on maize, sorghum, and millet in Burkina Faso (FSU Annual Report 1982, and 1983; Lang and associates 1984; Ohm and associates 1985a and 1985b). Still, in Burkina Faso, research has demonstrated a yield increase of between 15 and 20% for maize, around 24% for sorghum without fertilizer application and over 85% with fertilization, and 60% and 73% respectively for millet without and with fertilization (Kibreab, Yilala, and Prundencio 1986). Unfortunately, research carried out by ICRISAT in Mali did not yield satisfactory results as obtained in other sahelian countries (Table 44).

FSR/E has also researched the interaction between fertilization and ridging and the results are summarized in Table 45.

In 1989 test results, tied ridges gave an average yield of 695 kg/ha, 9% higher than simple ridges, with a net benefit per hectare of 2,058 CFA and per person/day of 229 CFA, which is less than the daily wage rate of a Malian worker (estimated between 250 and 500 CFA).

TABLE 42. ECONOMIC ANALYSIS OF FERTILIZATION OF MAIZE/SORGHUM STANDS ON FARMERS FIELDS IN LANDÉ IN THE OHV ZONE (1989-90)

Item	Fertilization[1]							
	T1		T2		T3		T4	
With manure	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Total yield, kg/ha	511	255	1,074	388	1,331	658	1,653	794
Adjusted yield	460	203	967	349	1,198	592	1,488	715
Value of production[2]	25,939		50,408		70,910		86,999	
Total costs	2,975		6,770		11,010		8,560	
Net benefit (NB)[3]	22,964		43,638		59,900		78,439	
Increase in NB	—		20,674		36,936		55,475	
Marginal rate of return (MRR)			544.8%		459.7%		993.3%	
Return/person day of additional labor	3,082		3,827		1,723		2,052	
Pct. of farmers losing money	0		0		0		0	
Without manure	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Total yield	309	266	616	365	829	456	1,059	666
Adjusted yield	278	239	554	329	746	410	953	599
Value of production	21,841		35,719		46,348		63,196	
Total cost	0		11,830		18,660		25,490	
Net benefits (NB)	21,841		23,889		27,688		37,706	
Increase in NB	—		2,048		5,847		15,865	
MRR			17.3%		31.3%		62.2%	
Return/person day of additional labor			171		325		1,322	
Pct. of farmers losing money			0		0		0	

[1] For farmers with manure T1 represents the application of 3.5 tons/ha of manure, T2 represents the application of 3.5 tons/ha of manure plus 25 kg/ha of urea, T3 represents 3.5 tons of manure, 25 kg/ha of urea and 300 kg/ha of PNT for 3 years and T4 represents 3.5 tons/ha of manure, 25 kg/ha of urea and 100 kg/ha of ammonium phosphate. For farmers without manure, T1 represents the absolute control, T2 represents 50 kg/ha of urea plus 300 kg/ha of PNT for 3 years, T3 represents 50 kg/ha of urea, 150 kg/ha of PNT and 50 kg/ha of ammonium phosphate and T4 represents 50 kg/ha of urea plus 100 kg/ha of ammonium phosphate.
[2] Yield multiplied by the average prices for maize and sorghum which were 33 and 53 CFA/kg respectively in 1989-90.
[3] Yield multipled by the average grain price less fertilizer costs and opportunity cost of animal manure in CFA. (Ammonium phosphate was 179 CFA/kg, urea was 151.8 CFA/kg and PNT was 42.4 CFA/kg in 1988-89, a ton of manure was evaluated at 850 CFA.)

Phosphorus application had a stronger effect on millet yield than the application of nitrogen. Millet yield was 760 kg/ha with PNT application, a 10% increase over yield from urea application.

Tied ridges in combination with PNT gave a yield of 755 kg/ha, an increase of 29% over yield from farmer practice (simple ridges). Even though the difference was not statistically significant, this suggests that the combined or interactive effect of tied ridges and phosphorus application is higher than their individual effects. The net benefits per hectare for this combination was close to 2,200 CFA, however, the net benefit per additionl person day needed was very low. In addition, the interactive effect of tied ridges and urea had negative net benefits per hectare due to millet yields that were lower than even those from simple ridges.

Manual construction of tied ridges consumes too much labor, over 100 person hours per hectare, and this is the principal constraint to this technology. This labor need can be reduced to an average of 75 person hours with the use of animal traction (Ohm et al 1985b). However, cash expenditure is minimal for this technology if family labor is available. Tied ridges have an additional constraint of not being very efficient in sandy soils because the ridges break easily during rainfall. Despite these constraints, over 15% of the cultivable land in Mali is suitable for the application of this technology. The western part of the OHV zone is adaptable to this technology.

The farmers in the OHV zone use various conservation methods including erosion control practices such as fallowing, stone rows or rock bunds, trunk barriers, tree planting and mulching. FSR/E has tested several of these techniques at the pre-extension stage in collaboration with the extension service. Much of the work has involved tree planting, rock bunds and earthen dikes and results of three years of work are summarized below.

With the planting of Bauhinia rusfescens and half-moons, the number of species increased from 32 in 1989 to 61 in 1992. Where Bauhinia rusfescens was planted without half-moons, the number of species increased from 43 in 1989 to 83 in 1991. With the installation of half-moons without Bauhinia rusfescens, the number of species increased from 32 in 1989 to 62 in 1992. With the control, the number increased from 47 in 1989 to 51 at the end of the experimental period.

Thus the installation of only Bauhinia rusfescens appears to give the best results with an increase of 40 species within the period of test. The control had the lowest number, an increase of only 14 species. An 80% soil recovery was obtained across the whole experimental field.

There was no significant difference between the height of Bauhinia rusfescens with and without half-moons (47 cm with half-moons and 35.9 without.) Both treatments give a significant biomass increase with 1.241 kg/m^2 for Bauhinia together with half-moons and 0.863 kg/m^2 for half-moons alone. With

Table 43. Economic Analysis of Fertilization of Maize/ Sorghum Stands on Farmers Fields in Déguéla in the OHV Zone (1990-91)

Item	Fertilization[1]					
	T1		T2		T3	
With manure	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Total yield, kg/ha	467	756	735	765	703	881
Adjusted yield	420	680	662	689	633	793
Value of production[2]	85,600		98,555		106,985	
Total costs	2,975		7,675		21,225	
Net benefit (NB)[3]	82,625		90,880		85,730	
Increase in NB	—		8,255		3,105	
Marginal rate of return (MRR)			175.6%		17.0%	
Return/person day of additional labor			—1,376		518	
Pct. of farmers losing money	0		0		0	
Without manure	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Total yield	714	1,099	765	1,050	572	1,120
Adjusted yield	643	989	689	945	515	1,008
Value of production	136,105		124,225		121,510	
Total cost	0		4,700		18,280	
Net benefits (NB)	126,105		119,525		103,230	
Increase in NB	—		-6,580		-22,875	
MRR	—		—		—	
Return/person day of additional labor			-1097		-3,813	
Pct. of farmers losing money	30		48			

[1] For farmers with manure T1 represents the application of 3.5 tons/ha of manure, T2 represents the application of 3.5 tons/ha of manure and 300 kg/ha of PNT for 3 years and T3 represents 3.5 tons/ha of manure and 100 kg/ha of ammonium phosphate. For farmers without manure, T1 represents the absolute control, T2 represents 300 kg/ha of PNT for 3 years, T3 represents 100 kg/ha of ammonium phosphate.
[2] Yield multiplied by the average prices for maize and sorghum which were 50 and 95 CFA/kg respectively in 1990-91.
[3] Yield multipled by the average grain price less fertilizer costs and opportunity cost of aniomal manure in CFA. (Ammonium phosphate was 182.8 CFA/kg, and PNT was 47 CFA/kg in 1990-91, a ton of manure was evaluated at 850 CFA.)

Table 44. Effect of Soil Preparation on Sorghum and Millet Yields in kg/ha (1988 and 1989)

Soil preparation	Sorghum			Millet
	Sotuba	Samanko		Cinzana
	1988	1988	1989	1988
Plowing	2,710	2,080	1,950	901
Ridging	2,310	2,240	—	—
Tied ridging	—	—	1,920	937

Source. ICRISAT annual report 1989 and 1990.

the use of Bauhinia and half-moons a total biomass production of 12.4 tons/ha can be expected.

There is a significant increase in the presence of useful plant species such as *Cassia obstisifolia*, *Cenchrus biflorus*, *Cucumis filicolis* and *Pennisetum pedicellatum* and the disappearance of species such as *Zornia glodutiata* whose presence indicates poor soil conditions. There is over 90% rate of soil recovery as compared to 7% before the installation. A green matter yield of 1,280 kg per square meter or 12.8 metric tons per hectare was recorded. There is also appreciable increase in vegetation heights with baobab increasing to between 53.5 and 130 cm while tamarind increased between 40.5 and 74 cm.

Tree planting in fields

Baobab showed the highest survival rate, over 75% for the first season and 97% and 89% for the second and third seasons, respectively. Tamarind comes second with about 50% rate of survival during the first season and 47 and 100% for the second and third season, respectively. Almost all of the néré trees died during the first season due to erroneous weeding, shock during transportation, insect attacks, and shortage of the rainfall season.

An acceptable germination rate for haie-vie of close to 40% was obtained, however, the survival rate was almost nil during the second year due to attacks by grasshoppers. The test is planned for five years and it is currently in its 4th year. The predominant species observed on the test fields include *Andropogon pseudapricus* 71.88% in 1992 as against 6.3% in 1990, *Schoenofeldia gracilis* 58% as against 25.9% and *Combretum glutinosum*, 6.66% as against 1.5%. The production of vegetative matter in 1992 was about 0.154 kg per square meter or 1,086 kg of dry matter per hectare.

The use of diguettes-murettes and small dams permitted an increase in area cultivated by up to three hectares. There was significant reduction in surface run-off speed and an increased infiltration rate. Based on the above results, the following techniques were recommended for diffusion by the extension service: rock bunds, diguttes-murettes and small dams, and planting of Bauhinia rufescens at a spacing of 2x2m.

These technologies produce the following effects: significant reduction in surface run-off speed and increased infiltration rate.

FSR/E introduced the improved fallowing method or technique in 1988 not only as a means of providing forage for livestock, but also to improve soil fertility and thereby increasing subsequent cereal yield. The improvement technique consisted of the implantation of *Stylosanthes hamata*, a forage legume. The interactive effect of the legume and fertilization was evalauted by the addition of fertilizers to the treatment at the end of the fallow period. Results are summarized below.

Effect on natural regeneration of plants

After the first year of test, the rate of appearance of leguminous plants varied between 2.33 and 36.33% on the land receiving the improved method of fallowing. Stylosanthes

Table 45. Economic Analysis of the Interactive Effect of Fertilization and Tied Ridges on Millet Yield in the North of OHV Zone

Item	Treatment[1]					
	SR	TR	SRU	TRU	SRP	TRP
	1989-90					
Total yield	584	677	594	664	744	755
Adjusted yield	526	600	535	598	670	679
Yield increase	—	74	9	72	144	153
Increase in net benefits[2]	—	3,108	-7,212	-4,566	1,808	2,186
Return/person day of added labor[3]	—	345	-480	-304	301	146
	Effect of Tied Ridges					
	SR	TR			SR	TR
	1988				1989	
Total yield	530	880			640	695
Adjusted yield	477	792			576	625
Yield increase	—	315			—	49
Increase in net benefits	—	13,230			—	2,058
Return/person day of added labor	—	1,470			—	229

[1]SR is the farmer practice, simple ridges without Fertilization; TR represents tied ridges without Fertilization; SRU represents simple ridges with urea application; TRU represents tied ridges with urea; SRP represents simple ridges with PNT and TRP represents tied ridges with PNT.
[2]Net benefits = increase in yield x average grain price (42 CFA/kg in 1988 and 1989) less fertilizer costs (50 kg/ha for urea at 151.8 CFA/kg and 300 kg/hs for three years for PNT at 42.4 CFA/kg.
[3]Net benefits divided by additional labor needed for the construction of ridges and fertilizer application. It has been estimated that manual tying of ridges and animal traction-aided tied ridges require 100 and 75 hours respectively of additional labor per hectare. These figures are equivalent to about 12 and 9 person days if a person day is assumed to be hours of work. The application of fertilizer requires roughly 48 hours of work or 6 person days.

hamata had a presence of 11.33%. There was also a large presence of gramineous plants.

Biomass production during the first was higher on the traditional fallows than on the improved fallows (Table 46). However, the quality of the dry matter as measured by the nitrogen content favored the improved fallows.

At the end of the fallow period, three years later, the appearance (percentages) of specific plant species was estimated and the results are shown in Table 47.

Even though there was no significant difference in percentage of land recovered, the improved fallows had a significantly higher percentage of leguminous plants (important for soil fertility) than traditional fallows.

The production of dry matter and the feeding capacity of the two types of fallows were also measured at the end of the three-year fallowing period. The results are summarized in Table 48. Dry matter production was higher on the improved fallow (1,257 kg/ha) than on the traditional fallows (997 kg/ha). The difference in dry matter production of 260 kg/ha could sustain one Tropical Livestock Unit (TLU) for 40 days.

Table 46. Effect of Fallowing Method on Biomass Production and Quality of Forage

Fallowing method	Dry matter	Quality of forage				
	Tons/ha	Cellulose Pct.	N Pct.	P Pct.	Ca Pct.	Ash Pct.
Traditional method	1.7	40.9	3.88	0.05	0.85	7.5
Improved method	1.1	44.3	6.59	0.09	1.06	7.5
Level of sig.	*	N.S	*	N.S	N.S	N.S

Table 47. Percentages of Specific Plant Species on Recovered Land

Fallow method	Gramineous plants	Legumineous plants	Non-forage plants	Recovered land
Traditional method	60	10	30	79
Improved method	44	42	14	79.3

Table 48. Dry Matter Production and Feeding Capacity of the Two Types of Fallows

Fallow type	Dry matter production kg/ha	Number of TLU/ha/year
Traditional fallow	997	0.42
Improved fallow	1,257	0.53

Effect on crop yields

Even though the yield figures in Table 49 do not show a statistically significant difference between the two fallowing methods, there is an appreciable increase of 30% (431 kg/ha) in yield for the improved method. It is possible that the effect of the improved method will become more apparent over time as the plots are returned to fallow. The fallows were planted to sorghum.

Despite the unavailability of results for post-fallow soil test to confirm the restoration of soil fertility, there has been a positive trend in the production of biomass and the quality of the ensuing forage.

In addition, the absence of significant treatment effect on yield does not negate the positive aspect of the improved fallowing technology. A yield increase of 30% as noted above is a big contribution towards the attainment of food self-sufficiency. This technology is economically feasible even at present lower than expected yields.

Mulch can be used to reduce surface run-off and increase water infiltration into the soil. However, crop residues such as those of millet and sorghum add very little to soil fertility. As was the case with organic manure, the major constraint to this technology is availability of mulching material. Crop residue available after harvest is often used either as livestock feed, fuel source or construction material. This has limited FSR/E

TABLE 49. ECONOMIC ANALYSIS OF THE EFFECT OF FALLOWING METHOD AND/OR FERTILIZATION ON SORGHUM YIELD IN TWO OHV VILLAGES

Item	Fertilization[1]			
	T1	T2	T3	T4
Dalacana				
Total yield (kg/ha)	1,054	1,646	1,670	1,798
Adjusted yield	948.6	1,481.4	1,503	1,618.2
Value of production[2]	99,603	155,547	157,815	169,911
Total costs[3]	0	12,000	12,550	24,550
Net benefit (NB)[4]	99,603	143,547	145,265	145,361
Increase in NB	—	43,944	45,662	45,758
Marginal rate of return (MRR)		366.2%	363.8%	186.4%
Return/person day of additional labor		3,662		3,815
Niaganabougou				
Total yield	1,603	1,427	1,982	2,004
Adjusted yield	1,442.7	1,284.3	1,783.8	1,803.6
Value of production	151,484	134,852	187,299	189,378
Total cost	0	12,000	12,550	24,550
Net benefits (NB)	151,484	122,852	174,749	164,828
Increase in NB	-28,632	23,265	13,344	
MRR		—	185.4%	54.5%
Return/person day of additional labor		-2,386		1,112
Average of two villages				
Total yield	1,328	1,536	1,826	1,901
Adjusted yield	1,195.2	1,382.4	1,643.4	1,710.9
Value of production	125,496	145,152	172,557	179,645
Total costs	0	12,000	12,550	24,550
Net benefits (NB)	125,496	133,152	160,007	155,095
Increase in NB	7,656	34,511	29,599	
MRR		63.8%	274.5%	120.6 %
Return/person day of additional labor		638		2,467

[1] T1 represents traditional fallow with no fertilization; T2 represents traditional fallow with fertilization; T3 represents improved fallow (15 kg/ha of at 4000 CFA/kg) without fertilization while T4 is improved fallow with fertilization (fertilization consisted of 300 kg/ha of PNT and 50 kg/ha of urea).
[2] Adjusted yield multiplied by the average sorghum price which was 105 CFA in 1992-93.
[3] An improved fallow can be put into cereal production for a maximum of five years hence the cost of fallow improvement is amortized over a five-year period.
[4] Adjusted yield multiplied by the average grain price less fertilizer cost (in 1992, a kilogram of PNT and a kilogram of urea cost 47.4 and 156.2 CFA respectively.

research effort in this area. Moreover, the residue does not provide sufficient nutrients to enrich the soil. Mulching has also been observed to reduce available nitrogen in the soil (Pieri 1985). Very little mulching is presently done in the OHV zone, however, with increased crop production through other soil and water conservation techniques, availability of mulching material is expected to increase thereby permitting more farmers to use it.

On-station and on-farm research results have demonstrated a significant yield increase from plowing and other soil preparation practices. Over 70% of farmers in the OHV zone practice some form of soil preparation either with draft animals or with hand tools such as "daba." However, often the plowing is very shallow or superficial because of the need to sow immediately after the first rains at which time the soils are still hard and difficult to be worked sufficiently by the draft animals which are already weakened by the long dry season (FSR/E Volet OHV, 1988). In addition, the application of green manure can increase soil fertility and water retention capacity of the soil. However, the application requires a lot of labor, hence only farmers possessing draft animals (about 30% of farmers in the OHV zone) to perform this function can easily adopt this technology.

LABOR-SAVING TECHNOLOGIES

A study of the effect of migration on agricultural production was conducted in 1990-91 to have a better understanding of the use of migration as a family strategy. On one hand, migration was found to be a source of labor shortage during the agricultural season, but it was also a source of income (through remittances) for agricultural investment. Over 95% of the households interviewed had at least one migrant family member and these migrants were mostly men and about 56% of the households reported being remitted. Migrant family members are sometimes a source of information on new production techniques.

Over 60% of the farmers in the OHV zone practice animal traction. The use of draft animals for other cultural practices such as seeding and weeding is rare and this results in small holdings per farmer since labor for weeding and sowing is severely limited (DRSPR/Volet OHV 1988, 1989). Yield increases and profitability of animal traction (Table 50) are evident in literature (Binswanger, 1978). This technology is used by the farmers at varying degrees of intensity with the marginal rate of return increasing with increased intensity of use. What is needed is an intensification of information dissemination, farmer training and improved animal feeding and health care in order to increase rate of use and its profitability.

Herbicides have the potential of alleviating the labor shortage bottleneck of production in the OHV zone especially for sowing and weeding. Herbicides are largely unavailable outside the distribution network of the development organiza-

TABLE 50. ECONOMIC BENEFITS OF ANIMAL TRACTION IN THE SOUTH OF MALI IN FCFA (1978)

Variable	Users of animal traction	Non-users of animal traction
Net revenue per farmer	1,406,252	216,794
Net revenue per hectare	95,859	74,756
Net revenue per farm worker	84,984	54,267

Source. Pingali P, Bigot Y, H.P Binswanger, 1987.

tion and their use presently is limited. The preponderance of crop associations in the farmers cropping systems also makes the application of herbicides difficult due to the different effects on different leaf formations. Economic analysis in the north of Nigeria showed that weeding done manually or with animal traction was more profitable than herbicide application.

Research work by FSR/E showed that a combination of manual weeding and herbicide application was more profitable than manual weeding only (Table 51).

Herbicide application was profitable with acceptable risks at the given values of the economic variables with a marginal rate of return exceeding the minimum acceptable value of 100%. It has a higher minimum average net benefit and even though the variation between farmers is higher, it has a lower variability index. No financial losses were accrued by any farmer.

Research results obtained by FSR/E show that a hectare of maize requires a total of 220 person days to perform all the necessary farm operations from plowing to harvesting. Using a daily wage rate of 500 CFA, this correponds to 100,000 CFA per hectare. Analysis has also shown that the application of herbicide reduces the needed labor by 50% or 50,000 CFA which is therefore opportunity cost of labor. Allowing for this reduction increases even further the net benefit per hectare of herbicide application.

Table 51. Economic Analysis of Herbicide Application on Maize in Tinguélé, in the OHV Zone (1990-91)

Item	Treatment[1]	
	T1	T2
Total yield in kg/ha	1,673	2,934
Adjusted yield	1,506	2,641
Value of production in CFA	75,300	132,050
Total costs in CFA	0	13,405
Net benefits[2]	75,300	118,645
Increase in net benefits	—	43,345
Marginal rate of return	—	323%
Standard deviation	41,778	52,519
Variability index[3]	55.5	44.3
Minimum net benefit	23,850	32,945
Pct. of farmers losing money	0	0

[1]T1 represents the farmer practice of manual weeding and T2 represents a combination of manual weeding and herbicide application (this treatment combination was necessary due to the poor weeding done by the farmers before applying the herbicide).
[2]Net benefits = the adjusted yield x average grain price for maize (50 CFA/kg in 1990) less herbicide cost (3.5 litre per hectare of Primagram at 3830 CFA/litre).
[3]Standard deviation divided by the average net benefit x 100.

Sensibility analysis of prices does not result in changes of technology choice. Even with a 20% reduction in maize price or doubling of herbicide price, the marginal rate of return is around 239 and 112%, respectively (Table 52). Even though over 25% of the farmers in the zone can use this technology at present time, more research work is needed.

Results of agro-economic studies have shown that weeding consumes over 50% of the labor time available to farmers for agricultural activities. This test was initiated to find a weed control technology which was suitable and economical to replace the preponderance of manual weeding in the OHV zone. The choice of sorghum/millet was based on the dominance of this association in the area where weeds and labor shortage were the most severe. Two different combinations of weeding methods were considered; mechanical/manual weeding and chemical/manual weeding. Fertilization consisted of the application of 300 kg/ha of PNT and 50 kg/ha of urea against a control of no fertilization. The two groups of treatments were combined to assess their interactive effects. Agronomic results are in Table 53.

Results of the two-year test show no significant difference in yield. Both mechanical and chemical weed control meth-

Table 52. Effect of Price Changes on the Profitability of Herbicide Application on Maize at Tinguélé (1990-91)

Item	Treatment	
	T1	T2
20% decrease in price of maize		
Total costs	0	13,405
Increased costs	—	13,405
Net benefits	60,228	92,219
Increased net benefits	—	31,991
Marginal rate of return	—	239%
Pct. of farmers losing money	0	
100% in herbicide price		
Total costs	0	26,810
Increased costs	—	26,810
Net benefits	75,285	105,220
Increased net benefits	—	29,935
Marginal rate of return	—	112%
Pct. of farmers losing money	0	

Table 53. Sorghum/Millet Grain Yield for Different Weeding Methods and Fertilization

Year	Treatment[1]							
	T1		T2		T3		T4	
	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
	Crop yields in kg/ha							
1992-93	328	56	758	107	392	74	666	178
1991-92	697	301	930	408	664	382	782	405

[1]T1 is a combination of mechanical and manual weeding without fertilization; T2 represents a combination of mechanical and manual weeding with fertilization; T3 is a combination of chemical and manual weed control without fertilization and T4 represents a combination of chemical and manual weeding with fertilization (fertilization: 300 kg/ha of PNT and 50 kg/ha of urea; chemical: 4 liters per hectare of propagard at 4390 CFA/lt).

ods gave similar yield results regardless of the level of fertilization. The application of rock phosphate did not significantly increase millet yield but its effect on sorghum was significant. Yields from fields that recieved PNT confirmed the hypothesis that sorghum responds to the residual effect of the rock phosphate better than does millet. Second year sorghum yield was 36% higher as compared to only 23% for millet. Cultivators (multiculteurs) and animal traction (draft animal plus equipment) are the main forms of mechanical weed controls. These are relatively more expensive than chemical weed control. The application of herbicide costs on the average 17,560 CFA per hectare as opposed to 30,000 CFA which is the opportunity cost for family labor needed for weeding a hectare. These considerations make chemical weed control an optimal choice.

Crop variety improvement technologies

Research results on the production systems of farmers show that the level of collaboration by farmers declines with the number of technological or cultural changes they are asked to make. With this in view, FSR/E initially concentrated on soil fertility improvement and soil and water conservation technologies. Efficiency of the adoption of new crop varieties are enhanced after soil and water management technologies are in place. Consequently FSR/E has very limited research results from on-farm trials. Thus this section of the document presents an overview of the different crop varietes in the OHV zone followed by highlights of the few results available from on-farm trials.

A brief list of the existing crop varieties are given in Table 54. All these varieties have characteristics potentially beneficial to farmers as indicated in the annual reports of ICRISAT-MALI (IER/ICRISAT MALI 1988, 1989).

Only a small percentage of the farmers in OHV zone use improved crop varieties. On-station research results show a significant increase in yield for some crop varieties but a wide gap exists between on-station and on-farm research results especially for sorghum and millet. The yield differences are less pronounced for the local crop varieties than they are for new improved ones (Matlon 1985). Yields from on-farm tests for improved maize, sorghum, and cowpea varieties rarely exceeded those from local varieties due to the better managed and controlled environment at the stations.

FSR/E started conducting on-farm trials on rain-fed rice and the highlights of the results are summarized in Table 55.

The process of selection of a suitable rice variety for the OHV zone has been characterized by the tremendous variation of yield performance and the level of annual rainfall. Rice yield is very sensitive to soil moisture conditions as evidenced by the figures in Table 55. In 1988-89, a year of better-than-average rainfall, the variety IRAT 144 gave yields that were much higher than those for Dourado but lower than those for the farmer variety when fertilization was applied. This yield result together with the poor taste of IRAT 144 made it less acceptable to the farmers. Hence in 1990-91 this variety was replaced with IRAT 147, but yields were again lower than the farmer variety with fertilization. This was a poor rainfall year. Thus it appears that the problem was due more to soil moisture management than variety.

Table 54. Existing Principal Crop Varieties in the OHV Zone

Crop varieties				
Sorghum	Millet	Maize	Peanuts	Cowpeas
Tiemarifing	Souna	Tiémanté	47-10	TVU 76-07
S-34	Sanio		28-206	Amary sho
ICSV-1063	Boboni		55-437	KN1
CSM-388	NKK			KVX 30-305-3G
Sako6ka	Synthetic 11			Shotely
Malisor 84-1	Synthetic 16			TN 88-63
Malisor 84-7	PN 4			
Bimbiriba	81 BHT			

Table 55. Economic Analysis of Rain-Fed Rice Variety Improvement Test

Item	Treatment, 1990-91[1]			
	T1	T2	T3	T4
At Balanzan				
Total yield	575	1,103	291	470
Adjusted yield[2]	345	662	175	282
Value of production	61,410	117,836	31,150	50,196
Total costs	0	26,530	0	26,530
Net benefits(NB)[3]	61,410	91,306	31,150	23,666
Increased NB	—	29,896	-30,260	-37,744
Marginal rate of return (MRR)	—	113%		
Return/person day of added labor		2,491		
Pct. of farmers losing money		0		
Av. of 2 villages Treatment, 1988-90				
Total yield	1,540	940	1,360	—
Adjusted yield	924	564	816	—
Value of production	157,080	95,880	138,720	—
Total costs	26,530	26,530	26,530	—
Net benefits (NB)	130,550	69,350	112,190	
Increased NB	—	-61,200	-18,360	
MRR	—	—		
Return/person day of added labor		-5,100	-1,530	
Pct. of farmers losing money				

[1] In 1990-91, T1 = farmer variety, (Lengu*) without Fertilization, T2 = farmer variety with Fertilization, T3 = improved variety, (IRAT 147), without Fertilization and T4 = improved variety with Fertilization. For 1988-89, T1 = farmer variety (Lengu*) with Fertilization; T2 = improved variety (Dourado, which is an early maturing variety) with Fertilization and T3 = improved variety, IRAT 144 with Fertilization: Fertilization = 50 kg/ha of urea and 100 kg/ha of ammonium phosphate).

[2] Yields were were adjusted downwards by 40% to represent harvest and transformation losses.

[3] Average price of a kilogram of grain rice was 178 fcfa in 1990-91 and 170 fcfa in 1988-89.

CROP ASSOCIATION PERFORMANCE IMPROVEMENT TECHNOLOGIES

On-station research has shown significant yield increases from cereal/legume associations, especially from cereal/cowpea associations. Unfortunately intensification of cowpea production often leads to increased insect attacks requiring insecticide application. On-farm research has identified insufficient moisture and soil fertility as the principal constraints to the performance of cereal/legume associations. FSR/E research effort in this area has concentrated on fertilization and planting arrangements and some of the results confirm the above hypothesis. For example, in the north of zone OHV, where moisture and soil fertility deficiency are the most severe, the Land Equivalent Ratio (LER) for millet/cowpea association is less than 1.0 (0.52) whereas in the more fertile and moisture-rich south, the LER for cereal/cowpea assoication is over 1.55 (DRSPR, Volet OHV 1987). A ratio of less than 1.0 is not acceptable to the farmers in attaining their objective of cereal self-sufficiency. Another aspect of cereal/legume intensification is the resulting increase in the labor need for sowing and weeding (DRSPR, Volet OHV 1989). Highlights of the FSR/E research results in alleviating some of these constraints follow in this publication.

Cropping density, arrangement and fertilization baseline data collected in 1988 and 1989 indicated that the cropping system in the OHV zone is dominated by crop associations (over 70% of total area cultivated, DRSPR/Volet OHV 1989, 1990). The same data revealed poor yields for the individual crops in the associations. Research work was initiated to improve yields through crop density and arrangement adjustments and soil fertility enhancement.

A sorghum/cowpea association test was begun in 1990. The goal of this research was to attempt to increase sorghum yield without reducing that of cowpeas. However, the results show that the best performing technology depends on the individual crop in question. Increased sorghum grain yield was obtained only at the expense of cowpea grain yield. Despite this increase there was only a small significant effect of cultural practice and fertilization for sorghum yield. This might be attributable to the nitrogen-fixing qualities of cowpeas present in all treatments. On the other hand, cowpea grain yield was highly responsive to the improved cultural practice and fertilization.

In 1990, the control treatment and the application of 300 kg/ha of PNT gave similar yield results for sorghum. However, the second year results (1990-91) in Table 56 show an increase in sorghum yield of 36% from PNT application as against fields that received no fertilization. It must be noted that ammonium phosphate was applied only once, hence in the second year monitoring was included for the delayed effect of fertilization. Thus the increase in yield from fields that received PNT confirms the expected second year effect of PNT. On the other hand, cowpea yields show no significant difference between PNT fields and the other fields. Also cowpea yield appears to increase with density, a phenomenon not observed with sorghum.

Economic analysis showed that alternating-lines planting with PNT and Urea fertilization dominates the other treatments with a marginal rate of return of about 273%.

The results from the 1990-91 season confirm farmers' fear that increasing cowpea density, i.e increasing the number of grains per hole, reduces sorghum grain yield (Table 56). Thus even though the alternating-lines technique has several advantages, the farmers recommended a planting density somewhere between their own low level and what has been recommended by research.

The results of 1991-92 showed a marked decreased in sorghum yield due to the effect of the alternating-line planting as compared to the farmers' planting arrangement. This was contrary to the objective of increasing sorghum yield. However, this reduction was compensated by an increase in the yield of cowpeas.

The 1992-93 season was the last year of the test and the results are given in Table 57.

The return to the additional person days needed ranges from about 460 CFA to over 1,500 CFA (Table 57). Averages, very often can hide important characteristics of production systems modifications. For example one can obtain high averages at the expense of stability, thus, information on standard deviation and index of variabilities of net benfits are essential. Figures in Table 57 show that modifying the cultural practice and applying fertilizer give very stable net benefits.

Other test results on this topic can be found in FSR/E annual reports (DRSPR/Volet OHV 1992, 1991).

TABLE 56. EFFECT OF PLANTING ARRANGEMENT AND FERTILIZATION ON SORGHUM/COWPEA GRAIN YIELD (1991)

Treatment			Grain yield, kg/ha					
			Déguéla		Tinguélé		Average	
PNT	Urea	Arrang	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea
0	0	farmer	810	31	792	134	801	82
300	50	farmer	1,047	22	1,111	175	1,078	99
0	0	alter.	733	282	631	252	681	267
300	50	alter.	972	413	984	330	977	372

Table 57. Economic Analysis of the Interactive Effect of Crop Arrangement and Fertilization on Sorghum/Cowpea Yield (1992-93)

Item	Treatment[1], 1992-93							
	T1		T2		T3		T4	
At Deguéla								
Crop	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea
Total yield	792	187	813	541	820	344	1,034	389
Adjusted yield[2]	713	168	732	487	738	310	931	350
Value of production	101,839		148,233		124,214		151,137	
Total costs	0		25,850		13,300		25,850	
Marginal costs	—		25,850		13,300		25,850	
Net benefits(NB)[3]	101,839		122,383		110,914		125,287	
Increased NB	—		20,544		9,075		23,448	
Marginal rate of return (MRR)	—		79%		68.2%		90.7%	
Return/added person day	—		1,712		9,075		1,954	
Standard deviation	14,255		7,902		21,886		2,163	
Index of variability	14.0		6.5		19.7		1.7	
Pct. of farmers losing money					0		0	
At Tinguélé Treatment, 1992-93								
Crop	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea
Total yield	1,256	28	1,051	336	948	216	1,272	266
Adjusted yield	1,130	25	946	302	853	194	1,145	239
Value of production	127,834		146,122		120,645		159,242	
Total costs	0		25,850		13,300		25,650	
Marginal cost	—		25,850		13,300		25,850	
Net benefits (NB)	127,834		120,272		107,345		133,392	
Increased NB	—		18,288		-20,489		5,558	
MRR	—		70.7%		—		21.0%	
Return/person day of additional labor			1,524		—		463	
Standard deviation	1,704		17,121		22,151		19,597	
Index of variability	13.3		14.2		20.6		14.6	
Pct. of farmers losing money			0		0		0	

[1] T1 is the farmer practice (farmer density and variety without fertilization); T2 is single alternating lines of sorghum and cowpea with fertilization ; T3 is 2 lines of sorghum alternating with single cowpea lines with no fertilization; T4 is 2 lines of sorghum alternating with single cowpea lines with Fertilization; (fertilization = single application of 300 kg/ha of PNT at 47.4 CFA/kg and 50 kg/ha of urea at 156.2 CFA/kg; all cowpeas treated with DECIS (6650 CFA/ha) except for T1).
[2] Yield reduced by 10% to reflect harvest and other losses.
[3] Average price for a kilogram of sorghum and cowpeas were 110 CFA and 139 CFA respectively.

Animal production and livestock-crop integration technologies

The technologies developed by FSR/E in the area of animal production and livestock-crop integration include the following: improved corralling method, livestock fattening, forage production techniques, improved honey production, draft-animal maintenance nutrition, monitoring young oxen and village poultry production improvement techniques (aimed at providing alternative income sources for women).

Traditional structures used by livestock owners for corralling are either owned individually or are operated on a community-wide basis. The principal objective is to enable farmers to obtain animal manure to fertilize their fields. However, the resulting manure is often insufficient in quantity and of poor nutrient quality. The system also requires excessive use of wood which increased the rate of cutting of the few remaining trees.

FSR/E started research work with the aim of developing a better structure that will permit increased production of better quality animal manure and which will better economize the available woodland. The quantity and quality of the manure were measured.

Construction costs varied between villages due to variation in input prices and availability of wood and labor. There is economy of size with the per unit cost declining with the number of animals to be housed. It ranges from 3,340 CFA per head for a herd of 10 animals to only 1,344 CFA for a 60 animal herd. The improved cattle pen technique produces about 643 kg of manure per head as against less than 150 kg/head for the traditional pen. The value of the manure produced was assessed by comparing its chemical compostion with those from a comparable chemical fertilizer. This gives an increase in net benefit per head of over 3,000 CFA if construction cost is amortized over three years. The net benefit per additional labor required to feeding is over 2,500 CFA per animal.

Despite this apparent profitability, the availability of feeding materials, mainly crop residues and other biomass material, inhibits the adoption of this technology. Variability in soil fertility and in manure quality across the zone render difficult the formulation of specific recommendations. A sample of 100 kg of manure from improved pens contains 0.61% , 0.21% and 1.25% of nitrogen, phosphorus and potassium respectively yielding a total of 2.07% of these principal elements. On the contrary, 100 kg of a complete fertilizer such as cereal complex contains 15% each of nitrogen, phosphorus and potassium or 45% of the principal nutrient elements. Thus, to have the same amount of these elements in the soil from the application of organic manure, a minimum of 2459 kg per hectare of it is needed. Another aspect of the utilization of manure is that of solubility. Mineralization rate of organic matter is highly dependent on soil conditions, such as acidity, microbe content, aeration, texture, and very often the nature of the organic matter. Results from the Soil Laboratory at Sotuba show that only 40% of the nitrogen in animal manure is available for plant nutrition during the first year and 8% during the second year. For phosphorus only 75% is usable and of this 80% is available for plant use in the first year. Over 80% of potassium content is available in year one. Thus the efficiency of the use of manure is restricted by the nitrogen component. Only six kg of nitrogen from the 2,459 kg of manure applied will be available during the first year. To have 15 kg of nitrogen during the first year an application rate of at least 6,148 kg/ha is needed. This quantity gives 37.5 kg of nitrogen of which 15 kg is available in the first year, leaving 22.5 kg in the soil for subsequent years.

Given that 643 kg of manure can be produced per head using the improved pens, a farmer with about six cattle should be able to produce enough manure to fertilize a hectare.

For detailed results on the other listed technologies developed by FSR/E in this domain the reader should consult the annual report of FSR/E (DRSPR/Volet OHV 1988, 1989, 1990, 1991, 1992, 1993)

Small ruminant productivity improvement

The OHV/zone has a potential for the profitable raising of small ruminants. However the lack of feed sources for the animals and lack of essential nutrients in their diet have made the realization of this potential virtually impossible. FSR/E research work in this area has therefore consisted of vaccination of animals against botulism and other diseases followed by complemetary feeding of phosphorus and calcium. Significant improvements on the number of gestations and births per animal and a reduction in the mortality rates have been achieved.

Draft-animals maintenance nutrition

Livestock feeding in the OHV zone is difficult especially during the dry season and as a result draft animals lose weight and are unable to perform at full capacity at the beginning of the agricultural season when land preparation is done. FSR/E conducted research into different ways of feeding the animals in order to maintain their weight at the end of the rainy season. In addition to weight maintenance, the effect of this conditioning on manure production and on total area cultivated were also investigated. Three treatments were considered: T1 was six oxen fed on natural pasture, cowpea plant residue and livestock feed (HUICOMA) both at the rate of two kg/animal for 45 days. T2 was similar to T1 except that the feeding period was 90 days. T3 represented the control which consisted of feeding only natural pasture. The evaluation of physical conditioning was based on the that proposed by Pullan 1978 and Van Neirkerk, Louw 1980. This measure ranges from one to 10. The results show a significant correlation between the animal weight and the physical conditioning for the N'Dama breed but not for Méré and Zébu.

There was also significant difference between the three treatments in terms of traction capacity and average weight of animal. The animals under the control, 45-day regime, and 90-day regime had weights of 281, 305, and 329 kg respectively; and correponding draft capacities of 27, 30, and 34 kg of force. However, these figures do not answer several questions that might be important for a farmer in decision making. For example does the extra four kg in draft capacity gained merit the extra 45-day feeding? How much draft force is necessary for a given area to be plowed? These questions can better be answered at research stations.

Technologies for providing alternative income sources and infant nutrition improvement

Specific technologies have been developed by FSR/E to alleviate chronic lack of income source for women and to help in infant nutrition improvement. These include local soap making, the making of soumbala, making of farine for child feeding, and fertilization of women's peanuts fields and vegetable gardens.

The manufacturing of two types of local soaps were introduced to the women in the villages to serve as additional sources of income. The first type known as "sodani" is made from the following ingredients: four liters of shea butter oil at 300 CFA per liter, one kilogram of caustic soda at 450 CFA, one kilogram of wheat flour at 250 CFA and two spoonfuls of "amidon" at 50 CFA. This set of ingredients produces 35 pieces of soap which sold for between 100 and 125 CFA a piece in 1991. Each production thus, yields a net revenue of about 2,210 CFA. The other type of soap the "koulikoro" also uses two liters of peanut oil and two packets of soap powder "barikatigui" in addition to the other ingredients already listed. Sixty pieces of soap can be obtained per each production and a piece sold for 75 CFA in 1991 yielding a net revenue of 1,230 CFA.

The opportunity cost of labor for soap manufacturing is negligible since it can be undertaken at the same time as other household and agricultural activities.

"Soumbala" can be produced either from soybeans or from néré (a local shrub), the other main ingredient being potassium. It is usually used in sauces. The unit cost of production is lower for soumbala from soybeans than that from néré due to the higher price per kilogram for néré. The net revenue is over 400 CFA for soumbala from soybeans and only 75 CFA for that from néré. It takes about 3-4 hours per production.

The main problem with this technique is the shortage or absence of soybeans on the market; the principal reason being low yields. Women often have access to only marginal lands which are relatively less fertile. FSR/E tested different varieties of soybeans and also introduced the technique of fertilizing soybean fields in two villages (Tinguélé in the east of the zone and Kominta in the west) to resolve this problem. There was neither significant variety nor fertilization effect. However, the application of 80 kg/ha of cotton complex in Tinguélé yielded a net revenue per hectare of over 205,000 CFA whereas at Kominta the application of 300 kg/ha of PNT followed by 25 kg/ha of urea was more profitable (a net revenue per hectare of over 90,000 CFA).

Peanut production is a major source of income for the women in the OHV zone. Field area measurements carried out by FSR/E (DRSPR/Volet OHV 1988, DRSPR/Volet OHV 1989) showed that peanut covered 72% of the total area cultivated by individual farmers in 1988 and 58% in 1989. Peanuts are produced for both auto-consumption and for sale with the income generated going towards the purchase of clothes, other food items and paying for children's education. Soil fertility is the major constraint confronting production since land allocated to women is usually of lower quality especially in phosphatic nutrients. FSR/E initiated research into the economic fertilization of peanuts to resolve this problem in three villages (Yékébougou in the west, Balanzan in the south and Gouani in the east of the zone). The results are summarized in Table 58.

The results show that the optimum choice of fertilizer depends on several agro-ecologic and economic factors. In areas of good rainfall, as in Balanzan, about 20 to 25% of the nutrients in PNT are available for plant use during the first year (Traoré A, 1990). Within a given agro-ecologic zone, land allocation plays an important role. In Gouani, for example, women have access to land which often had been in fallow for at least three years, thus being sufficiently fertile for crop production. It has been hypothesised that the presence of a cash crop in the cropping system puts women at a disadvantage since men tend to have a monopoly over this crop. However, in Gouani women have access to land that benefitted from the residual effects of earlier mineral fertilizer application. This explains in part why fertilization is relatively less profitable in Gouani than it is in the other two villages. Return to the additional day needed for fertilizer application is actually negative for both Simple Super and PNT (Table 58). Peanut yields at Balanzan were relatively lower for all treatments, despite good rainfall, because of lower sowing density in the farmers' practice. In such a case, less expensive fertilizer such as PNT is more profitable. The return to the additional labor needed is over 2,600 CFA for PNT at Balanzan but only about 450 CFA at Yékébougou where planting density is higher. In Yékébougou, the return per added person day is over 1800 CFA.

Production of vegetables, especially of tomatoes and onions, on small village plots is a potential source of extra income for the women. One of the main constraints to achieving this potential has been disease and insect infestations. Late planting appears to predispose the plants to viral attacks. FSR/E started research work during the 1992-93 season in Balanzan in the south of OHV initially to determine the effect of planting date and treatment on tomato yield, and secondly, to determine the effect of crop rotation and treatment on tomato yield. The treatments in the tomato test consisted of insecticide and fungicide application, application of insecticide only, and a control and two planting dates were tested: planting during the first ten days of December and planting at least one month later.

Results indicated that the absence of any treatment resulted in significantly lower tomato yields regardless of the planting date. In addition, early planting produced yields significantly higher than those from later planting. Economic analysis is presented in Table 59.

TABLE 58. ECONOMIC ANALYSIS OF FERTILIZATION OF WOMEN'S PEANUT FIELDS IN THE OHV ZONE (1989-90)

Item	Fertilization[1]		
	T1	T2	T3
Yékébougou			
Total yield (kg/ha)	540	720	620
Adjusted yield[2]	486	648	558
Value of production[3]	47,142	62,856	54,126
Total costs	0	4,362	4,240
Net benefit (NB)[4]	47,142	58,494	49,886
Increase in NB	—	11,352	2,744
Marginal rate of return (MRR)	—	260.2%	64.7%
Return/person day of additional labor[5]	1,892	457	
Pct. of farmers losing money	0	0	
Balanzan			
Total yield (kg/ha)	221	391	452
Adjusted yield	199	352	407
Value of production	19,303	34,144	39,479
Total cost	0	4,362	4,240
Net benefits (NB)	19,303	29,782	35,239
Increase in NB	—	10,479	15,936
MRR	240.2%	375.8%	
Return/person day of additional labor	1,747	2,656	
Pct. of farmers losing money	0	0	
Gouani			
Total yield	858	813	773
Adjusted yield	772	732	696
Value of production	74,884	71,004	67,512
Total costs	0	4,362	4,240
Net benefits (NB)	74,884	66,642	63,272
Increase in NB	—	-8,242	-11,612
Return/person day of additional labor	—	-1,373	-1,935
Pct. of farmers losing money	0	0	

[1] T1 represents the farmer practice without fertilization, T2 represents the application of 65 kg/ha of Simple Super and T3 represents the application of 300 kg/ha of PNT for a 3-yr period.
[2] Yield is adjusted by a decrease of 10 % to reflect harvest and other forms of losses.
[3] Yield multiplied by the average peanut price which was 97 CFA/kg in 1990.
[4] Yield multiplied by the average grain price less fertilizer costs in CFA (SS was 67.1 CFA/kg and PNT was 42.4 CFA/kg in 1990).
[5] Net benefits divided by the number of additional person days necessary for fertilizer application which is estimated at 6 person days. Thus, the application of Simple Super and PNT each uses 6 person days.

TABLE 59. ECONOMIC ANALYSIS OF TREATMENT AND DATE OF PLANTING ON TOMATO YIELD IN BALANZAN (1992-93)

Item	Treatment[1]			
	T1	T2	T3	T4
Total yield in kg/ha	9,533	10,866	1,267	2,200
Adjusted yield$_2$	7,626.4	8,692.8	1,013.6	1,760
Value of production in CFA	739,760	843,201	98,319	170,720
Total costs in CFA	0	12,095	0	12,095
Net benefits$_3$	739,760	831,106	98,319	158,625
Increase in net benefits	—	91,346	—	60,306
Marginal rate of return	—	60.5%	50%	
Standard deviation	105,134	144,946	70,365	92,688
Variability index	14.21	17.44	113.35	185.43
Minimum net benefit	558,720	639,745	31,040	49,985
Pct. of farmers losing money	0	0	0	0

$_1$T1 represents early planting without chemical treatment; T2 represents early planting with chemical treatment; T3 represents late planting without chemical treatment; and T4 represents late planting with chemical treatment; (chemical treatment consisted of 1.5 liters per hectare of insecticide Decis and one kilogram per hectare of fungicide Maneb.

$_2$Yield is adjusted by a decrease of 20% to reflect harvest and other forms of losses.

$_3$Yield multiplied by the average tomato price less insecticide and fungicide costs in CFA (tomato was 97 CFA/kg in 1992 and a liter of Decis and a kilogram of Maneb 9975 and 2120 CFA respectively).

Economically, early planting is more profitable than late planting with or without chemical treatment and the net benefits have lower indices of variability. Without chemical treatment, early planting adds over 640,000 CFA to the net revenue per hectare and over 670,000 CFA when chemical treatment is applied. The marginal rates of return when chemical treatment is applied are 60 and 50% for early and late planting, respectively. Both of these rates are below the minimum acceptable rate of 100%, making them less desirable. Thus it appears that early planting without chemical treatment might be the technology of choice for most farmers in the OHV zone.

Results on the test for the effect of crop rotation and treatment on onion yield are presented in Tables 60 and 61. In the presence of crop rotation, the application of both insecticide and fungicide produce significanly higher yield than either the application of insecticide only or the the control (Table 60). The marginal rate of return is over 1,400% with an average net benefit per hectare of over 630,000 CFA. The application of insecticide only is also more profitable than the control but a move from T3 to T2 yields a marginal rate of return of about 65.8%.

For fields without crop rotation, again the absence of insecticide and/or fungicide results in reduced yields (Table 61) but there is very little yield difference between the two chemical treatments (T2 and T3) indicating that perhaps when crops are not rotated damage from insect attacks supercede those from fungus build-up.

TABLE 60. ECONOMIC ANALYSIS OF TREATMENT AND CROP ROTATION ON TOMATO YIELD IN BALANZAN IN 1992-93 (FIELD WITH ROTATION)

Item	Treatment[1]		
	T1	T2	T3
Total yield in kg/ha	5,725	6,300	8,125
Adjusted yield$_2$	4,580	5,040	6,500
Value of production in CFA	444,260	488,880	630,500
Total costs in CFA	0	9,975	12,095
Net benefits$_3$	444,260	478,905	630,500
Increase in net benefits	—	34,645	174,145
Marginal rate of return	—	347%	1440%
Standard deviation	73,716	152,507	134,012
Variability index	15.73	32.58	23.07
Minimum net benefit	372,480	300,425	422,465
Pct. of farmers losing money	0	0	0

$_1$T1 represents control (no insecticide or fungicide); T2 represents treatment with insecticide only; T3 represents treatment with both insecticide and fungicide; (insecticide consisted of 1.5 liters per hectare of Decis and fungicide consisted of one kilogram per hectare of fungicide Maneb.

$_2$Yield is adjusted by a decrease of 20% to reflect harvest and other forms of losses.

$_3$Yield multiplied by the average tomato price, less insecticide and fungicide costs in CFA (tomato was 97 CFA/kg in 1992 and a liter of Decis and a kilogram of Maneb 9975 and 2120 CFA respectively).

TABLE 61. ECONOMIC ANALYSIS OF PHYTOSANITARY TREATMENT AND CROP ROTATION ON TOMATO YIELD IN BALANZAN IN 1992-93 (FIELD WITHOUT ROTATION)

Item	Treatment[1]		
	T1	T2	T3
Total yield in kg/ha	6,700	7,925	7,350
Adjusted yield$_2$	5,360	6,340	5,880
Value of production in CFA	519,920	614,980	570,360
Total costs in CFA	0	9,975	12,095
Net benefits$_3$	519,920	605,005	558,265
Increase in net benefits	—	85,085	38,345
Marginal rate of return	—	852.9%	317%
Standard deviation	153,828	167,616	105,718
Variability index	27.84	26.50	19.34
Minimum net benefit	372,480	409,065	391,425
Pct. of farmers losing money	0	0	0

$_1$T1 represents control (no insecticide or fungicide); T2 represents treatment with insecticide only; T3 represents treatment with both insecticide and fungicide; (insecticide consisted of 1.5 liters per hectare of Decis and fungicide consisted of one kilogram per hectare of the fungicide Maneb.

$_2$Yield is adjusted by a decrease of 20% to reflect harvest and other forms of losses.

$_3$Yield multiplied by the average tomato price less insecticide and fungicide costs in CFA (tomato was 97 CFA/kg in 1992 and a liter of Decis and a kilogram of Maneb 9,975 and 2,120 CFA respectively).

In fact application of only insecticide produces a much higher marginal rate of return (852.9%) than that for both applications (317%). The net revenue per hectare is also higher for T2 than for T3, albeit a slightly higher index of variability.

Poultry production plays an important role in the attainment of food self-sufficiency in terms of serving as a protein source and also income source through sales of birds. Over 80% of the poultry meat in the zone is provided by small rural production systems which are largely traditional and rudimentary. FSR/E therefore initiated research into these systems with the aim of improving bird productivity. The use of supplementary feed was the main option given the availability of the nutrients: maize and bonemeal. The results are summarized in the Table 62.

In terms of weight gain, a ration of bonemeal and maize is only slightly more profitable than feeding maize alone, adding 39 CFA per bird for each month of feeding versus 38.6 CFA for the latter. However, there is actually a net loss of revenue from egg-laying for the combination while maize alone yields 13.6 CFA per birds per month. Combining the effects on the two parameters, the feeding of maize alone is more profitable than feeding it in combination with bonemeal. The added net revenue per bird for each month was 52.2 and 23 CFA respectively. These unexpected results are attributable to the less than significant difference in weight performance and egg-laying capacity between the two rations.

Table 62. Economic Analysis of Supplementary Feeding of Chickens (Average Monthly Effect)

Item	Treatment[1]		
	Control	Maize and bonemeal	Maize only
Effect on bird weight			
Cost/bird[2]	0	16	6.4
Weight/bird	1.14	1.25	1.23
Revenue/bird[3]	570	625	615
Net revenue/bird	570	609	608.6
Added net revenue/bird	—	39	38.6
Effect on egg-laying			
Cost/bird	0	16	6.4
Eggs/bird	2	2	3
Revenue/bird[4]	40	40	60
Net revenue/bird	40	24	53.6
Added net revenue/bird	—	-16	13.6
Total effect of feeding			
Added net revenue/bird	—	23	52.2

[1] The treaments consisted of a control (no feed supplement), a combination of maize and bonemeal and maize only.
[2] A kilogram of bonemeal was 200 CFA and that of maize was 53 CFA in 1991-92. Preparation of bonemeal/maize mixture (one kilogram of bonemeal plus one kilogram of maize) at the mill was 10 CFA per kilogram. Each bird was fed 120 gm or 0.12 kg of the feed.
[3] A kilogram weight of a bird sold for an average of 500 CFA in the villages in 1991.
[4] Unit price of eggs in the village in 1991 was 20 CFA.

TECHNICAL AND ECONOMIC EVALUATION OF PROPOSED TECHNOLOGIES

Tables 63 and 64 give a summary of the technical and economic feasibility of each of the technologies or cultural practices being proposed by FSR/E. In addition observations or comments are made on the principal constraints to their adoption.

The sequence given in Tables 63 and 64 hypothesizes that the adoption of technologies will begin with those that alleviate the problems of soil fertility and soil and water conservation. However, the feasibility of adoption of these technologies will require the presence of labor-saving technologies such as animal traction. Improvement in the agronomic environment will then permit the use of improved crop varieties in the intermediate-run and crop intensification as a whole in the long-run. The resulting increase in biomass production will then facilitate the use of mulch and compost and green manure in the long run. The resulting higher natural vegetative production would also increase animal feed source and, therefore, higher animal productivity as a by-product of which manure availability and traction power could improve.

Production constraints, household resource endowment and the decision-making process are very heterogenous, implying the need for differentiating between farmers in terms of their technological needs and the modes of adoption. Thus there is need to develop recommendation domains to orient research, extension and government policy. This section of the report hence deals with the development of recommendation domains based on their production constraints and farmer characteristics and resource levels. In addition the modalities of technology adoption are presented.

Data obtained from a rapid reconnaissance survey carried out in 1987 were used for this classification (Valencia 1987). Results of the survey indicated that land was not a production constraint except for the areas around the Mandingo mountains and the immediate proximities of the urban centers. However, rainfall levels and distribution and soil fertility vary strongly across the OHV zone. The northern section of the zone recieves very little rainfall and the soils are poor in fertility. The southern portion, on the other hand, has above average annual precipitation with rich soils. Four recommendation domains were delineated based on these agro-climatic factors:

i. the south with good annual rainfall and fertile soils.

ii. the east with average rainfall and soil quality.

iii. the west also with average rainfall but rocky soils.

iv. the north, which represents the Sahelian portion of the zone, with low rainfall and poor sandy-clay soils.

The risk aversion nature of farmers has been very well documented (Binswanger, 1980; Dillon and Scandizzo, 1978). The amount of risk a farmer is willing to take depends, among other factors, on the level of resource endowment and a measure of wealth which is incorporated in livestock possession in the Sahel region. The adoption of a new technology is always accompanied by a certain amount of risk in terms of inability to recover the cost involved in the adoption; for example, due to crop failure or excessive livestock mortality. Another hypothesis is that agricultural productivity depends largely on the use of the appropriate agricultural tools and equipment.

Table 63. Technical and Economic Feasibility of Agronomic Technologies or Cultural Practices Proposed for OHV Zone

Technology	Feasibility			Comments
	Technical		Economic	
	Station	Farmer		
Technologies for the short-term				
Dikes/diguettes	na	+++	***	material
Tied ridges	na	+	*	labor
Chemical fertilizer	+++	+++	**	cost and risk
PNT	++	+++	***	texture, solub.
Organic manure	+++	++	**	material, transport
Improved fallow	na	++	**	duration
Animal traction	na	++	**	cost
Pesticides	+++	+	**	risk
Rock bunds	na	+++	***	materials
Small dams	na	+++	***	materials
Haie vive	na	+++	***	environ.
Technologies for the medium term				
Improved varieties	++	+	-	environ.
Crop association intensification	++	+	-	environ. labor
Technologies for the long-term				
Compost	+++	++	**	material
Mulch	+++	++	**	material
Green manure	++	++	-	animal traction
Herbicides	++	++	-	more research needed

Table 64. Technical and Economic Feasibility of Animal Production, Livestock-Crop Integration and Woman and Child Welfare Improving Technologies or Cultural Practices Proposed for OHV Zone

Technology	Feasibility			Problems
	Technical		Economic	
	Station	Farmer		
Improved pens	na	+++	*	cost
Improved beehives	na	+++	***	number per unit area
Small ruminant production	na	+++	***	minimum
Livestock fattening	na	+++	***	minimum
Soap making	na	+++	**	minimum
Soumbala[1]	na	+++	***	minimum
Cowpea meal[2]	na	+++	***	minimum
Fertilization of vegetable gardens	+++	+++	**	cost and risk
Fertilization of peanut fileds	+++	+++	**	land tenure

1This is an ingredient made from either soybeans or from Néré (a tree that grows in the wild and often on farmers' fields)
2This is used as protein supplement in infant nutrition. It can also be made from soybeans.

Based on the above two hypotheses, households from five representative villages in the project area were surveyed in 1990 and were grouped in terms of their possession of livestock and possession and utilization of agricultural implements. Thus this grouping assumed that a farmer's ability to use certain technologies would depend on the ability to take risk and also to execute certain agricultural activities which often require equipment.

Three groups of farmers were delineated using the method of "cluster analysis" (Table 65). These were:

Group 1: This group consists of farmers that have a high risk-bearing ability and are very well equiped to perform animal traction and other agricultural activities on time. This group constituted 8% of the farmers surveyed.

Group 2: Farmers of this second group have an average risk bearing ability and their equipment possession is less than those of Group 1. It contained 20.5% of the farmers.

Group 3: This group contains over 70% of the farmers and they have little or no means of bearing risk in terms of crop failures and are poorly equipped to perform animal traction and other activities such as weeding in a timely fashion.

In 1991, another study was conducted to refine and provide more descripitve information about the three groups of farmers. The family structure and ownership of land were analyzed. The results showed that households in Group 1 were relatively larger than the other two groups, 37 persons as against 32 for Group 2 and less than 20 for Group 3. This could affect the availability of family labor hence the area to be cultivated. In terms of land availability, again, households in Group 1 had more land (40 hectares per household) than those in Group 3 (24 hectares).

The distribution of the three groups across the four agroclimatc zones form the basis of the recommendation domains. The hypothesis for the sequential adoption of technologies are

Table 65. Socio-Economic Discriminant Factors for the Farmers of OHV (1990)

Group	Discriminant factors							
	Livestock		Draft animals		Plows		Other equipment	
	Avg.	Standard	Avg.	Standard	Avg.	Standard	Avg.	Standard
1	44.3	12.5	8.3	2.0	3.1	1.3	3.7	2.0
2	11.3	7.7	5.2	2.2	1.8	0.9	1.9	.5
3	2.8	3.4	1.4	1.4	0.6	0.6	0.3	0.6

then formulated as summarized in Tables 66-68. Twelve recommendation domains are presented in Tables 66-68 based upon the household characteristics and agro-climatic factors described earlier. Each table gives the potential sequential adoption patterns of the available technologies for a recommendation domain across the four agro-climatic zones. The sequential patterns of the technologies for each recommendation domain are based on the previous discussion of farmers' adoption strategies where technologies are adopted singly or in clusters in a logical agronomic and economic sequence.

Table 66. Sequential Adoption of Technologies Across Agro-Climatic Zones of OHV by Farmers in Group I

Northern part of OHV	Southern part of OHV	Eastern part of OHV	Western part of OHV
Dikes/diguettes/ rock bunds	Chemical fertilizers	PNT	Dikes/diguettes/ rock bunds
Tied ridges/animal traction	PNT	Chemical fertilizers	Tied ridges/Animal traction
PNT	Dikes/diguettes/ rock bunds	Dikes/diguettes/rock bunds	Chemical fertilizers rock bunds
Chemical fertilizers	Animal traction	Animal traction	PNT
Improved corrals	Improved corrals	Improved corrals	Improved corrals
Organic manure	Organic manure	Organic manure	Organic manure
Improved crop varieties	Improved crop varieties	Improved crop varieties	Improved crop varieties
Crop intensification	Crop intensification	Crop intensification	Crop intensification
Compost/mulch/ green manure	Compost/mulch/ green manure	Compost/mulch/ green manure	Compost/mulch/ green manure

Group 1, Northern part of OHV:

The use of soil water conservation techniques and animal traction was the best option in the initial stages of the adoption process. However, due to the famers lesser risk aversion and ability to buy purchased inputs, the adoption of local rock phosphate is the logical next step. With increased production, due to available soil moisture and fertility, the adoption of chemicals will be contemplated. Livestock acquisition and investment in improved corrals follows making organic manure available .

Group 1, Southern part of OHV:

These are animal traction farmers exhibiting a lower risk aversion and greater ability to buy purchased inputs. Chemical fertilizers and local rock phosphates will be suitable options for such farmers. Soil and water conservation techniques and animal traction will be options to recover land in the outlying low rainfall areas since land availability is not a constraint.

The increased biomass production will encourage the adoption of improved corral systems since site-feeding will then become feasible. This will lead to the availability of better quality organic manure from the pens.

Group 1, Eastern part of OHV:

The adoption sequence is similar to that in the south except that the cheaper and less risky local rock phosphate will be a better option during the initial stages than chemical fertilizers. This is because the rainfall level in this region is lower than that in the south, hence fertilizer use is a little more risky. The availability of organic manure for village fields due to improved corrals is more beneficial here since other fields are too distant for manure to be applied.

Group 1, Western part of OHV:

Once again, as was the case in the northern part, soil water conservation techniques and animal traction will be the best option to recover degraded lands and improve soil moisture. Rainfall levels are slightly higher here than in the north, permitting the adoption of both local rock phosphates and chemical fertilizers. Cattle corralling and the resulting organic manure will improve soil fertility even further.

Group 2, Northern part of OHV:

The adoption sequence will be similar to that for Group 1, northern region with a reduced capacity to take risks and buy inputs.

Group 2, Southern part of OHV:

This group is similar to Group 1 in the south, but with reduced risk capacity and financial resources.

Group 2, Eastern part of OHV:

Similar to Group 1 in the east. They are relatively less likely to take risk, hence will adopt PNT more readily than the more expensive chemical fertilizers.

Group 2, Western part of OHV:

Similar to Group 1 in the east with reduced capacity for risk.

Group 3, Northern part of OHV:

Given the limited ability to buy purchased inputs and high risk aversion, the initial stages of technological adoption by farmers will be dominated by soil/water conservation techniques such as dikes/diguettes and rock bunds. The use of tied ridges would become more attractive once animal traction has been fully developed. However, the sandy nature of the soil makes the full adoption of tied ridges a little uncertain.

The next sequence of adoption would involve a cash outlay. Fertilizer is an option, beginning with the local rock phosphate (PNT) which is relatively less expensive. Chemical fertilizers would be an option once soil and water conservation techniques have improved soil structure, leading to better yields and increased income. The southern parts of the region with higher rainfall would be more appropriate.

The last step in the sequence would be the investment in new crop varieties and intensification of crop associations.

GROUP 3, SOUTHERN PART OF OHV:

Farmers in this group could practice animal traction earlier in the sequence than their counterparts in the northern section due to relative availability of biomass and water sources for the animals.

The second and last stages of the adoption sequence are similar to those in the north.

GROUP 3, EASTERN PART OF OHV:

The adoption sequence for farmers in this group would be similar to those in the south.

GROUP 3, WESTERN PART OF OHV:

The adoption sequence similar to that for the north except that tied ridges can be more efficiently constructed here than in the north.

INTERMEDIATE IMPACT INDICATORS OF TECHNOLOGIES PROPOSED BY FSR/E

In a study begun in 1991-92, the use of new technologies by close to 300 households in five villages in the OHV were monitored.

Over 50 different technologies have so far been identified ranging from soil fertility improving ones to those for crop-livestock integration and technologies designed specifically for the welfare of women and children. FSR/E was identified by a number of households surveyed as the main source of knowledge for over 62% of the technologies they use. This section of the report highlights the impact of some of the most promising technologies.

SOIL FERTILITY IMPROVEMENT TECHNOLOGIES

Contrary to popular belief, chemical fertilizers are used by farmers in the OHV zone on cereals. During the 1991-92 agricultural season, a total of over 40,000 hectares or about 30% of total area allocated to cereal production received some form of chemical fertilizer. The principal fertilizers being ammonium phosphate used by 23% of the farmers, cotton complex used by over 30% and urea used by about 38% of the farmers surveyed.

Impact indicators for ammonium phosphate are shown in Table 69. Principal crops are cereals (sorghum, maize, rice and millet). In the 1991-92 agricultural season, 36,604 hectares or 28% of the total crop area received ammonium phosphate. Farmers who applied this technology produced an average cereal yield of 1,500 kg/ha as against 800 kg/ha for farmers who did not. The average rate of application was about 87 kg/ha which is slightly below the recommended rate for cereals of 100 kg/ha. Farmers using this technology produced 130,000 metric tons of cereals, an increase of 25,600 metric tons (25%) attributable to ammonium phosphate.

TABLE 67. SEQUENTIAL ADOPTION OF TECHNOLOGIES ACROSS AGRO-CLIMATIC ZONES OF OHV BY FARMERS IN GROUP 2

Northern part of OHV	Southern part of OHV	Eastern part of OHV	Western part of OHV
Dikes/diguettes/rock bunds	PNT	PNT	Dikes/diguettes/rock bunds
Tied ridges/animal traction	Chemical fertilizers	Chemical fertilizers	Tied ridges
PNT	Dikes/diguettes/	Dikes/diguettes/	PNT
	rock bunds	rock bunds	
Chemical fertilizers	Animal traction	Improved corrals	Chemical fertilizers
Improved corrals	Improved corrals	Organic manure	Improved corrals
Organic manure	Organic manure	Improved crop varieties	Organic manure
Improved crop varieties	Improved crop varieties	Crop intensification	Improved crop varieties
Crop intensification	Crop intensification	Compost/mulch/	Crop intensification
		green manure	
Compost/mulch/	Compost/mulch/	Herbicides	Compost/mulch/
green manure	green manure		green manure
Herbicides	Herbicides		Herbicides

TABLE 68. SEQUENTIAL ADOPTION OF TECHNOLOGIES ACROSS AGRO-CLIMATIC ZONES OF OHV BY FARMERS IN GROUP 3[1]

Northern part of OHV	Southern part of OHV	Eastern part of OHV	Western part of OHV
Dikes/diguettes/rock bunds	Animal traction	Animal traction	Dikes/diguettes/rock bunds
Animal traction	Dikes/diguettes/	Dikes/diguettes/	Animal traction
rock bunds		rock bunds	
Tied ridges	Tied ridges	PNT	Tied ridges
PNT	PNT	Chemical fertilizers	PNT
Chemical fertilizers	Chemical fertilizers	Chemical fertilizers	PNT
Improved crop varieties	Improved crop varieties	Crop intensification	Improved crop varieties
Crop intensification	Crop intensification	Compost/mulch/	Crop intensification
		green manure	
Compost/mulch/	Compost/mulch/	Herbicides	Compost/mulch/
green manure	green manure		green manure
Herbicides	Herbicides		Herbicides

[1]The full adoption of animal traction in this group would require some form of credit and training programs by the extension agencies.

Table 69. Impact Indicators for Ammonium Phosphate Adoption (Current Situation)

Ammonium phosphate: Current situation	
Main cereal crops affected	sorghum, millet, maize rice
Total crop area cultivated	130,730 hectares
Total crop area Fertilized	36,604 hectares
Total production	130,000 metric tons
Change in production	25,600 metric tons
Yield	1,500 kg/ha
Change in yield	700 kg/ha
Pct. of farmers adopting technology	23% or 9,479 households
Pct. of users quoting FSR/E as source	8% or 21 households
Pct. annual adoption rate	1%
Net revenue per hectare	38,000 CFA
Generated income for all users	1,390,952,000 CFA
Constraints to adoption: cost, risk, and limited availability	

Ammonium phosphate is currently used by an estimated 9,479 households (23% of the households) and thus benefits 274,891 persons. About 8% of the users in villages where FSR/E has had contact cited FSR/E as the main source of this technology during the 1991-92 agricultural season. This represented 21 households or 615 persons.

The increased production contributes to about 44% of the annual cereal needs of the users. The users are self-sufficient in cereal production.

The net revenue increase per hectare ranges from about 38,000 CFA or $138.28 for sorghum to over 87,000 CFA or $316.36 for rice producers based on average of 80 CFA or 29 cents per kilogram of sorghum and 150 CFA or 55 cents per kilogram for rice. This corresponds to an overall increase in returns to family labor, the main production input, of over $5.05 million for all users in 1991-92. The above revenue situation is subject to prevailing economic conditions. Should the increased production lead to uncontrolled price fall, the net revenue increase will fall accordingly even if fertilizer price holds steady. At a price of 25 CFA/kg for sorghum, the farmer will barely break even, reducing returns to family labor to zero. Thus government policies which will increase demand for the output either through export or processing and storage would be necessary to forestall such a situation and maintain farmer confidence in the technology.

Prospective impact in five years for ammonium phosphate adoption is shown in Table 70. In five years 11,539 households (28% of total) are expected to be applying this technology to over 43,000 hectares, thus benefiting directly about 334,631 persons. The total cereal production is expected to be around 134,800 metric tons without further expansion of the total area planted, an increase of about 3.7% over current production.

The increase in the value of total production for all farmers using ammonium phosphate is expected to reach

Table 70. Impact Indicators for Ammonium Phosphate Adoption (Prospective Impact in Five Years)

Ammonium phosphate: Estimated impact in five years	
Main cereal crops affected	sorghum, millet, maize rice
Total crop area cultivated	130,730 hectares
Total crop area Fertilized	43,141 hectares
Total production	134,800 metric tons
Change in production	30,200 metric tons
Yield	1,500 kg/ha
Change in yield	700 kg/ha
Pct. of farmers adopting technology	28% or 11,539 households
Pct. of users quoting FSR/E as source	——
Pct.annual adoption rate	1%
Net revenue per hectare	38,000 CFA
Generated income for all users	1,639,358,000 CFA

Table 71. Impact Indicators for Organic Manure Adoption (Current Situation)

Organic manure: Current situation	
Main cereal crops affected	sorghum, maize, millet
Total crop area cultivated	130,730 hectares
Total crop area Fertilized	24,839 hectares
Total production	109,600 metric tons
Change in production	5,000 metric tons
Yield	1,000 kg/ha
Change in yield	800 kg/ha
Pct. of farmers adopting technology	50% or 20,606 households
Pct.of users quoting FSR/E as source	3% or 618 households
Pct. annual adoption rate	2%
Net revenue per hectare	16,000 CFA
Generated income for all users	397,424,000 CFA
Constraints to adoption: availability and transportation	
Animal manure is currently used by 50% of the households (estimated to be 20,060 households zone-wide) and thus benefits 581,740 persons.	

Table 72. Impact Indicators for Organic Manure Adoption (Prospective Impact in Five Years)

Organic manure: Estimated impact in five years	
Main cereal crops affected	sorghum, maize, millet
Total crop area cultivated	130,730 hectares
Total crop area Fertilized	37,912 hectares
Total production	112,200 metric tons
Change in production	7,300 metric tons
Yield	1,000 kg/ha
Change in yield	800 kg/ha
Pct. of farmers adopting technology	60% or 24,727 households
Pct. of farmers quoting FSR/E as source	——
Pct. annual adoption rate	2%
Net revenue per hectare	16,000 CFA
Generated income for all users	606,592,000 CFA

$6.0 million assuming stable prices for inputs and outputs and adequate rainfall.

Another soil fertility improving technology in use is the various forms of organic manure of animal and plant sources (Table 71).

Principal crops are again cereals (sorghum, maize, and millet). In the 1991-92 agricultural season, 24,839 hectares or 19% of the total crop area received animal manure at an average rate of 2,188 kg/ha. Farmers who applied manure obtained an average yield of 1,000 kg/ha as against 800 kg/ha for non-fertilized fields. Farmers using this technology produced 109,000 metric tons of cereals, an increase of 5,000 metric tons (4.5%) attributable to animal manure application.

Animal manure is currently used by 50% of the households (estimated to be 20,060 households zone-wide) and thus benefits 581,740 persons.

The net revenue increase per hectare is about 16,000 CFA or $58.18 for sorghum and millet. This corresponds to an overall increase in returns to labor of over $1.55 million net for all users in 1991-92.

In five years about 24,727 households (60% of total) are expected to be applying animal manure to about 37,912 hectares thus benefiting directly about 717,083 persons (Table 72). This number of users is determined in part by the number of potential owners of livestock. A minimum of six cattle in improved corrals is needed to produce sufficient manure to fertilize a hectare of cereals.

The total cereal production is expected to be around 112,200 metric tons without further expansion of the total area planted, an increase of about 7,300 metric tons (6.5%) directly attributable to this technology. The increase in the value of total production for all farmers using organic manure is expected to reach $2.2 million net assuming stable prices.

The available natural resource management techniques include tied ridges, animal traction, rock bunds, dikes/digues, haie vive, and the use of mulch (Table 73). An average of 19% of the households (7830 households) use either tied ridges, rock bunds, dikes/digues, haie vive, or mulch, and 11% of the users surveyed cited FSR/E as their source for knowledge about this technology. Yields of close to 2,000 kg/ha for sorghum and 1,000 kg/ha for millet have been observed with the use of tied ridges. Monitoring of these technologies in the OHV zone is continuing and results will be available in the near future.

Close to 80% (32,970) of the households practice plowing with draft animals. During the 1991-92 agricultural season, close to 60% of the total area cultivated was plowed using animal traction (Table 74).

Table 73. Current Use of Natural Resource Management Technologies by Farmers in OHV (1991-92)

Technology	Current use		Annual rate of adoption
	Number of farmers	Percentage of farmers	Pct.
Tied ridges	22	8	<1.0
Animal traction	209	79	2.3
Rock bands	12	05	<1.0
Dikes/digues	4	02	<1.0
Haie vive	75	28	1.5
Mulch	26	10	1.0

Table 74. Area Plowed with Animal Traction in Some OHV Villages in 1991-92

Village	Total area cultivated		Women's fields	
	Hectare	Plowed	Hectare	Plowed
		Pct.		Pct.
Balanzan	345	82	87	25
Landé	270	73	13	5
Mountougoula	122	55	11	9
Kominta	195	49	9	5
Dorébougou	740	40	49	7
Average	334	60	34	10

Despite this high percentage of land area plowed, only about 35% of the households have a full set of plowing equipment and draft animals (Volet OHV 1991a). This might account for the low percentage of women field areas plowed since community farms tend to have preference over individual fields. Policy is needed to permit the acquisition of animal traction equipment. It is also hoped that the increased revenue from the adoption of other yield increasing technologies will help farmers acquire the needed equipment and draft animals. This technology has been available in Mali for decades. The main constraint to its adoption is the high initial cost of investment.

In five years the use of tied ridges, rock bunds, and tree planting is expected to increase dramatically due to renewed efforts on the part of researchers and developers. A community approach rather than an individual farm approach has been adopted to the extent that now whole degraded areas are being recovered instead of individual fields. This will speed up the impact of this technology on agricultural production. An accompanying social problem is the determination of when to put reclaimed land into use when more than one household is involved. However, this is not insurmountable with adequate community discussions before, during, and after the tests are installed.

Specific technology for Women and Children

FSR/E has developed specific technologies to respond to the needs of women and children through the provision of additional income sources and/or serving as supplementary sources of child nutrition.

The main fertility sources for women's peanut fields are simple superphosphate, organic manure and PNT(Table75). Users obtained an average of 1,000 kg/ha of peanuts as against about 800 kg/ha for non-users. In 1991-92, out of a total of 15,256 hectares planted to peanuts, 915 hectares, or 6% of the total area, received one of the above sources of fertilization. Users produced close to 12,386 metric tons with about 183 metric tons due to fertilization.

About 2% of the households (824 households) fertilize their peanut fields. This technology benefits about 23,900 individuals.

Peanuts are produced mainly for the market with the derived income going towards meeting food and other needs of the family.

The average increase in net revenue per hectare is about 24,582 CFA or $89.39 with an estimated zone-wide increase in additional income of 22,493,140 CFA or $81,793. However, if PNT is used, this benefit is available for a period of three years without incurring additional fertilization cost (i.e an average net revenue of $89.39 can be obtained for each of the three years since the fertility elements of PNT are available to the plant for three years).

Prospective impact in five years is shown in Table 76. The principal constraints to the continued adoption of this technology has to do with the fertilization with PNT. Since the benefits of this fertilizer accrue over a three-year period, the farmer needs to have acess to the same piece of land for a minimum of three years. However, this is not often the case since the male household heads take the fertilized field from the female operators in order to benefit cereal production. Under this condition, the increase in net revenue per hectare is only 18,970 CFA or $68.98 for each of the three years. Discussions between the heads of houshold and developers will help alleviate this bottleneck.

Given a resolution of the above cited problem an estimated 6,594 production units (16% of the households) will be expected to be applying the technology to about 2,441 hectares (an increase of 156% or 1,426 ha from the present area of applicaation) in five years with an overall increase in generated income of 60,004,662 CFA or $218,198.

Market gardens have become a major source of income for women in villages close to urban centers (Table 77). One such village is Kominta in the western part of the OHV zone, about 60 kilometers from Bamako. Cotton Complex and organic manure are the main sources of fertility in these gardens. The principal crops include potatoes, sweet potatoes, tomatoes, onions, and cucumbers.

Table 75. Impact Indicators for the Fertilization of Women's Peanut Fields with SS, PNT or Organic Manure (Current Situation)

Fertilization of women's peanut fields: Current situation	
Main crop affected	peanuts
Total crop area cultivated	15,256 hectares
Total crop area Fertilized	915 hectares
Total production	12,388 metric tons
Change in production	183 metric tons
Yield	1,000 kg/ha
Change in yield	800 kg/ha
Pct. of farmers adopting technology	2% or 824 households
Pct. of farmers quoting FSR/E as source	3% or 25 households
Pct. annual adoption rate	<1 %
Net revenue per hectare	24,582 CFA
Generated income for all users	22,492,530 CFA
Constraints to adoption: cost, risk, gender, transportation	

Table 76. Impact Indicators for the Fertilization of Women's Peanut Fields with SS, PNT or Organic Manure (Prospective Impact in Five Years)

Fertilization of women's peanut fields: Estimated impact in five years	
Main cereal crops affected	peanuts
Total crop area cultivated	15,256 hectares
Total crop area fertilized	2,441 hectares
Total production	12,700 metric tons
Change in production	500 metric tons
Yield	1,000 kg/ha
Change in yield	800 kg/ha
Pct. of farmers adopting technology	16% or 6,594 households
Pct. of farmers quoting FSR/E as source	——
Pct. annual adoption rate	2%
Net revenue per hectare	24,582 CFA
Generated income for all users	60,004,662 CFA

Users of Cotton Complex are able to obtain about 17.5 tons per hectare as against 8 tons per hectare of onions barring disease and insect infestation. FSR/E has begun on-farm trials with insecticides and fungicides on women's fields to control such infestations. However, preliminary results indicate lack of significant effect of these treatments on onion and potato yields.

In 1991-92, close to 94% of the households sampled applied either cotton complex or animal manure to an area of about 9.3 hectares (36% of total area cultivated).

Over 435 or 30.6% of the population benefited directly from this technology and the garden produce is mostly destined for urban markets.

TABLE 77. IMPACT INDICATORS FOR THE FERTILIZATION OF WOMEN'S MARKET GARDENS WITH COTTON COMPLEX OR ORGANIC MANURE (CURRENT SITUATION)

Fertilization of women's market gardens: Current situation	
Main crops affected	onions, potatoes
Total crop area cultivated	25.7 hectares
Total crop area fertilized	onions: 4.6 hectares, potatoes: 4.6 hectares
Total production	onions: 148 metric tons, potatoes: 343 metric tons
Change in production	onions: 44 metric tons, potatoes: 33 metric tons
Yield	onions: 17.5 tons/ha, potatoes: 31.0 tons/ha
Change in yield	onions: 9.5 tons/ha, potatoes: 7.0 tons/ha
Pct. of farmers adopting technology	94% or 45 households
Pct. of farmers quoting FSR/E as source	——
Pct. annual adoption rate	2 %
Net revenue per hectare	onions: 628,000 CFA potatoes: 542,000 CFA
Generated income for all users	5,382,000 CFA
Constraints to adoption: market, storage, cost, and risk	

TABLE 78. IMPACT INDICATORS FOR THE FERTILIZATION OF WOMEN'S MARKET GARDENS WITH COTTON COMPLEX OR ORGANIC MANURE (PROSPECTIVE IMPACT IN FIVE YEARS)

Fertilization of women's market gardens: Estimated impact in five years	
Main crops affected	onions, potatoes
Total crop area cultivated	25.7 hectares
Total crop area fertilized	25.7 hectares
Total production	onions: 226 metric tons, potatoes: 400 metric tons
Change in production	onions: 123 metric tons, potatoes: 90 metric tons
Yield	onions: 17.5 tons/ha, potatoes: 31.0 tons/ha
Change in yield	onions: 9.5 tons/ha, potatoes: 7.0 tons/ha
Pct. of farmers adopting technology	100% or 49 households
Pct. of farmers quoting FSR/E as source	——
Pct. annual adoption rate	2%
Net revenue per hectare	onions: 628,000 CFA, potatoes: 542,000 CFA
Generated income for all users	15,034,500 CFA

The average increase in net revenue per hectare was about 628,000 CFA or $2,283.64 for onions assuming a price of 85 CFA or $0.31 per kilogram, thus yielding an estimated increase in additional income generated of 2,888,800 CFA or $10,504.74 for onion growers. For potatoes, the average increase in net revenue per hectare was 542,000 CFA or $1970.90 at a per kilogram price of 150 cfa or 55 cents. The total increase in generated income for potato growers was about 2,493,200 CFA or $9,066.18.

Over the next five years, all households in the village will be using this technology (Table 78). The proportion of each woman's garden fertilized will increase over time. Thus the percentage of the total area fertilized will increase in direct proportion to the increase in the number of users and with time. As farmers become more convinced of the benefits of the technology and with the increased income accrued over the years, more land area will be fertilized by each farmer even if no new land is brought into production.

Continued favorable prices are a necessary condition. Over 1,400 individuals will be benefiting directly by applying this technology to over 25 hectares of land.

CONCLUSION

The population of the OHV zone in 1991-92 was about 1,973,893 persons and annual cereal requirement has been estimated at 212 kg per person, according to a study conducted by "Direction National de Statistic et Informatique" (DNSI). This implies that the total cereal requirement for the whole population was about 418,488 metric tons of cereals. The application of ammonium phosphate resulted in a total production of 130,000 metric tons of cereals, an increase of 25% or 25,600 metric tons attributable to the fertilizer. The total cereal requirement for the 9,479 households applying the fertilizer was 58,277 metric tons of cereals (an average of 29 persons per household). The 25,600 metric tons increase due to ammonium phosphate constitute 44% of this cereal need making the users self-sufficient in cereal production. This implies that an increased use of ammonium phosphate will lead to cereal self-sufficiency for the entire zone.

The higher grain yield and increased total production would lead to less land to be cultivated once the farmers'goals of food self-sufficiency and some cash for regular daily expenses have been achieved. This would give an opportunity for natural vegetative regeneration, and ultimately ecological stability. The higher vegetative production would then increase animal feed source and, therefore, higher animal productivity as a by product of which manure availability and traction power could improve. Provided prices are favorable (under conditions of local and foreign market availability for cereals), the increase in income would be expected to encourage the farmer to pay for the investment in soil and water management and livestock acquisition.

The increased production and subsequent increases in disposable income are expected to increase overall rural demand for manufactured and processed goods. Rural industrialization in the long run leading to employment and reduced urban migration should be expected.

The increased production and the accompanying surpluses will have to be met with increased effort at regional export of cereals and increased government and private sector capacity for storage. These will be necessary for stable prices.

A list of identified technologies in use in the OHV zone is given in the appendices.

Institutional Development

The FSR/E project has contributed to the development of the national farming system research program through the development of human resources, the acquisition of materials and financial support, and the elaboration of Farming System Research methodology and execution.

IMPROVEMENT OF RESEARCH CAPACITY

The National Farming System Research (NFSR) was initiated fully by national research staff. The FSR/E project provided support to the NFSR and IER in general to strenghten its research capacity through (a) the development of methodologies for the FSR program as a result of the technical assitance of USAID/Mali through SECID; (b) covering operational costs of the NFSR program so as to help the national institute to bear the whole responsibility of running the program autonomously at the end of the project life; (c) supplying equipment so as to increase the investigative capacity of the institute; and (d) through publication of research methodology and results which would improve the information data base of the institute in farming system research.

TRAINING AND SHORT-TERM CONSULTANTS

There was a provision for the support of national staff to participate in workshops, seminars and short term training. Thus by injecting technical, financial and informational support to the NFSR program, FSR/E (through USAID funding) has helped IER to develop a self-sustaining FSR program.

The project agreement called for giving 19 Malians long-term training in the United States. The last of the envisaged trainees left for the U.S in January 1991. A summary report of the training activity is given in Table 79. All of the participants have returned to the country and have assumed positions in IER and other sections of the Government of Mali.

The short-term teaching had two components: in-country training and training outside of Mali. In-country training included the training of researchers, field agents, and farmers in appropriate areas. Farmer training consisted mainly of visting other farmers to encourage discussions in new methods and practices of agricultural and livestock production. Field agents were trained to acquire the neces-

TABLE 79. A SUMMARY REPORT ON LONG-TERM TRAINING ACTIVITY, AUGUST 1993

Name	Degree	University	Year started	Year returned	Previous post	Current post
Abdoul Kadri	M.S.	Auburn Univ.	June 29, 1988	1990	DRSPR Bougouni	DRSPR Mopti
Abou Berthé	Ph.D.	Univ. of Florida	Aug. 9, 1987	1991	DRSPR Bamako	DRSPR Mopti
Adama Coulibaly	M.S.	Tuskegee Univ.	June 25, 1988	1992	DET	Minist0re
Boubacar Dembelé	M.S.	Tuskegee Univ.	July 25, 1987	1989	IPR	IPR
Modibo Diallo	M.S.	Univ. of Arkansas	July 7, 1989	1993	DRA	
Amadou Gakou	Ph.D.	Auburn Univ.	July 25, 1987	1994	DRA N'tarla	
Doré Guindo	M.S./Ph.D	Univ. of Arkansas	July 25, 1987	1993	DRA Sotuba	DRA Sotuba
Alpha Kergna	M.S.	Texas A&M	July 25, 1987	1989	IPR	
Moriba Komakara	B.S./M.S	Tuskegee/Iowa St	Jan. 19, 1989	1994	DRSPR Bamako	
Bakary Koné	M.S.	Tuskegee Univ.	Feb. 1, 1991	1994	DRSPR Bamako	
Alpha Ma6ga	Ph.D.	Virginia Tech.	June 29, 1988	1992	DRSPR Bamako	DRSPR Bamako
Dramane Mariko	M.S.	Mississippi SU	Feb. 1, 1991	1994	DET	
Akousso Niangaly	M.S.	Texas A&M	Aug. 14, 1987	1989	DNFAR	DNFAR
Antimeé Sagara	M.S.	NC A&T Univ.	June 29, 1988	1992	DNFAR	DNFAR
Odiaba Samaké	M.S.	Texas A&M	July 25, 1987	1990	DRA	DRA Mopti
Siné Sow	M.S.	NC A&T Univ.	Feb. 6, 1989	1993	DNFAR	
Mahamadou Tangara	Ph.D.	Iowa St. Univ.	July 25, 1987	1992	DRSPR Bamako	DRSPR Bamako
Aboubacar Touré	Ph.D	Texas A&M	June 29, 1988	1993	Intsorm(IER)	
Yacouba Traoré	M.S.	Iowa St. Univ.	Aug. 30, 1989	1993	DRSPR Bamako	DRSPR Bamako

sary tools for performing field operations such as questionnaire administration, area and yield measurements, rapid soil and crop identifications, and exposing them to the use and analysis of data collected in the field to reach certain conclusions. Training in English language enabled researchers to read scientific journals written in English and also prepare them for future training in English speaking countries. Training in information systems was a regular component of the FSR/E program.

Short-term training outside Mali included visits of researchers and technicians to other African countries, short-term training in appropriate areas such as computers, statistics, accounting and human resource development in the U.S, and other Third World countries.

Experts in various fields were often called upon to provide short-term help to the project either as direct support to research or as a form of on-site training of the national staff. The fields included economics, agronomy, information systems, animal science, and financial management. In addition, the SECID Campus Coordinator visited the project twice a year to participate in the review of project activities, resolve potential problems, and to provide technical advice as necessary.

FINANCIAL MANAGEMENT

The FSR/E project had an expatriate financial management specialist until March 1992 as part of the technical assistance component. The financial management unit (FMU) is currently staffed by highly trained Malians both at Bamako and at Mopti. There is close linkage between the two volets with Bamako serving as the main unit.

The FMU at Bamako consists of four accountants, a cashier and a warehouseman. The unit is fully computerized.

Mopti has only one warehouseman and one accountant who also serves as a cashier. The unit here too is fully computerized.

INFORMATION SYSTEMS MANAGEMENT

The project's technical assistance had an information systems management component until March 1993. The functions included the installation and maintenance of hardware and software, training of national staff, program design, software utilization in data processing and analysis, and extended service to other units of IER.

Installation and maintenance centered around the regular maintenance and the repair of computers, printers, and other equipment such as transformers and UPS units necessary for the proper functioning of computers. The control and prevention of software contamination was an essential component.

Training of researchers and support staff in the use of relevant computer software was a major function of the computer center. The center conducted workshops in word-processing, spreadsheet, database, and analysis of research and financial data bases. The staff played a supporting role in training the staff of the FMU.

A major function of the computer center was to provide data processing services to the research units of the project. The staff assisted researchers in the design of data collection instruments. After the data were collected, the staff archived the data using a data base management system and provided the data to the researchers in formats that could be used by their statistical programs . Finally, they provided technical assistance as needed to the researchers with their analyses.

Program design involved the development of computer software that was better suited to the specific research and financial management needs of the project.

All the previously described activities were made available to the other volets of DRSPR and units of IER as needed, however, the bulk of the time for the unit was spent at the project.

Budget

Tables 80 and 81 give an illustration of the budget requirements to implement FSR/E activities at the two volets for the 1993-94 research year and a consolidated budget is given in table 82.

The total amount budgeted for the OHV Volet 1993-94 research year was 198,873,511 CFA or $736,569. Out of this total amount, $186,316 was for commodities, $66,667 for training and $469,316 was for operating costs. A summary of this budget is provided in Table 80.

The total amount budgeted for the Mopti volet 1993-94 research year 82,494,127 CFA or $305,534. Out of this total amount, $39,722 was for commodities and $248,925 was for operating costs. The requested budget for training for this volet was included in the budget for the OHV volet. A summary of this budget is provided in Table 81.

Thus the total budget required for the FSR/E activities was 281,367,638 CFA or $1,042,103 of which $226,038 was earmarked for commodity acquisitions, $66,667 for short-term training, and $718,241 was for operational costs (Table 82).

Table 80. Annual Budget: May 1993 to April 1994 (OHV Volet)

Item	CFA[1]	Dollars
Construction Maintenance	2,050,000	7,593
Commodities	52,108,129	192,993
Transport Equipments	37,100,000	137,407
Other Commodities	9,860,275	36,520
Research Equipments	3,345,000	12,389
Miscellaneous	1,802,854	6,677
Training	18,000,000	66,667
Total Operational Cost	126,715,382	469,316
Personnel	63,721,737	236,006
Travel and Per Diem	8,748,000	32,400
Maintenance and Repair	16,138,000	59,770
Fuel, Utilities, Rent, etc	14,452,640	53,528
Cooperative Agreements	9,200,000	34,074
Office Supplies and Communication	11,364,386	42,090
Miscellaneous	3,090,619	11,447
Total Proposed Budget	198,873,511	736,569

[1]The exchange rate used was 270 CFA = $1 (U.S.A.)

Table 81. Annual Budget: May 1993 to April 1994 (Mopti Volet)

Item	CFA[1]	Dollar
Construction Maintenance	3,500,000	12,963
Commodities	11,784,375	43,646
Transport Equipments	400,000	1,481
Other Commodities	7,875,000	29,167
Research Equipments	2,450,000	9,074
Miscellaneous	1,059,379	3,924
Training	0	0
Total Operational Cost	67,209,752	248,925
Personnel	16,803,340	62,235
Travel and Per Diem	6,166,000	22,837
Maintenance and Repair	11,412,500	42,269
Fuel, Utilities, Rent, etc	11,622,540	43,046
Cooperative Agreements	8,702,500	32,231
Office Supplies and Communication	10,820,000	40,074
Miscellaneous	1,682,872	6,233
Total Proposed Budget	82,494,127	305,534

[1]The exchange rate used was 270 CFA= $1 (U.S.A.).

Table 82. Annual Consolidated Budget: May 1993 to April 1994 (FSR/E, Mali)

Item	OHV Volet		Mopti Volet		Total CFA	Total Dollar
	CFA	Dollar	CFA	Dollar	CFA	Dollar
Con.Re	2,050,000	7,593	3,500,000	12,963	5,550,000	20,556
Comm.	52,108,129	192,993	11,784,375	43,646	63,892,504	236,639
Trans.	37,100,000	137,407	400,000	1,481	37,500,000	138,888
Other	9,860,275	36,520	7,875,000	29,167	17,735,275	65,687
Res. eq	3,345,000	12,389	2,450,000	9,074	5,795,000	21,463
Misc	1,802,854	6,677	1,059,375	3,924	2,862,229	10,601
Train.	18,000,000	66,667	0	0	18,000,000	66,667
Tot. Opr	126,715,382	469,316	67,209,752	248,925	193,925,134	718,241
Pers.	63,721,737	236,006	16,803,340	62,235	80,525,077	298241
Travel	8,748,000	32,400	6,166,000	22,837	14,914,000	55,237
Repairs	16,138,000	59,770	11,412,500	42,269	27,550,500	102,039
Fuel	14,452,640	53,528	11,622,540	43,046	26,075,180	96,574
Coop	9,200,000	34,074	8,702,500	32,231	17,902,500	66,305
Supp	11,364,386	42,090	10,820,000	40,074	22,184,386	82,164
Misc	3,090,619	11,447	1,682,872	6,233	4,773,491	17,680
Total	198,873,511	736,569	82,494,127	305,534	281,367,638	1,042,103

Summary, Conclusions, and Policy Recommendations for Future Research and Extension

The OHV zone of the FSR/E project was divided into four principal agro-climatic regions ranging from the humid south with rich and fertile soils to the dry north with sandy soils. The principal crops are millet, sorghum, maize, and rice and legumes, such as cowpeas and peanuts. Crops are grown mainly in associations and livestock consists mainly of cattle, sheep, and goats. Poultry production is limited.

Crop production constraints include insufficient soil moisture, poor and degraded land, labor shortage, poor quality production inputs, limited financial resource availability, limited access to credit, and pest and disease attacks. Livestock production constraints are water and feed unavailability especially during the dry season, and animal diseases. Lack of adequate rainfall is the principal bottleneck of agro-forestry practice. Natural rainfall is not sufficient to support adequate tree growth. Watering of plants is hindered by the absence of sources such as wells, ponds, and streams.

Demographic studies showed that there is no correlation between family size and availability of family labor despite the high variation between villages in the same region and across the entire zone.

The cropping system is dominated by farms owned collectively by the entire household consisting of several families. These farms are slightly larger than individually owned farms. Sorghum is the most important crop both in terms of area cultivated and for its role in the diet of the farmers. Among the legumes, cowpea is the most important for the same given reasons.

Animal traction is the major land preparation technique and labor shortage is most pronounced during weeding. This, in addition to other factors already cited lead to very poor crop yields. Livestock feeding is done mainly through grazing of natural pastures. Very few farmers give nutrient supplements to their animals. Principal diseases include pasteurellosis and gastro-intestinal parasites. Very little vaccination is done as preventive measures against these diseases. An average household possesses 5.75 tropical livestock units with the highest number being in the southern part of the zone.

Monitoring farmers use of improved technologies identified more than 52 improved techniques of crop and livestock production and other household management techniques. Among these are fertilization, techniques of soil and water conservation and infant nutrition improvement technologies. Contrary to what is widely believed, the farmers in the zone use chemical fertilizers on cereals; the most important being cotton-complex and ammonium phosphate.

The first priority of policy-makers, agricultural researchers and extension agents is to develop technologies capable of increasing the yield of the cereal-dominated production system of the OHV zone. This effort should concentrate on alleviating the constraint of poor soil fertility and poor water retention capacity of the soils. Chemical fertilizers and soil and water management techniques such as digues/dikes/diguettes, rock bunds and labor-saving technologies such as animal traction are already available for diffusion in most of the sahelian region. The yield-increasing quality of chemical fertilizers are well known, but the rate of adoption is still low as compared to what one would have expected. Different reasons have been given, including the absence of credit for investment, lack of information and the shortage of the products themselves. However, it appears that the principal discouraging factor is the inherent risk of chemical fertilizer usage. The use of chemical ferilizer needs to be accompanied by an assurance of water availability especially during certain critical periods of plant growth, such as flowering. The adoption of packages of technologies rather than adoption singly or individually has been viewed as a potential solution, but research has shown that farmers resist adoption of several new technologies at the same time. There is a need for the development of rural financial institutions or credit programs for farmers agricultural investment, improvement in the information service for the management of the production systems, and the development of markets for both inputs and outputs. Technologies that are more likely to be adopted by farmers ought to be presented to them first in order to provide the encouragement and economic preconditions for adoption. Technologies for soil fertility improvement and those for soil and water retention, such as chemical fertilizers, dikes/diguettes, rock bunds and animal traction should be used on demonstration farms with farmer participation according to the recommendation domains developed. Government should intervene by the construction of dams and big dikes to control the flow of water at the village level. In each region of the zone, each family can construct tied-ridges and/or diguettes according to needs and resources. Extension agents should undertake the training of farmers in animal traction practice such as animal health and feeding to sustain effective field work.

References

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Appendices

List of Technologies Proposed by FSR/E

Appendix I. Soil Fertility Improvement Technologies

Local rock phosphate (PNT)
Ammonium phosphate
Cereal Complex
Cotton Complex
Simple Super Phosphates
Potassium Chloride
Urea
Manure
Improved fallowing method
Green manure
Compost
Potassium Sulphate

Appendix II. Soil and Water Conservation Technologies

Tied Ridges
Animal Traction
Rock Bunds
Dikes/Digues
Haie vive
Mulching

Appendix III. Labor Saving Technologies and Improved Crop Varieties

Pesticides
Guided Straight-line sowing
Automatic seeder
Alternating pockets sowing
Alternating lines sowing
Herbicides
Improved millet variety
Improved sorghum variety
Improved maize variety
Improved rice variety
Improved cowpea variety
Improved peanut variety
Improved tomato variety
Improved sweet potato variety
Improved potato variety
Improved onion variety
Improved okra variety

Appendix IV. Technologies for Livestock and Crop Production Integration

Improved corral systems
Improved honey production method
Livestock fattening
Deparasitizing
Treatment of small ruminants
Improved poultry production methods
Use of veterinary products
Forage production

Appendix V. Technologies Specifically Developed for Women

Soumbala from soybeans
Farine for child nutrition
Improved method for local soap manufacturing
Fertilization of womens peanut fields
Fertilization of womens vegetable gardens
Fertilization of womens rice fields.

Publications List

Document List

1986 SECID Orientation document

Work Plans

1987-May 1987 - April 88 FSRE team

This workplan was supplemented by a global workplan presented during the 1987 in house review. Refer to that report for details.

1988-May 1988 - April 89 FSRE team

1989-1989 - 90 FSRE team

1989-Work Plan for the 1989-90 Campaign.

1990-April 1990 - May 91 FSRE team

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In house review

1986-Six months progress report. January-June, 1986.

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Personnel of the FSR/E Program

This was the personnel situation at the end of the project. There was turnover in personnel both national and technical assistance over the life of the project.

Project Director

The Department of National Farming System Research and Extension is currently headed by Mr. Bino Témé who is an economist by profession.

OHV Volet

The section below provides a list of Malian Project personnel for the OHV volet.

1. Makan Fofana — Volet Coordinator (Agricultural Economist)
2. Diby Diakite — Agronomist
3. Mme Sissoko Haoua — Agronomist
4. Tagalifi Maïga — Agricultural Economist
5. Mme Mariko Oumou — Computer Specialist
6. Dioukou Sissoko — Agronomist (serves as sociologist)
7. Torade Khibé — Animal Scientist
8. Tahirou Tangar — Animal Scientist
9. Mahamadou Soumaré — Field Research Controller
10 Koni Daou — Field Research Controller
11. Moumouni Traore — Field Research Controller
12. Sanoussi Coulibaly — Field Agent
13. Seydou Dao — Field Agent
14. Mamadou Dembele — Field Agent
15. Ibrahim Traoré — Field Agent
16. Boubacar Haïdara — Field Agent
17. Cheickna Traoré — Secretary
18. Ousmane Coulibaly — Driver
19. Mme Mariko Aissata — Research Assistant
20. Mme Bah Haby — Research Assistant
21. Mme Kouyate Sadio — Research Assistant
22. Aliou Kouyate — Field Research Controller
23. Drissa Diallo — Field Agent
24. Sirima Diawara — Field Agent
25. Adama Sangaré — Field Agent
26. Aboubacar Koné — Field Agent
27. Mamadou Coulibaly — Field Agent
28. Habiram Kanouté — Field Agent
29. Yacouba Keïta — Field Agent
30. Endé Timbiné — Field Agent
31. Matenin Fofana — Field Agent
32. Drissa Goïta — Field Agent
33. Moussa Katilv — Office Manager
34. Makan Traoré — Purchasing Agent
35. Kalilou Tigana — Computer Specialist
36. Fabou Soumaré — Accountant
37. Moussa Somboro — Accountant
38. Dramane Sidibé — Accountant
39. Moussa Camara — Accountant
40. Lassina Bagayoko — Inventory Clerk
41. Siaka Coulibaly — Reproduction Clerk
42. Lassana Sidibv — Receptionist
43. Mme Coulibaly Orokya — Cashier
44. Daouda Dembele — Dispatcher
45. Lassine Camara — Driver
46. Moussa Traoré — Driver
47. Mady Keïta — Driver
48. Seydou Diallo — Driver
49. Nouma Traoré — Driver
50. Moussa Koné — Driver
51. Ousmane Samake — Messenger
52. Moussa Bah — Maintenance Chief
53. Ziffau Mounkoro — Custodian
54. Chaka Bengaly — Custodian
55. N'Tio Coulibaly — Guard
56. Cheick Coulibaly — Guard
57. Drissa Konv — Guard
58. Adama Konare — Guard
59. Oyahid Dicko — Guard
60. Niamanto Coulibaly — Guard
61. Yacouba Yanougé — Guard
62. Moussa Sangaré — Administrative Assistant

Eighteen of the above personnel including the director are paid by the Government of Mali and the rest by the project.

Mopti Volet

The list of personnel for the Mopti branch is as follows:

1.Abou Berthé — Volet Coordinator
2.Mohamadou Abdoul Kadri — Agronomist
3.N'Golopé Koné — Animal Scientist
4.Hamadou Maïga — Agricultural Economist
5.Boutout Ly — Sociologist

All five are paid by the Government of Mali.

In addition the Government of Mali is providing the following personnel:

1.Abdoulaye Sidibé — Accountants
2.Moussa Diawara — Controller
3.Mamadou Diallo — Field Agent
4.Robert Berthv — Field Agent
5.Lassine Touré — Field Agent

and the project is providing the following:

1.Tata Sidi Touré — Research Assistant
2.Mamadou Traoré — Custodian
3.Mahamadou Keïta — Computer Specialist
4.Touré Oumou Coulibaly — Secreatry
5.Abdoulaye Boré — Computer Specialist
6.Youssouf Traoré — Field Agent
7.Belco Keïta — Field Agent
8.Aly Kouta — Field Agent
9.Awa Cissé — Field Agent
10.Amadou Ambitigué — Watchman
11.Ibrahim Kassambara — Watchman
12.Amadou Guindo — Watchman
13.Seydou Sanogo — Driver
14.Nampé Traoré — Driver
15.Modibo Doumbia — Driver
16.Siaka Bamba — Warehouseman

Technical Assistants

1. Dr. Anthony Yeboah, Economist and Chief of Party
2. Dr. Sauveur Mahotière, Agronomist, Mopti Volet