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Feasibility Study of the Expansion of the Farming Systems Research Division Into the Fifth Region of Mali

5. Author(s)

1. Bruno Henry de Frahan
2. Youssouf Cisse
3. Samba Traore
4. Moussa Bora Diarra

6. Contributing Organization(s)

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The purpose of this study was to evaluate the feasibility of expanding the activities of the Farming Systems Research Division (DRSPR) into the Mopti region (fifth region). Four key factors influencing its success are: the small stock of available technologies at the research station level which can be adapted and transferred to producers; the low infrastructural and institutional development in the region; the coordination between commodity and systems research; and the productivity of the research team on which research results depend.

The study identifies homogeneous agro-climatic zones, major farming systems, major production constraints as well as evaluating the potential contribution of systems research to increasing productivity. The research program is evaluated through the analysis of four technical packages.

The results are that if the role of DRSPR is confined to adapting and transferring station research results, it will have a small impact. Its impact will be larger if in the longer term, it contributes to technological and socio-economic improvements.

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FEASIBILITY STUDY OF THE EXPANSION OF THE FARMING SYSTEMS RESEARCH DIVISION INTO THE FIFTH REGION OF MALI.

Bruno Henry de Frahan
Youssouf Cissé
Samba Traoré
Moussa Boré Diarra

June 1989.

FOREWORD

This feasibility study was conducted jointly by researchers from the Malian Institute of Rural Economy (IER) and the Department of Agricultural Economics of Michigan State University (MSU), with funding provided by the U.S. Agency for International Development under the Food Security in Africa Cooperative Agreement between MSU and USAID (No. DAN-1190-A-00-4092-00). This cooperative agreement is financed by USAID's Bureau of Science and Technology and Africa Bureau, with additional funding in Mali provided by the local USAID mission. The agreement aims to identify both country-specific and more general elements of food security problems in the different sub-regions of the African continent, through comparative analysis of the food and agriculture sectors of a number of African countries.

One of the Mali components of the second phase of this cooperative agreement is an economic study of farming systems research in the Fifth Region of Mali. Specifically, the study aims to establish the feasibility of expanding the work of the Farming Systems Research Division of the Institut d'Economie Rurale (DRSPR-IER) to the Fifth Region.

The present document is the final report of the feasibility study. The study on which the report is based was conducted in Mali over a period of 18 months, from June 1987 to December 1988. The original version of the final report was submitted in French in December 1988 and benefitted from numerous helpful comments on the part of the IER director and staff members and of USAID/Mali staff members. The original version was translated into English on the MSU campus while the economic analysis of this report was substantially revised in April and May 1989. The revised version is submitted herein. A revised French version is also available either from USAID/Mali or:

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This document would not have seen the light of day without the contribution of the Institute of Rural Economy researchers, the Directors and staff of the Opérations de Developpement Rural and the farmers, herders and fishermen of the Fifth Region. Their knowledge of the environment and their expertise have been invaluable. We would particularly like to thank the staff of Opération Mils de Mopti and Opération Riz de Mopti who facilitated contact with both the administration and rural producers.

We would also like to thank those who have reviewed and commented on the drafts of this report, M. Goïta, A. Cunard, J. Staatz, E. Crawford, T. Atwood, D. Atwood, E. Washington and A. Dembele. Finally, we thank D. Boughton and M. Sullins for the translation of, and improvements to, the French manuscript. Any remaining errors of analysis or interpretation remain the responsibility of the authors.

FEASIBILITY STUDY OF THE EXPANSION OF THE FARMING SYSTEMS RESEARCH DIVISION INTO THE FIFTH REGION OF MALI

EXECUTIVE SUMMARY AND RECOMMENDATIONS

EXECUTIVE SUMMARY

Systems research in Mali was institutionalized in 1979 by the creation of the Farming Systems Research Division (DRSPR) within the Institute of Rural Economy (IER). The institute has gradually attracted sizeable amounts of external funding. It became clear to the United States Agency for International Development (USAID) that the technologies extended by the Opérations de Développement Rural (ODR) were often inappropriate to the agro-climatic and socio-economic constraints of farmers, and that the results of station research needed to be adapted to their specific circumstances. For this reason, in 1985, USAID proposed to IER a program of finance and technical assistance over a ten-year period. The objectives of the program were to provide institutional support to IER in order to develop technologies appropriate to the needs and environments of Malian farmers, and promote their effective transfer.

For the first phase of this program, USAID proposed supporting the IER farming systems research division (DRSPR) in expanding its activities from the Compagnie Malienne Des Textiles (CMDT) zone to the Opération Haute Vallée (OHV) zone. It was envisaged that the second phase of this program would see an expansion of the DRSPR to the Fifth Region (Mopti region). However, as the agro-climatic, socio-economic and institutional constraints appeared more binding in the Fifth Region than in the OHV zone, the need for an economic analysis to establish the feasibility of this expansion was indicated. Furthermore, in order to avoid putting in place a research structure that would be too burdensome for the Malian government to sustain after financial and technical support from USAID terminated, the decision to support the expansion of the DRSPR would also be made taking into account IER's capability to follow through the research activities of the DRSPR.

Four keys factors that would influence the success of the DRSPR in the Fifth Region have been initially identified in the report. The first factor is the small stock of available technologies at station level from which the DRSPR can draw with a view to adapting and transferring them to producers in the Fifth Region. However, it is reasonable to hope that this stock of technologies appropriate to the agroclimatic conditions of the Fifth Region will increase in the course of the next decade.

The second factor is the low level of development of infrastructure and institutions in the Fifth Region. This low level of development further reduces the stock of technologies appropriate not only to the agroclimatic conditions of the Fifth Region, but also to the socio-

economic and institutional conditions which producers in the Fifth Region experience. Systems research can also serve as a source of information and proposals for guiding the reforms necessary in the Fifth Region.

The third factor concerns coordination between commodity and systems research. In this regard, the structure of research, i.e., its organigram, and the formal and informal opportunities for meeting between station and systems team researchers, are important elements to consider in order that the systems research, with the support of commodity research, can have an impact on the productivity of natural resources.

Finally, the fourth important factor is the productivity of the research team, on which the results of systems research largely result. The two systems research teams which have worked in a zone of Mali more favorable than the Fifth Region took 3 to 7 years in order to obtain results ready for extension.

In addition to these four key factors that would influence the success of the DRSPR in the Fifth Region, the production potential of the Fifth Region is also critical to the economic results of the expansion of the DRSPR into the Fifth Region. It is generally recognized that the Fifth Region has vast production potential. According to a study financed by the World Bank (Stryker et al., 1987), the comparative advantage (activities in which Mali enjoys relatively higher productivity than for other domestic activities) lies with cotton and livestock for export on the one hand, and rice and cereals for consumption in the producing areas on the other hand. Apart from cotton, the other three (livestock, rice and cereals) are activities in which the Fifth Region partakes. According to the National Bureau of Statistics (DNSI), the Fifth Region's contribution to national production during the last decade averaged 23% for cattle, 20% for small ruminants, 16% for cereals and 26% for rice. More seriously affected by the droughts in recent decades than southern regions, the Fifth Region has seen its contribution to most of the activities for which it held a winning hand decline. The constraints to production in the Fifth Region are daunting. Can systems research contribute to the alleviation of these constraints to the region's production? Such was the question that confronted this feasibility study.

In order to answer this question, and in particular to establish the return to investment in systems research in the Fifth Region, the feasibility study undertook the following five steps:

1) identification of homogeneous agro-climatic zones;

2) identification and understanding of the major farming systems of the Fifth Region;

3) identification of the major constraints to production of these farming systems;

4) identification of the potential contribution of systems research to increased productivity of these farming systems;

5) economic evaluation of the contribution of systems research to increased productivity of these farming systems.

These steps have been carried out by means of formal and informal surveys, analysis of secondary data sources and interviews with key research personnel and agents of the rural community services (ODRs, BNDA, DNACOOP, SMECMA, SMPC, SONAREM, etc.). Because of inadequate personnel resources in relation to the complexity and diversity of farming systems in the Fifth Region, formal surveys that would have permitted better verification and refinement of a number of research hypotheses could not be carried out for all of the numerous farming systems. Moreover, the formal surveys that were implemented were incomplete in the sense that they were designed to identify mainly the bio-physical and technical constraints of production at the farm level while other type of constraints exist at higher levels. These gaps have been partially overcome by asking ODEM to study the constraints and priorities for intervention and applied research in the Fifth Region livestock sector (Diakite and Keita, 1988), and exhaustively reviewing available documentation.

Work in the Fifth Region began with the identification of homogeneous agro-climatic zones in order to take account of the effects of agro-climatic variables on the development of farming systems. This also facilitated the delineation of farming systems. Three broad natural zones have been distinguished: the Delta, the Seno and South-Gourma, and the Bandiagara plateau. The Delta comprises four agro-climatic zones and the Seno, South-Gourma and the Bandiagara plateau comprise seven. Only three of these seven zones were included in the study, principally on account of their importance in terms of population, area cultivated and production potential.

The principal farming systems of the Fifth Region have been identified and geographically located according to agro-climatic zones. The Delta comprises primarily a mixed farming system, a pastoral system and fishing. Each of these systems has been sub-divided according to their principal activities. The Seno, South-Gourma and the Bandiagara plateau consist principally of a mixed farming system and a pastoral system. These two systems have been further characterized according to bio-physical factors, access to markets and input supply infrastructure, and population pressure on arable land. The study of the principal farming systems has revealed their diversity, complexity and fragility in the face of often severe climatic conditions.

The principal constraints impinging on farming systems have been classified according to whether they are caused by the physical and biological environment or by the socio-economic, policy and institutional environment. The principal constraints of the physical and biological environment are the deterioration of rainfall and hydrological regimes, poor soils, wind and water erosion, harmful

insects, granivorous birds, weeds and parasitic diseases of animals. The principal socio-economic constraints are the unfavorable ratio of input to agricultural output prices, the thinness of agricultural product and livestock markets, the population pressure on arable land and the lack of investment opportunities besides livestock. The principal institutional constraints are the inadequate input and agricultural credit delivery systems for rainfed agriculture, the isolation of production areas, the ambiguities of land tenure, the limited techniques for water control and the insufficient livestock support infrastructure. The principal policy constraints are the fiscal and administrative charges (head and other taxes, marketing expenses, customs duties) and the overvaluation of the CFA franc, which discourages exports.

The contribution of the systems research to alleviating the effect of these different constraints on production has been identified through fifteen research themes. These fifteen themes constitute the plan of research that has been suggested for the DRSPR in the Fifth Region. The plan of research comprises studies relating to the marketing constraints for inputs and agricultural products, focused surveys to get a better understanding of certain constraints and the means of alleviating them, tests of technology packages based on available or forthcoming results from station research, and cooperative programs with commodity researchers to identify technological solutions to certain agro-climatic constraints. The fifteen themes of research are the following:

1. Study of input factor markets and agricultural credit;

2. Study of agricultural product and livestock markets and transactions;

3. Intensification of millet-cowpea intercropping;

4. Intensification of the sole millet-cowpea cropping pattern;

5. Development of secondary and minor crops;

6. Improvement of cropping methods;

7. Integration of agriculture and animal husbandry;

8. Study of cropping systems in the Delta;

9. Study of cropping systems in village irrigation areas;

10. Evaluation of rice-sorghum intercropping in areas at risk for rice cultivation in the Delta;

11. Development of anti-erosion and agroforestry techniques;

12. Improvement of storage and processing techniques for agricultural products;

13. Collection of local millet germ plasm;

14. Research on cropping systems practiced during flood recession;

15. Collection and selection of Oryza glaberrima rice varieties.

These fifteen research themes have taken into account both current and expected technologies available to the on-going research. Each theme has been expanded along the same outline and has contained four parts. The first part has introduced the theme and given its context in Mali and in the Fifth Region. The second part has identified and defined the research objectives. The third part has presented the main elements justifying each research theme. The information comprising the third part had been either collected in formal and informal surveys and from available documents, or had been compiled and analyzed from this data. The fourth part has explained how the research team might approach the topic more concretely and has indicated either qualitatively or quantitatively (depending on the available data) the expected results.

It is important to indicate that these research themes do not seek only technical solutions for the production constraints of farming systems. In order to address the socio-economic, institutional and policy constraints, technological solutions are insufficient. Systems research, in order to have an impact on production, should also identify and propose economic, institutional and policy measures.

The fifteen research themes proposed have been organized in a research program of nine years duration, including the period for construction and installation of the DRSPR research unit in Mopti. Considering the experience gained by the two oldest research units of the DRSPR in systems research (the Fonsebougou Section and Bougouni-Sikasso Section), the research program has been planned on the basis of three years of testing and three years of pilot extension for the majority of research themes. In order to conduct these fifteen research themes, the research team will probably need to be strengthened somewhat, particularly if the market studies confirm that the proposed research themes are justified.

This report repeatedly underlines the type of approach that systems research ought to take in the Fifth Region. Two pillars support this approach. The first pillar is an awareness of the importance of the macroeconomic environment to farming systems. The second pillar is the coordination of DRSPR activities with those of crop and livestock disciplinary research, the Opérations de Développement Rural and institutions responsible for cereals policy, credit, etc. For example, as few appropriate technologies are currently available from station research, it is important that systems research provide effective guidance to station research programs. It is also important that systems research show decision makers (whether at the level of regional administrative authorities, the Ministry of Agriculture, the Ministry of Finance, etc.) the impact of their decisions on the productivity of farming systems and the limits to technological research possibilities.

The research program has been evaluated first through a financial analysis of four technical packages, which have brought together the results of eight research themes; and second through an economic analysis of the expansion of the DRSPR based on the economic results of the four technical packages. The four technical packages that have been included in the financial and economic analysis of the expansion of the DRSPR in the Fifth Region, were the following:

- millet-cowpea intercropping;
- sole millet and cowpea cropping pattern;
- groundnut-millet-groundnut rotation;
- sesame cultivation.

Because only eight of the fifteen research themes have been included in the four technical packages used for the economic analysis, the economic evaluation of the expansion of the DRSPR is, consequently, a partial evaluation. However, because it has been anticipated that the most rapid and concrete results will arise from the introduction and transfer of these four technical packages, the evaluation reflects the earliest results to be expected despite being partial in nature. It is these early results that have the most influence on the economic value of the expansion of the DRSPR due to discounting of costs and returns. Also, these four technical packages were put together on the basis of the most reliable technical data and are relevant to the largest recommendation domains.

Although these four packages all relate to rainfed agriculture, the evaluation team did not mean to suggest that systems research in the Fifth Region should focus uniquely on rainfed agriculture. The importance and the opportunity that the research themes not included in the technical packages and, consequently, in the economic analysis represent, have been discussed in Chapter IV. Despite the fact that these themes did not easily lend themselves to economic evaluation because of lack of reliable data, the benefits of these themes should not be assumed to be zero. Rather, to the extent that one can expect any return to the four technical packages for which quantitative estimates are made, then the overall estimates of the project value that is provided are underestimated.

The four technical packages were evaluated according to the agroclimatic zone, the farming system and the level of technology of the potential adopter. The financial analysis of the four technical packages displays marginal rates of return estimated at between 14% and 269% depending on the specific package, agro-climatic zone and level of technology of the eventual adopters. The marginal return per man day ranks between 411 and 5679 CFA francs, a figure higher than the current opportunity cost of labor. Financially, these technology packages are very sensitive to 10% - 20% changes in yield or agricultural product prices and to similar changes in costs of production.

Estimated rates of adoption varied according to the technical package, the agro-climatic zone, the farming system and level of technology. The estimated net economic value of the project amounts to US $ 648,000 (approximately 194 million F CFA) at an opportunity cost of capital of 12%. The internal rate of return is estimated at 14%. The economic value of the expansion of the DRSPR is, however, very sensitive to variations in yields or prices of agricultural products, the time needed to move from developing research themes to the extension stage, the farm level production costs and the rate of adoption. Other variables tested, specifically the adoption ceiling, the life of the innovation, the success of systems research and the costs of the project, have a smaller effect on the stability of the project's economic value than the first four variables mentioned above. The distribution of eventual benefits from the expansion of the DRSPR is relatively even across the recommendation domains and across gender.

The principal finding of this economic analysis is the following. If the DRSPR confines itself to adapting and transferring results currently available from station research, and if it is only able to render the socio-economic and institutional environment slightly more favorable, then the economic value of its expansion into the Fifth Region would be small and fragile. However, in the longer term, it is possible that the expansion of the DRSPR could have a larger impact if it contributes effectively to the development of new technologies and to the improvement of the socio-economic and institutional environment of the Fifth Region.

Eleven recommendations are given below for the expansion of the Farming Systems Research Division into the Fifth Region of Mali.

RECOMMENDATIONS

1. Because the Fifth Region has comparative advantage in livestock for export and in rice and cereals for local consumption, alleviating production constraints in these areas of comparative advantage makes sense and should be encouraged. Other areas of comparative advantage probably exist but have not been demonstrated in the available literature. Such areas might be fisheries, legumes and vegetables, in which the region has production potential. Therefore, the comparative advantage of the region in fisheries, legumes and vegetables should be assessed before investing resources in systems research related to these three areas.

2. Because of the diversity, complexity and fragility of farming systems in the Fifth Region, the farming systems research approach is called for in order to confront the production constraints experienced by these systems.

3. Significant increases in production from rainfed agriculture can be expected rapidly (5 to 6 years) if systems research adapts the results currently available, or available in the near future

(2 to 3 years), to the local agro-climatic, socio-economic and institutional conditions. However, results that are available and appropriate to the Fifth Region are limited in number and importance, and all are to some degree subject to climatic hazards and market constraints.

4. Because of the limitations to the feasibility study, and also the lack of available research station results appropriate to the Fifth Region, concrete and rapid results that systems research could achieve in the areas of flooded agriculture, recession agriculture and livestock have been less clearly established by this report. However, as production in these three areas depends on a relatively more reliable source of water, i.e., the Niger river and its tributaries, than rainfed agriculture, it is expected that in the long term, successful commodity and farming systems research related to these three areas would provide higher and more stable increases in production than research confined to rainfed agriculture, where production potential is more limited.

5. Because of the relatively low and unstable financial profitability of the technical packages evaluated, systems research in the Fifth Region should give attention to collecting sufficient information to be able to improve the relevance to farmers of research conducted on station or in village fields trials. Very close coordination between systems and commodity research is an essential activity for the development of appropriate technologies.

6. The profitability of the technical packages analyzed depends heavily on the markets for inputs and agricultural products and for credit. Systems research should therefore also concentrate on identifying marketing and credit constraints with a view to suggesting means of alleviating them, on developing technical packages which take account of these constraints, and promoting cash crops.

7. In addition to market constraints, problems in the areas of land tenure, fiscal policies and commercial arrangements are also important in the Fifth Region. For this reason systems research should establish effective coordination with agencies and decision makers involved in these areas.

8. The results from systems research depend not only on 1) the results obtained by commodity research, 2) the extent to which the socio-economic and institutional environment facilitates the diffusion of the technology packages developed, and 3) coordination between the different agencies involved in rural areas, but also on the research team. The level of motivation of this team is important for the achievement of rapid and concrete results. Although the systems approach is no longer novel to Mali, the lack of qualified staff for carrying out in-depth analyses of the socio-economic, institutional and political aspects of problems, and to propose realistic solutions, should be noted.

9. While the question of the financial and manpower resources of IER has not been broached by this study, any decision to expand the work of the DRSPR to the Fifth Region should take these capabilities into account. The results of the current study of the restructuring of agronomic and livestock research in Mali will help to answer this important question[1]. In case it is impossible for IER to increase significantly its capabilities to conduct farming systems research, two alternative options are offered. First, farming systems research activities in the OHV section could be strengthened by broadening the systems approach to include a study of market constraints and encouraging stronger coordination between systems research on the one hand, and commodity research, the agencies involved in rural areas and decision makers on the other hand. Second, preliminary socio-economic studies could be carried out in the Fifth Region to define with more precision the input and output market constraints for agriculture, livestock and fishery production. To be useful, these studies should propose realistic measures or reforms to be made by decision makers and the relevant authorities.

10. Other types of intervention in the Fifth Region could also promote agricultural, livestock and fishery production. These interventions would include:

- introduction of a fiscal reform to encourage commerce and investment, recognizing that this would encourage production in turn,

- introduction of a commercial policy to stimulate exports in order that the region can realize the full benefits of its areas of comparative advantage,

- introduction of a land tenure arrangement permitting a better allocation of natural resources (arable land, grazing and water),

- encouragement of the private sector or support of nongovernmental organizations in order to supply the Fifth Region with agricultural inputs (pesticides, inorganic fertilizer and agricultural equipment),

- support for the collection, evaluation and distribution of superior local varieties of millet and Oryza glaberrima rice,

- investment in repair and expansion of the road network.

11. If, for the moment, IER and USAID decide that it is not appropriate to expand the farming systems research division to the Fifth Region, this feasibility study could be useful in orienting future

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1/ Study sponsored by the World Bank and USAID with the technical assistance of ISNAR.

commodity research and making the approaches of rural institutions to increase farm production more appropriate.

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LIST OF ACRONYMS

AEDES	-	Association Européenne pour le Développement et la Santé (European NGO).
BCEAO	-	Banque Centrale des Etats de l'Afrique de l'Ouest (Central Bank of West African States).
BNDA	-	Banque Nationale pour le Développement Agricole (Agricultural Credit), Mali.
CABO	-	Centre for Agrobiological Research, The Netherlands.
CAC/DNACOOP	-	Centre d'Action Coopérative de la DNACOOP (Representation of the DNACOOP at the circle level), Mali.
CCCE	-	Caisse Centrale de Coopération Economique (French Economic Cooperation Fund), France.
CEC	-	Commission od the European Communities.
CFA	-	Communauté Financière Africaine (Financial Community of Western and Eastern Francophone African states, except Guinea and Mauritania).
CFAF	-	CFA Francs (Currency unit of the CFA Zone).
CIF	-	Cost, Insurance, and Freight.
CIRAD	-	Centre International de la Recherche Agronomique et de Développement (French Research Institute), France.
CMDT	-	Compagnie Malienne de Développement des Textiles (Malian Company for the Development of Textiles), Mali.
CNRA/IER	-	Comité National de la Recherche Agronomique (National Comitee for Agronomic Research), IER, Mali.
CTRA/IER	-	Commission Technique de la Recherche Agronomique (Technical Commission for the Agronomic Research), IER, Mali.
DAF/IER	-	Division Administrative et Financière (Administrative and Financial Division), IER, Mali.

DDI/IER	-	Division de la Documentation et de l'Information (Division of Documentation), IER, Mali.
DET/IER	-	Division des Etudes Techniques (Division of Technical Studies), IER, Mali.
DMA	-	Division du Machinisme Agricole (Agricultural Mechanization Division), Ministry of Agriculture, Mali.
DNA/IER	-	Direction Nationale de l'Agriculture (National Direction of Agriculture), Mali.
DNACOOP	-	Direction Nationale de l'Action Coopérative (National Direction of Cooperatives Organizations), Mali.
DNSI	-	Direction Nationale de la Statistique et de l'Informatique (National Direction of Statistics and Computing), Mali.
DPE/IER	-	Division Planification et Evaluation (Division of Planning and Evaluation), IER, Mali.
DRA/IER	-	Division de la Recherche Agronomique (Division of Agronomic Research), IER, Mali.
DRSPR/IER	-	Division de Recherche sur les Systèmes de Production Rurale (Farming Systems Research Division), IER, Mali.
EDF	-	European Development Fund.
FAC	-	Fonds d'Aide et de Coopération (French Development Fund), France.
FAD	-	Fonds d'Aide et de Développement, France.
FSR/E	-	Farming Systems Research/Extension Project, Mali.
GTZ	-	German Development Agency, Germany.
ICRISAT	-	International Crop Research Institute for the Semi-Arid Tropics.
IDRC	-	International Development Research Centre, Canada.

IER	-	Institut d'Economie Rurale (Institute of Rural Economy), Mali.
ILCA	-	International Livestock Centre for Africa.
INRZFH	-	Institut National de Recherche Zootechnique, Forestière et Hydrobiologique (Zootechnical, Forestry and Hydrobiological Research Institute), Mali.
IRAT	-	Institut de Recherche en Agronomie Tropicale (Tropical Agronomic Research Institute), France.
ISNAR	-	International Service for National Agricultural Research.
IUCN	-	International Union for Conservation of Nature, United Kingdom.
MSU	-	Michigan State University, USA.
NGO	-	Non Gouvernmental Organization.
ODEM	-	Opération pour le Développement de l'Elevage à Mopti (Mopti Livestock Development Program), Mali.
ODIB	-	Opération de Développement Intégré de Baguineda (Baguineda Integrated Development Project), Mali.
ODIPAC	-	Opération de Développement Intégré des Productions Arachidières et Céréalières (Integrated Groundnuts and Cereals Development agency), Mali.
ODR	-	Opération de Développement Rural (Rural Development Agency), Mali.
OHV	-	Opération Haute Vallée (Niger River Upper-valley Development Agency), Mali.
OMBEVI	-	Office Malien du Bétail et de la Viande (Livestock and Meat Agency), Mali.
OMM	-	Opération Mils de Mopti (Mopti Millet Program), Mali.
ON	-	Office du Niger (Niger River Irrigated Agricultural Development Agency), Mali.

OPAM	-	Office des Produits Agricoles du Mali (Agricultural Marketing Agency), Mali.
OPM	-	Opération Pêche de Mopti (Mopti Fish Program), Mali.
OPSS	-	Opération de Production de Semences Sélectionnées (Improved Seed Production Program), Mali.
ORM	-	Opération Riz de Mopti (Mopti Rice Program), Mali.
ORS	-	Opération Riz de Ségou (Segou Rice Program), Mali.
OSCE	-	Office Statistique des Communautés Européennes Statistical Agency of the European Community).
OXFAM	-	Oxford Famine Relief (British NGO).
PAR	-	Point d'Appui de Recherche (Local Research Station), Mali.
PIRT	-	Projet d'Inventaire des Ressources Terrestres (Land-resource Inventory Project), Mali.
PPIV	-	Petits Périmètres Irrigués Villageois (Small Village Irrigation Areas), Mali.
PRMC	-	Programme de Restructuration du Marché Céréalier (Cereals Market Restructuring program), Mali.
SAFGRAD	-	Semi Arid Food Grain Research and Development.
SAP	-	Système d'Alerte Précoce (Early Warming System), Mali.
SCAER	-	Société de Crédit Agricole et d'Equipement Rural (Agricultural Credit and Input Distribution Agency), Mali.
SMECMA	-	Société Malienne d'Etudes et de Construction de Matériel Agricole (Agricultural Mechanization), Mali.
SMPC	-	Société Malienne des Produits Chimiques (Chemical Products Company), Mali.

SONAREM	-	Société Nationale de la Recherche Minière (National Company for Research on Mining), Mali.
SRCSS/DRA/IER	-	Section de Réglementation et Contrôle des Semences Sélectionnées (Seed Selection Control), IER, Mali.
SRCVO/DRA/IER	-	Section de Recherche sur les Cultures Vivrières et Oléagineuses (Food Crop and Oilseed Research), IER, Mali.
TRP	-	Tilemsi Rock Phosphate.
UMOA	-	Union Monétaire des Etats de l'Afrique de l'Ouest (Monetary Union of West African States).
UP	-	Unité de Production (Farm Production Unit).
USAID	-	United States Agency for International Development.
VST	-	Vétérinaire Sans Frontières (French Veterinary NGO).
WARDA	-	West African Rice Development Agency.
WB	-	World Bank.

I. INTRODUCTION.

A. FEASIBILITY STUDY OBJECTIVES.

The Institute of Rural Economy (IER) and the United States Agency for International Development (USAID) are interested in the possibility of expanding the work of the Farming Systems Research Division (DRSPR) into the Fifth Region of Mali. Michigan State University (MSU) was requested to carry out a feasibility study for this expansion of DRSPR activities to the Fifth Region.

According to the terms of reference for the feasibility study, the primary objective is "to provide an estimate of the investment costs of an expansion of the Farming Systems Research Project (FSRP), and expected benefits in the form of output growth and increased productivity and incomes in the Fifth Region of Mali. Furthermore, the study will also consider factors affecting the returns to agricultural research in general, and the Mali FSR project in particular, such as agricultural pricing policy, marketing, and the relationships between technology and food security."

The study commenced on June 1987, with a budget of $230,000 and a duration of 18 months. The study team consisted of an expatriate agricultural economist, two IER researchers (one agricultural economist and one agronomist) and an agronomy consultant. The study benefited from the professional advice of two Michigan State University professors, and intellectual and logistical support from IER and the USAID mission in Bamako. Logistical support comprised one all-road Toyota, 4 mobylettes, and an office equipped with micro-computer and accessories. Four enumerators were employed for four months for a formal survey in the Seno plain and Bandiagara plateau. A special study on livestock in the Fifth Region was carried out by the director and the deputy director of ODEM (the livestock extension service for the fifth region) under the guidance of the evaluation team.

B. FEASIBILITY STUDY FRAMEWORK.

This feasibility study is one component of a larger project undertaken by USAID over a 10 year period. This project officially started in 1986 in order to help IER to expand and improve the effectiveness of its far ing systems research program with a view to the development and successful promotion of technologies appropriate to the needs of farmers (AID, 1985, p.1).

Since 1986, USAID has contributed to the fitting out of the DRSPR's Bamako offices, training for Malian researchers, and getting the division's research activities off the ground in the second region, in the Operation Haute Vallee zone (OHV). This is an Operation de Developpement Rural (ODR) engaged in the promotion of husbandry methods and the supply of agricultural inputs to farmers in the zone. USAID also provides financial and technical assistance to this ODR.

Prior to its present support for the DRSPR, USAID contributed to a multilateral effort to undertake a farming systems research project based at Sikasso and working in the area between Sikasso and Bougouni (southern Mali). Support amounting to $250,000 over a 4 year period provided for infrastructure costs, equipment, vehicle and support staff. The Ford Foundation contributed $100,000, while the heaviest burden was borne by the International Development Research Centre (IDRC Canada) which provided for operational expenditures, research allowances for four Malian researchers and the salaries of two expatriates, totalling $418,000 for the first three years 1979-81 (Ariza-Niño, 1980, p.2).

The Bougouni-Sikasso research team is currently located at Bougouni. In order to cover its operational costs this team receives a modest sum from IDRC (60 million CFA[1] for the fourth phase: mid 1987-1989). The research team, all nationals, is composed of an animal scientist (team leader), agronomist, sociologist and two agricultural economists.

In 1979, another farming systems research project, financed by the Dutch and Malian governments, and having begun in four study villages around Fonsebougou (Sikasso region), was also integrated into the DRSPR. Since then the project has been known as the Fonsebougou Section within the DRSPR. This section is now in its third phase (1986-1989) with an annual operating budget of CFA 200 million[2], and a team of 8 Malian and 8 expatriate researchers. The Section receives technical support from the Royal Tropical Institute (IRRT, Amsterdam, The Netherlands) as well as professional advice from the Center for Agro-biological Research (CABO, Wageningen, The Netherlands).

The DRSPR consequently has three sections at present: the Fonsebougou Section financed by the Dutch government since 1979, the Bougouni-Sikasso Section financed by Canada since 1980, and the OHV Section financed by USAID since 1986. The issue now is whether to open a fourth section in the Fifth Region as a continuation of the research program financed by USAID.

C. ORGANIZATION AND EXTENT OF THE REPORT.

This report is organized in five chapters. After the first chapter, which constitutes the introduction to the report, the second chapter presents the expected roles of the DRSPR in the Fifth Region, and is composed of four sections. The first section briefly presents the evolution of farming systems research in Mali. The second section presents the roles of the DRSPR according to the agreement between the IER and USAID. The systems approach is attractive, but achieving it entails a number of difficulties. The third section underlines three

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1/ equivalent to $85,700 per annum at 1$ = 280 F CFA.

2/ equivalent to $714,000 per annum at 1$ = 280 F CFA.

such difficulties encountered by the approach. More specifically, the fourth section identifies four key factors affecting the success of the systems approach in the Malian and Fifth Region contexts.

The third chapter presents the farming systems of the Fifth Region. This chapter is also sub-divided into four sections. The first section gives an overview of the Fifth Region. Because the farming systems are heavily dependent on the agro-climatic environment, the second section proposes an agro-ecological zoning of the Fifth Region. Following this, the third section identifies and briefly describes the major farming systems of the Fifth Region. The fourth section identifies the major constraints of these farming systems.

The fourth chapter contains a proposed research program for the DRSPR in the Fifth Region. The program takes account of both key factors affecting the success of the DRSPR and the major production constraints of the farming systems. The chapter's first section presents the research themes; the second outlines the strategy and means for carrying out the research program. The proposed timetable for research activities is then given in the third section.

The fifth chapter evaluates the economic potential of the proposed research program. After stating the assumptions for the financial and economic evaluations in the first section, the second presents a financial analysis of selected research themes presented in chapter IV. The third section provides an economic analysis of expanding DRSPR's work to the Fifth Region. As will become apparent, it is a partial economic analysis, being limited to those themes which are amenable to this type of analysis.

The summary of this feasibility study and the recommendations for expanding DRSPR activities into the Fifth Region were presented above.

The observations, analyses and proposals presented in this report are the result of the following research activities[3]:

- An examination of secondary data and information available on the Fifth Region of Mali in general and on technologies promoted by Operations de Developpement Rural (ODR) and developed through station research in particular.

- Reconnaissance surveys in the major zones of the Fifth Region (Seno plain, Bandiagara plateau, and the Delta). These reconnaissance surveys are based on interviews with development staff of the ODR (OMM, ORM, ODEM, and OPM), researchers at the agronomic research stations (Cinzana, Mopti and Koporo), the NGOs active in the region (Catholic Mission, IUCN, Save the Children, CARE, OXFAM, AEDES, VSF), local

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3/ The acronyms used in this section are defined in the first pages of this report.

government, Co-operative Action, Water and Forests, development projects (GTZ and EDF) and rural producers (farmers, livestock breeders, and fishermen).

- Preliminary study of data from a formal survey carried out in the Seno plain and Bandiagara plateau (a sample of 316 farm households from 34 villages).

- Direct contact with technicians from the Fonsebougou Section, the Bougouni-Sikasso Section, the OHV Section and the CMDT.

- Discussions with staff of the SRCVO of IER, the Improved Seed Production Program (OPSS), ICRISAT, SAFGRAD, USAID, input distribution companies and the BNDA.

Information relating to the Seno plain and the Bandiagara plateau has already been presented and analyzed in a working document entitled "Results of a Preliminary Survey in the Fifth Region of Mali. I. The Seno Plain and the Bandiagara Plateau". Three information notes have treated specific subjects. The first information note entitled "Etude de la Traction Animale dans le Séno" has been written on animal traction in the Seno plain. The second note entitled "Les Principaux Résultats de la Recherche sur les Cultures Associées Mil-Niébé au Mali" has been written on the research results on millet and cowpea intercropping. A third note entitled "Enquête informelle sur les Cultures Maraîchères du Plateau de Bandiagara" has been written on vegetable production on the Bandiagara plateau. The Opération pour le Développement de l' Elevage à Mopti (ODEM) carried out a specific livestock study of their own according to terms of reference prepared by this team of researchers. This livestock study is entitled "L'Elevage en Cinquième Région: Contrraintes et Actions Prioritaires d'Intervention et de Recherche Appliquée."

The above sources of information and analyses have been used for this report, which identifies both the limitations and gaps in current knowledge. The proposals put forward in this report should be consolidated through more thorough discussions with scientists at the IER and INRZFH and representatives of the ODR. They should also be refined by more thorough analysis of the formal survey data for the Seno plain and Bandiagara plateau, and small-scale focused surveys. A formal survey of the Delta area could not be carried out due to limited time and funds. Consequently, information gathered through the informal survey of the Delta should be interpreted with more caution.

Secondly, estimates of the benefits to be gained from an extension of the DRSPR are partial in nature. While it has been possible to propose research themes and to anticipate some of their outputs, it has not been possible to estimate the impact of all of the proposed research themes on output or productivity. Many of the results of these research themes have not yet been tested under farmers' conditions and in some cases have simply not yet seen the light of day. In addition, even the results available from tests carried out in rural areas by SAFGRAD on

Tilemsi rock phosphate and improved cowpea varieties present some problems for using them directly for the estimation of the benefits. These results cannot be taken at face value because our surveys on the ground show that these two technologies will not be adopted by farmers in the way that they have been tested. Consequently, adjustments to available results from station or in village fields trials have been necessary. These adjustments could be a source of large errors. Farmer adoption rates could be another. Although approximate in nature, the estimates of costs and benefits for each output of the farming systems research in the Fifth Region should nevertheless enable research priorities to be set. Helping establish such priorities may be the most valuable feature of the report.

II. THE ANTICIPATED ROLES AND CONSTRAINTS OF THE DRSPR IN THE FIFTH REGION.

This second chapter begins by reviewing the evolution of systems research in Mali. The review identifies the reasons that led to the establishment of a farming systems research division (DRSPR) in Mali. It is important that these reasons be taken into consideration when deciding whether to expand the DRSPR in the Fifth Region. Next, the anticipated roles of the DRSPR are presented according to the IER-USAID agreement. These roles are analyzed in the light of the principal difficulties which could significantly affect their implementation. Finally, four key factors for the success of the DRSPR are discussed in the context of Mali and the Fifth Region.

A. THE EVOLUTION OF THE SYSTEMS RESEARCH IN MALI.

In 1976, an international colloquium on farming systems research was held in Bamako. This colloquium was organized by the IER and the Ford Foundation with the participation of Dr. David Norman. At this colloquium the first foundations for the development of the systems approach in Mali were laid (Norman, 1976). The colloquium took place at the same time that the hopes placed in the ODR were succumbing to widespread dissatisfaction (Sanogo, Fonsebougou Section Coordinator, personal communication, June 1988). In addition to internal management problems, these agricultural development agencies were unable to extend the results of commodity research. Out of this experience there emerged a consensus that it was necessary to create a bridge between commodity research and the ODRs, a third institution which would be in close contact with the needs and problems of rural producers. This consensus re-emerged at the National Committee for Agronomic Research, and was confirmed in 1978 during a seminar with the theme "Improvement of Animal Production Systems". The DRSPR was officially institutionalized within IER in 1979. The DRSPR became the institute's sixth division alongside the Agronomic Research Division (DRA), the Technical Studies Division (DET), the Planning and Evaluation Division (DPE), the Documentation and Information Division (DDI) and the Administrative and Financial Division (DAF).

At the same time, it also became clear to USAID that the ODR which it was financing had few appropriate research themes to offer farmers. In the Fifth Region, for example, where the physical environment is difficult (low rainfall, poor infrastructure and distant markets), the Operation Mil Mopti (OMM) financed by USAID had few appropriate techniques to extend to farmers. Six years after the termination of USAID financing in 1982 the major impact of OMM that is still visible is the widespread promotion of fungicidal seed treatment (Thioral) and animal traction. The staff fielded by OMM are still on the ground but with a much reduced operating budget. In 1987, the staff comprised 250 agents and was costing the Mali government 84 million F.CFA in personnel costs and 18 million F.CFA in operating expenses, i.e. an operating budget per agent in the order of 72000 F.CFA per year (Direction

Nationale du Budget, 1987). At the beginning of 1988, the OMM was dissolved. The agents employed by OMM have been put at the disposal of the Regional Department of Agriculture.

Noting the lack of appropriate technologies, particularly for the less favored regions of the Center and North of the country, USAID invested in agronomic research and became the major provider of research funds in Mali. In 1985, its contribution supporting principally the operating and equipment expenses for research, represented 66% of all external contributions to IER and INRZFH, the country's two major research institutes (Cassas, 1987). This contribution represents 34% of the total budget of these two institutes and amounts to 637 million F.CFA.

Aware of the problems in adapting and transferring technologies developed on station to the rural community, USAID firstly undertook the Semi Arid Food Grain Research and Development project (SAFGRAD) to test technologies developed on station in the rural environment. This top down approach to agronomic research (station research -pilot extension - extension - farmers) could not by itself generate technologies appropriate to farmers because the conditions and selection criteria on station can be quite different from those of farmers in their own environment. For this reason USAID completed its involvement with agronomic research in 1985 by assisting the DRSPR to expand and conduct its research activities in other zones.

Nine years after its creation in 1979, the DRSPR in 1987 comprised 16 national and 11 expatriate researchers (from The Netherlands and the USA) out of a total of 143 national and 21 expatriate researchers within IER. The Agronomic Research Division (DRA) is by far the largest division with 91 national and 10 expatriate researchers in 1986, 62% of the effective total for IER (Cassas, 1987). According to the report of the financial commission (1988), the DRSPR had an operational budget[1] of 310 million F.CFA[2] in 1987, of which 272 million F.CFA (88%) was financed externally (The Netherlands, USAID, and IDRC). The same year, the DRA had 989 million F.CFA at its disposal[3], of which 604 million F.CFA (61%) was financed externally (principally CIRAD-France and USAID through ICRISAT and SAFGRAD). In terms of financial resources per scientist (nationals and expatriates combined) the DRSPR could count on 11.5

1/ Excluding technical assistance costs and equipment paid overseas.

2/ Equivalent to 1.1 million US dollars at $1 = F.CFA 280.

3/ Equivalent to 3.5 million US dollars at $1 = F.CFA 280.

million F.CFA per researcher[4] while the DRA could count on approximately 9.8 million F.CFA per researcher[5].

The World Bank has recently requested the International Service for National Agricultural Research (ISNAR) to assist the government of Mali to prepare a long term plan for national agronomic research (ISNAR, 1988). The preparation of this plan is to be divided into three phases: 1) review of the agronomic research system, 2) preparation of the long term plan, 3) preparation of a body of proposals for its implementation. During the second phase involving the preparation of a long term plan, one of the working groups will address farming systems and the rural economy. The four other working groups will be focused on specific production sectors: rainfed crops, irrigated crops, livestock and the environment (including forestry, fisheries and the protection of natural resources). These working groups will propose research priorities. The preparation of this long term plan will bring together high level administrators and researchers. The different phases of preparation will be spread over a 10 month period from January 1989 and will be financed by the World Bank with a contribution from USAID.

A number of proposals for the restructuring of research have already been suggested. These revolve primarily around the decentralization of research activities across the country and the fusion of IER with the National Institute for Livestock Research, Forestry and Hydrobiology (INRZFH). With the preparation of this plan important changes in the organization and the establishment of priorities for research are to be expected. The organization of research on rural production systems could be affected by the reorganization of agronomic research in Mali.

B. THE ROLES OF THE DRSPR ACCORDING TO THE AGREEMENT BETWEEN IER AND USAID.

The goal of the USAID project is to improve the production, productivity and income of Malian rural households (AID, 1985). The objectives of the project are to furnish institutional support to IER in order to develop technologies appropriate to the needs and environment of Malian farmers and to promote the effective transfer of such technologies. The principal tasks of the project are: 1) the expansion of research on rural farming systems and extension in the second region during 1985 and the Fifth Region by 1989, 2) improvement of the linkages between research and development, 3) training of researchers.

By reading the protocol of agreement between IER and USAID one can determine the roles assigned to the DRSPR in the Mali context, which can be expressed in the following way. By means of close co-ordination of research activities with the research institutions (DRA of IER, INRZHF,

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4/ Equivalent to 41000 US dollars at $1 = F.CFA 280.

5/ Equivalent to 35000 US dollars at $1 = F.CFA 280.

DMA, etc.) and the ODR, by means of a specific training program for scientists, and by means of funds for construction, equipment and operational costs, the DRSPR should contribute to the increase of output and productivity of the rural sector. This contribution should arise through the introduction of appropriate technology packages to rural producers and through bringing to light information capable of orienting station research programs on the one hand and support programs for the rural population on the other. This would be accomplished by means of reconnaissance surveys, surveys focussed on specific issues, on-farm tests of promising technology with monitoring and calculation of profitability, etc.

One of the major roles of the DRSPR is consequently to ensure that technologies generated by the DRA are adapted to the varying conditions of producers. This requires the testing and modifications of the results from commodity research to the micro-climates and specific circumstances of producers. However, this role is not an easy one to fulfill. Accomplishing it depends on a number of preconditions. Primarily these are 1) the availability of technologies ready for testing in the rural environment, 2) the effectiveness of subsequent support from services to the rural areas, 3) a policy environment favorable to stimulating agricultural development. These three preconditions are key elements for the fulfillment of the role of research on rural farming systems. The more these technologies are lacking the more circumscribed will be the choice of technologies and the weaker their impact on the productivity of agricultural resources. These preconditions are treated in more detail in the following section.

In the course of the 10 year period anticipated, USAID will contribute to the financing of (AID, 1985):

- technical assistance (6.14 million dollars);
- training of researchers (1.84 million dollars);
- contribution to the national and regional offices (1.01 million dollars);
- equipment (1.42 million dollars);
- operational expenses (3.52 million dollars);
- 10% contingencies (1.39 million dollars);
- 5% inflation (4.18 million dollars).

USAID's contribution to recurrent costs will be regressive: from 82% in the first seven years to 63% in the last three years. The total cost of the project is estimated at 21.3 million dollars of which 19.5 million (92%) will be contributed by USAID and 1.8 million (8%) by the Government of Mali.

According to our estimates, based on the sums given in the project document (1985) and provided in tables 2.1 to 2.3, the total cost of expanding the project to the Fifth Region amounts to 5.73 million dollars, 27% of the total project cost, of which 5.24 million dollars (91%) will fall to USAID and 0.49 million dollars (9%) to the Government of Mali.

A multidisciplinary team of researchers comprising 4 Malians (agricultural economist, sociologist, agronomist and livestock scientist) and two expatriates for 4 years (agronomist and agricultural economist) is anticipated for the expansion of the DRSPR in the Fifth Region. The equipment and operational budgets are detailed in tables 2.1 to 2.3.

USAID is relatively open to other suggestions in regard to the use of the sum budgeted for the expansion of the DRSPR in the Fifth Region. In the event that this study should indicate the existence of better investment opportunities tnan research on rural farming systems in the Fifth Region, USAID would envisage the possibility of directing part or all of the funds to these opportunities.

The reasons for having chosen the Fifth Region are presented in the project document and are three in number (AID, 1985, p 15):

1) The region includes two zones important for cereal production, one in the south-east concentrating on the production of millet, the other in the north-west concentrating on the production of rice.

2) The region includes two research stations, one focusing on rainfed crops (principally millet, sorghum and cowpea), the other focusing on floating rice.

3) Besides the existence of the Operation Mil Mopti and the Operation Riz Mopti, there exists a third ODR. This is the Operation pour le Developpement de l'Elevage dans la region Mopti (ODEM) which facilitates research and extension in regard to the integration of crop and livestock production.

The project document does not consider alternative regions for an expansion of the DRSPR.

C. DIFFICULTIES CONFRONTING THE SYSTEMS APPROACH.

The primary objective of research on farming systems is the development of technologies which can overcome the principal constraints facing producers. These technologies should enhance the productivity of the farmers' resources and, as a result, their well being.

The literature reviewed (Norman, 1976; Byerlee, Collinson et al., 1980; Eicher and Baker, 1982; Martinez and Arauz, 1983) present similar approaches which include the following principal steps:

1) the descriptive phase during which the farming system is studied with a view to identifying the principal constraints impinging on the system;

TABLE 2.1: CAPITAL COSTS FINANCED BY AID (in $1000)

ITEMS	Year 1 (1988)	Year 2 (1989)	Year 3 (1990)	Year 4 (1991)	Year 5 (1992)	Year 6 (1993)	Year 7 (1994)	TOTAL	%
TECHNICAL ASSISTANCE :	0.00	340.00	325.00	310.00	305.00	5.00	5.00	1290.00	33.89
Agronomist	0.00	150.00	150.00	150.00	150.00	0.00	0.00	600.00	15.76
Agricultural economist	0.00	150.00	150.00	150.00	150.00	0.00	0.00	600.00	15.76
Short-term ass.(1)	0.00	40.00	25.00	10.00	5.00	5.00	5.00	90.00	2.36
SHORT-TERM TRAINING (1) :	0.00	35.00	27.50	27.50	27.50	0.00	0.00	117.50	3.09
Courses	0.00	10.00	10.00	10.00	10.00	0.00	0.00	40.00	1.05
Language training	0.00	7.50	0.00	0.00	0.00	0.00	0.00	7.50	0.20
Observation tours	0.00	7.50	7.50	7.50	7.50	0.00	0.00	30.00	0.79
In-country workshops,	0.00	10.00	10.00	10.00	10.00	0.00	0.00	40.00	1.05
COMMODITIES :									
Vehicles :	0.00	60.00	0.00	0.00	60.00	0.00	0.00	120.00	3.15
2 4WD	0.00	30.00	0.00	0.00	30.00	0.00	0.00	60.00	1.58
2 Pick up	0.00	24.00	0.00	0.00	24.00	0.00	0.00	48.00	1.26
2 motorcycle	0.00	2.00	0.00	0.00	2.00	0.00	0.00	4.00	0.11
8 mobylettes	0.00	4.00	0.00	0.00	4.00	0.00	0.00	8.00	0.21
RESEARCH EQUIPMENT (1) :	0.00	24.00	1.50	14.00	26.50	11.50	14.00	91.50	2.40
Computers	0.00	10.00	0.00	0.00	0.00	10.00	0.00	20.00	0.53
Computers Software	0.00	1.50	1.50	1.50	1.50	1 50	1.50	9.00	0.24
Field Equipment	0.00	12.50	0.00	12.50	25.00	0.00	12.50	62.50	1.64
OFFICE EQUIPMENT	0.00	20.00	0.00	0.00	20.00	0.00	0.00	40.00	1.05
FURNISHING (2) :	0.00	175.00	25.00	0.00	0.00	0.00	0.00	200.00	5.25
Koporo Station housing	0.00	40.00	0.00	0.00	0.00	0.00	0.00	40.00	1.05
Fifth region generators	0.00	25.00	0.00	0.00	0.00	0.00	0.00	25.00	0.66
Fifth region housing	0.00	50.00	25.00	0.00	0.00	0.00	0.00	75.00	1.97
Fifth region offices	0.00	60.00	0.00	0.00	0.00	0.00	0.00	60.00	1.58
CONSTRUCTION (2) :	305.60	348.20	76.00	0.00	0.00	0.00	0.00	729.80	19.17
Koporo Station Development:	113.00	94.00	0.00	0.00	0.00	0.00	0.00	207.00	5.44
Office addition	18.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	0.47
Professional housing	40.00	39.00	0.00	0.00	0.00	0.00	0.00	79.00	2.08
Staff housing	40.00	30.00	0.00	0.00	0.00	0.00	0.00	70.00	1.84
Guest house	15.00	25.00	0.00	0.00	0.00	0.00	0.00	40.00	1.05
DRSPR :	192.60	254.20	76.00	0.00	0.00	0.00	0.00	522.80	13.74
Office construction	30.00	42.00	0.00	0.00	0.00	0.00	0.00	72.00	1.89
Professional housing	50.00	80.00	30.00	0.00	0.00	0.00	0.00	160.00	4.20
Staff housing	50.00	70.00	20.00	0.00	0.00	0.00	0.00	140.00	3.68
Water tower	16.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00	0.42
Guest house	20.00	20.00	0.00	0.00	0.00	0.00	0.00	40.00	1.05
Garages	0.00	10.00	10.00	0.00	0.00	0.00	0.00	20.00	0.53
Construction coordinator	10.00	10.00	10.00	0.00	0.00	0.00	0.00	30.00	0.79
10% A&E services,supervision	16.60	22.20	6.00	0.00	0.00	0.00	0.00	44.80	1.18
SUB-TOTAL	305.60	1002.20	455.00	351.50	439.00	16.50	19.00	2588.80	68.02
Contingency : 0.10	30.56	100.22	45.50	35.15	43.90	1.65	1.90	258.88	6.80
Inflation : 1.05	72.44	304.58	170.22	157.41	230.56	10.01	13.14	958.36	25.18
TOTAL	408.60	1407.00	670.72	544.06	713.46	28.16	34.04	3806.04	100.00

(1) Only 50% of the budget estimates.

(2) Furnishing and construction are rescheduled on years one and two of the project.

Source: USAID/MALI. Farming Systems Research and Extension. Project Paper. AID. March 6, 1985.

TABLE 2.2: RECURRENT COSTS FINANCED BY AID (in $1000)

ITEMS	Year 1 (1988)	Year 2 (1989)	Year 3 (1990)	Year 4 (1991)	Year 5 (1992)	Year 6 (1993)	Year 7 (1994)	TOTAL	%
SALARIES :									
Professional Staff:	0.00	14.52	14.52	14.52	14.52	14.52	14.52	87.12	5.78
Agronomist	0.00	1.86	1.86	1.86	1.86	1.86	1.86	11.16	0.74
Economist	0.00	1.86	1.86	1.86	1.86	1.86	1.86	11.16	0.74
Livestock Specialist	0.00	1.86	1.86	1.86	1.86	1.86	1.86	11.16	0.74
Sociologist	0.00	1.86	1.86	1.86	1.86	1.86	1.86	11.16	0.74
2 Research assistants	0.00	3.24	3.24	3.24	3.24	3.24	3.24	19.44	1.29
8 Moniteurs	0.00	3.84	3.84	3.84	3.84	3.84	3.84	23.04	1.53
Support Staff:	0.00	20.46	20.46	20.46	9.42	20.46	20.46	111.72	7.42
2 Accountants	0.00	3.00	3.00	3.00	1.86	3.00	3.00	16.86	1.12
2 Data Specialists	0.00	7.44	7.44	7.44	3.24	7.44	7.44	40.44	2.69
Typist	0.00	1.80	1.80	1.80	0.54	1.80	1.80	9.54	0.63
Messenger	0.00	0.60	0.60	0.60	0.18	0.60	0.60	3.18	0.21
3 Drivers	0.00	5.22	5.22	5.22	2.70	5.22	5.22	28.80	1.91
2 Guards	0.00	0.60	0.60	0.60	0.36	0.60	0.60	3.36	0.22
Warehouseman	0.00	1.80	1.80	1.80	0.54	1.80	1.80	9.54	0.63
VEHICLE MAINTENANCE	0.00	13.50	14.50	14.50	10.50	10.50	10.50	74.00	4.91
OFFICE SUPPLIES	0.00	10.00	10.00	10.00	7.00	7.00	7.00	51.00	3.39
RENTS, UTILITIES, BUILDING MAINTENANCE	0.00	16.50	16.50	16.50	11.55	11.55	11.55	84.15	5.59
EXPENDABLE RES. SUPPLIES	0.00	12.00	12.00	12.00	8.40	8.40	8.40	61.20	4.06
COOPERATIVE RES., STUDIES(1) :	0.00	30.60	30.60	30.60	30.60	30.60	30.60	183.60	12.19
with DRA	0.00	15.00	15.00	15.00	15.00	15.00	15.00	90.00	5.98
with DMA, PIRT, INRZFH	0.00	15.00	15.00	15.00	15.00	15.00	15.00	90.00	5.98
with IPR	0.00	0.60	0.60	0.60	0.60	0.60	0.60	3.60	0.24
EVALUATIONS (1) :	200.00	0.00	0.00	40.00	0.00	0.00	80.00	320.00	21.25
inc. economic evaluation	200.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00	13.28
SUB-TOTAL	200.00	117.58	118.58	158.58	91.99	103.03	183.03	972.79	64.59
LOP Contingency : 0.10	20.00	11.76	11.86	15.86	9.20	10.30	18.30	97.28	6.46
Inflation : 1.05	47.41	35.73	44.36	71.01	48.31	62.48	126.62	435.93	28.95
TOTAL	267.41	165.07	174.80	245.45	149.50	175.82	327.95	1506.00	100.00

(1) 50% of the budget estimates.

Source: USAID/MALI. Farming Systems Research and Extension. Project Paper. AID. March 6, 1985.

TABLE 2.3: RECURRENT COSTS FINANCED BY THE GOVERNMENT OF MALI (in $1000)

ITEMS	Year 1 (1988)	Year 2 (1989)	Year 3 (1990)	Year 4 (1991)	Year 5 (1992)	Year 6 (1993)	Year 7 (1994)	Year 8 (1995)	Year 9 (1996)	Year 10 (1997)	TOTAL	%
SALARIES :												
Professional Staff:	0.00	37.20	37.20	37.20	37.20	37.20	37.20	0.00	0.00	0.00	223.20	45.63
Agronomist	0.00	4.20	4.20	4.20	4.20	4.20	4.20	0.00	0.00	0.00	25.20	5.15
Economist	0.00	4.20	4.20	4.20	4.20	4.20	4.20	0.00	0.00	0.00	25.20	5.15
Livestock Specialist	0.00	4.20	4.20	4.20	4.20	4.20	4.20	0.00	0.00	0.00	25.20	5.15
Sociologist	0.00	4.20	4.20	4.20	4.20	4.20	4.20	0.00	0.00	0.00	25.20	5.15
2 Research assistants	0.00	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	36.00	7.36
8 Moniteurs	0.00	14.40	14.40	14.40	14.40	14.40	14.40	0.00	0.00	0.00	86.40	17.66
Support Staff:	0.00	3.60	3.60	3.60	14.70	3.60	3.60	0.00	0.00	0.00	32.70	6.69
2 Accountants	0.00	3.00	3.00	3.00	4.20	3.00	3.00	0.00	0.00	0.00	19.20	3.93
2 Data Specialists	0.00	0.00	0.00	0.00	4.20	0.00	0.00	0.00	0.00	0.00	4.20	0.86
Typist	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	1.26	0.26
Messenger	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.42	0.09
3 Drivers	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.00	0.00	0.00	2.52	0.52
2 Guards	0.00	0.60	0.60	0.60	0.84	0.60	0.60	0.00	0.00	0.00	3.84	0.79
Warehouseman	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	1.26	0.26
VEHICLE MAINTENANCE	0.00	0.00	0.00	0.00	4.35	4.35	4.35	0.00	0.00	0.00	13.05	2.67
OFFICE SUPPLIES	0.00	0.00	0.00	0.00	3.00	3.00	3.00	0.00	0.00	0.00	9.00	1.84
RENTS, UTILITIES, BUILDING MAINTENANCE	0.00	0.00	0.00	0.00	4.95	4.95	4.95	0.00	0.00	0.00	14.85	3.04
EXPENDABLE RES. SUPPLIES	0.00	0.00	0.00	0.00	3.60	3.60	3.60	0.00	0.00	0.00	10.80	2.21
COOPERATIVE RES., STUDIES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUB-TOTAL	0.00	40.80	40.80	40.80	67.80	56.70	56.70	0.00	0.00	0.00	303.60	62.07
LOP Contingency : 0.10	0.00	4.08	4.08	4.08	6.78	5.67	5.67	0.00	0.00	0.00	30.36	6.21
Inflation : 1.05	0.00	12.40	15.26	18.27	35.61	34.39	39.22	0.00	0.00	0.00	155.15	31.72
TOTAL	0.00	57.28	60.14	63.15	110.19	96.76	101.59	0.00	0.00	0.00	489.11	100.00

Source: USAID/MALI. Farming Systems Research and Extension. Project Paper. AID. March 6, 1985.

2) the planning phase during which a number of technologies are selected for their potential to alleviate constraints identified during the first phase (they are then developed and tested through station research);

3) the experimentation phase during which a smaller number of the most promising technologies are evaluated on farmers' fields with their participation;

4) the pilot extension phase during which technologies best able to overcome the identified constraints undergo exposure to real production conditions across a larger number of farmers, with a view to assessing their likely future diffusion and adoption.

The successive implementation of these four phases, however, raises some major difficulties. Firstly, factors exogenous to the farming system, such as infrastructure and agricultural policy, can be so constraining on the farming system that it would be more effective to tackle these factors initially. In effect, if the productivity of the farming system is seriously constrained by such factors, it would only be those technologies requiring the least inputs from outside the system (fertilizer, improved seed), the least institutional support (credit, extension) and the least dependence on external markets which would be selected in response to the constraints impinging on the farming system. Consequently, these would also be the technologies least able to bring about a radical improvement in the productivity of the resources of the system. In certain cases, therefore, it is preferable to use the descriptive phase to develop recommendations pertaining to the improvement of infrastructure or policy reforms. The potential benefits in terms of increased production which would arise from any given measure can be communicated to public decision makers.

Secondly, the availability of technologies already developed, at station level or in other countries with a similar environment, and capable of providing leverage on the constraints to the farming system affects the development of third phase - that of experimentation. If few technologies are available this phase is considerably retarded (Norman, 1976). In Burkina Faso for example, as far as the improvement of millet varieties is concerned there has been no selected variety up to the present which is better than local varieties. Matlon (1985) attributes this to the methods used on station. He recommends close co-ordination between station and farm level research and to work in an iterative fashion.

Thirdly, the results of systems research depend heavily on good coordination between commodity research and systems research. Given their complementarity, co-ordination should be in both directions without one receiving priority over the other. On the one hand systems research communicates the problems encountered at farm level to commodity research, and participates in the development of station research programs. On the other hand, commodity research will assist systems research to design, implement and analyze farm level tests. In

this way also, commodity research receives greater feedback and can quickly reorient its station experimental program.

These three major difficulties will be analyzed in the next section in the light of the current situation in the Fifth Region of Mali. The analysis of one additional factor affecting the success of the systems approach will be added to these three difficulties: the effectiveness of the systems research team responsible for implementing the research program. This analysis will be carried out on the basis of the experience accumulated in Mali in regard to farming systems research.

D. KEY FACTORS AFFECTING THE SUCCESS OF THE DRSPR IN THE FIFTH REGION.

This section begins by presenting the principal factors capable of affecting the success and therefore the feasibility of systems research in the Fifth Region. The presentation gives more weight to the first factor discussed, the present or future availability of potential technologies which might be extended to farmers through the efforts of the DRSPR. This is so not because it is necessarily the most important factor to consider for the development of the Fifth Region but because it is the mandate that systems research is generally expected to fulfill in regard to technology. Focussing on this aspect is not intended to play down the importance of other aspects such as the institutional and socio-economic environment, the co-ordination between research and development, and the effectiveness of the systems team. These will be taken up according to their influence on the availability and transfer of appropriate technologies.

1. Identification of Key Factors.

One can consider the DRSPR to be part of a system established in order to generate and transfer technologies appropriate to crop or livestock farmers. The other components of this system are: 1) the national commodity research institutes (DRA, INRZFH, etc.) and the international research institutes (ICRISAT, ILCA, SAFGRAD, etc.), 2) the extension services (ODR), 3) the support services for rural areas[6] (BNDA, DNACOOP,etc.), 4) the private sector for the input and commodity markets and 5) the agricultural policy of the country which affects each of the system components. The DRSPR lies at the center of this system

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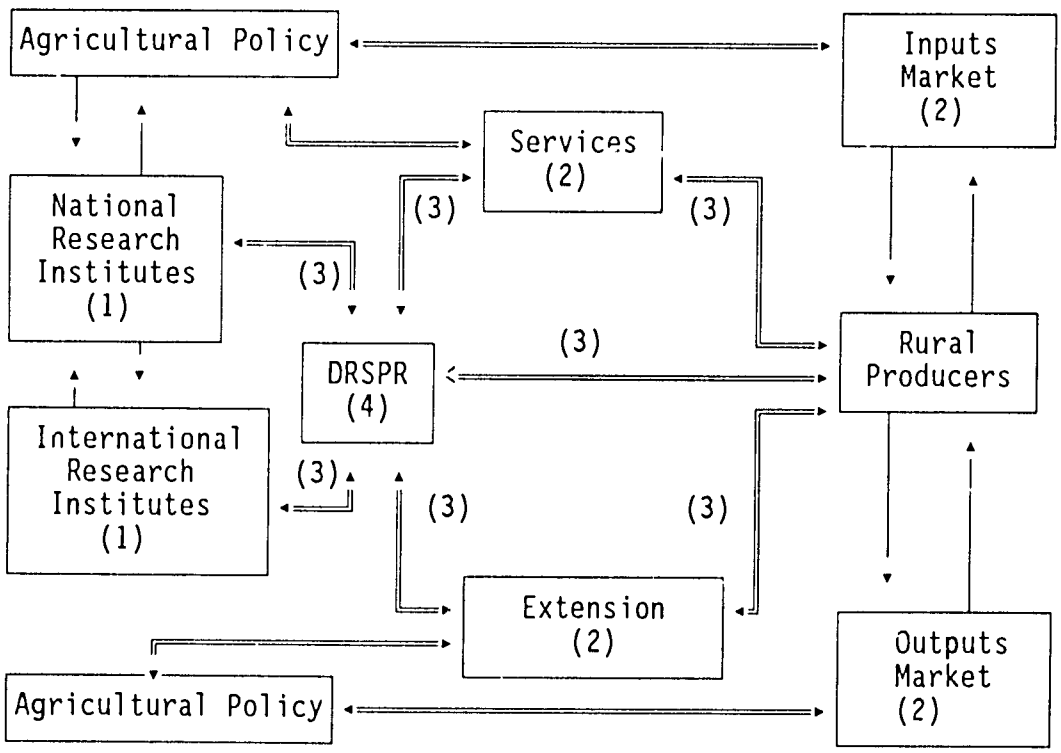
6/ A distinction is drawn here between extension and other support services for the rural population. The extension services are public institutions whose beneficiaries cannot be identified precisely (i.e. exactly which farm households benefit from the service and to what extent). The effects of these services are spread throughout the rural community. For other services such as credit, on the other hand, it is possible to allocate the cost of the credit services to the specific farm households who are the beneficiaries.

for generating and transferring technologies with a special relationship to the eventual clients of the system, i.e. the crop and livestock farmers in the target zone (Figure 2.1)

The DRSPR refines the technology packages which can be considered as intermediate products, i.e. final products for the research system but inputs for the production system of the crop and livestock farmers which use them. The benefits from the development of these intermediate products can only be measured when they are finally adopted and give rise to increased revenues or decreased costs of production at farm level.

FIGURE 2.1: THE SYSTEM FOR THE GENERATION AND TRANSFER OF IMPROVED TECHNOLOGIES.



For the remainder of the report we will consider there to be four key factors exercising a heavy influence on the profitability of any expansion of the DRSPR in the Fifth Region. These four factors are introduced in this section. They relate to 1) the stock of potential technologies which are currently available at the level of commodity research or which will be available in the near future, 2) the effect of institutions and level of infrastructural development on the diffusion and eventual adoption of promising technologies, 3) the degree of coordination between commodity research, systems research, extension and rural people, 4) the effectiveness of the systems research team. These four factors (identified by number in figure 2.1) have been included because they strongly affect 1) the timing of the development and diffusion of technologies, 2) the phasing of research activities

progressively addressing a larger and larger number of recommendation domains[7] 3) the increase in the productivity of resources under the control of the farm household. These effects, represented in table 2.4, will determine the feasibility and profitability of an eventual expansion of the DRSPR in the Fifth Region.

TABLE 2.4: THE KEY FACTORS AFFECTING THE CONTRIBUTIONS AND IMPACT OF SYSTEMS RESEARCH.

FACTORS	EFFECTS	IMPACT
1) Potential technologies stock	2) Technologies development and diffusion timing	Regional production and productivity increase
2) Infrastructures and institutions	2) Research activities timing	
3) Research and development co-ordination	3) Farm unit resources productivity increase	
4)Research systems team		

2. The Availability of Potential Technologies in Relation to the Constraints Impinging on Agriculture in the Fifth Region.

This section points to the lack of technology currently available at research station or pilot extension level capable of mitigating the major constraints facing farmers in the Fifth Region. A number of technologies on which researchers had placed their hopes did not in the end show themselves to be better than traditional technologies. On the other hand, the current directions in station research allow optimism that several promising technologies will be available in the next decade.

a. The Technologies Potentially Available.

A potentially available technology is defined here as one which has already proved itself in station research or in pilot extension but which, for one reason or another, has not spread widely through the rural community. It is possible that diffusion on a wide scale requires slight adaptation to the current form of the technology or a brief push from farmer services. In analyzing the results achieved on station and

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7/ A recommendation domain (RD) is a group of farmers for whom one can propose the same types of recommendation, and therefore technologies, because they experience the same constraints.

through pilot extension, only two technologies appear to have real promise for the Fifth Region. These are early cowpea varieties with chemical protection and Tilemsi rock phosphate.

(1) Early cowpea varieties.

SAFGRAD has tested improved cowpea varieties with inorganic fertilizer in the Fifth Region (1985, 1986, 1987). These improved cowpea varieties, which received 40 kg/ha triple superphosphate and one to three applications of pesticide are significantly more productive than local cowpea varieties under the same management (tables 2.5 and 2.6). For the central Seno zone (21 sites over 3 years), the average grain yield of these two improved varieties was 2.7 times higher than that of local varieties. There was no difference in the hay yield on the other hand.

(2) Tilemsi rock phosphate (TRP).

SAFGRAD has also tested TRP in the Fifth Region (1979, 1980, 1981, 1982). A single dose of 300 kg/ha TRP was applied at the outset of three year rotations for groundnut-millet-groundnut and millet-millet-millet. The most significant increases in yield were those obtained with application of TRP to the three year rotation millet-millet-millet (1389 and 775 kg/ha for the first and second series of tests respectively, table 2.7).

The first technology presented above reduces the effect of the reduction in rainfall. The improved cowpea varieties are earlier than the local varieties (60-70 days compared to 80-90 days) and more resistant to drought stress. They are consequently better adapted to the reduced rainfall of the Fifth Region. These varieties are however more susceptible to attack by insect pests. They require protection both in field and storage. Being a legume, cowpea has a beneficial effect on soil fertility. The production of hay from improved varieties is neither greater or less than that of local varieties (tables 2.5 and 2.6). Given the limited number of replications, however, this should be confirmed.

The second technology mitigates the effect of soil phosphate deficiency on crop yields, at least in the southern zones of the Fifth Region where rainfall is sufficient for the TRP to become soluble. If this package is adopted on a large scale, admittedly after first resolving the problems of supply and formulation, it could contribute to the maintenance and perhaps even the improvement of soil fertility.

b. Technologies with Limited Potential.

The remainder of this section presents an evaluation of several technologies tested on-farm but which may not lead to improved recommendations because their performance is not superior to that of

traditional technologies. This brief review is made in order 1) to show that, contrary to the hopes placed on them, these technologies cannot be taken up by the DRSPR for transfer to the farming community and 2) to indicate that a well executed systems research program in co-ordination with commodity research and extension can lead to more effective use of the manpower and financial resources available to research. Three examples are used for this review. The first is the testing of inorganic fertilizer on improved varieties of early millet. The second

TABLE 2.5: TESTS OF EARLY COWPEA VARIETIES IN OPERATION MILS MOPTI AREA: SENO, BANDIAGARA PLATEAU AND DOUENTZA.

AREAS	YEAR	Rainfall (mm)	Yield in Grain (kg/ha) for Cowpea Varieties			Yield in Hay (kg/ha) for Cowpea Varieties			Number of Experiment
			Local	TN 88-63	Gorom-gorom	Local	TN 88-63	Gorom-gorom	
	1985	259	13	308	-	-	-	-	1
Douentza	1986	301	354	709	1447	-	-	-	1
	1987	287	281	669	431	-	-	-	1
Douentza Average		282	216	562	939	-	-	-	3
Central	1985	293	72	310	-	-	-	-	9
Seno	1986	378	241	671	759	-	-	-	8
	1987	252	374	652	636	433	413	392	4
Central Seno Average		308	229	544	698	433	413	392	21
South	1985	285	17	193	-	-	-	-	1
Seno	1986	394	38	701	402	-	-	-	2
	1987	347	329	497	525	131	200	225	2
South Seno Average		342	128	464	463	-	-	-	5
Bandiagara	1985	-	-	-	-	-	-	-	-
Plateau	1986	350	0	151	27	-	-	-	1
	1987	-	-	-	-	-	-	-	-
Bandiagara Plateau Av.		350	0	151	27	-	-	-	1

Notes: Inputs in 1985 : 65kg/ha of "super simple" phosphate with 21% of P_2O_5.
1 treatment of Décis (3.5l/ha) with T15 or ULV
1986 : 40kg/ha of "super triple" phosphate with 45% of P_2O_5.
3 treatments of Décis
1987 : 76kg/ha of "super simple" phosphate with 18% of P_2O_5.
2 treatments of super ED Cymbush (750 ml/ha) with Electrodyn

Source: Rapport des campagnes 1985, 1986, 1987. Projet conjoint N°31 de l'OUA-CSTR-SAFGRAD. Programme PRAA-Mali. IER, Bamako.

TABLE 2.6: TESTS OF EARLY COWPEA VARIETIES IN OPERATION MILS MOPTI AREA: THE DELTA ZONES.

AREAS	YEAR	Rainfall (mm)	Yield in Grain (kg/ha) for Cowpea Varieties			Yield in Hay (kg/ha) for Cowpea Varieties			Number of Experiment
			Local	TN 88-63	Gorom-gorom	Local	TN 88-63	Gorom-gorom	
Central Delta	1985	291	50	303	-	-	-	-	3
	1986	264	638	1094	650	-	-	-	1
	1987	175	35	96	43	100	156	175	1
Central Delta Average		243	241	498	347	100	156	175	5
South Delta	1985	338	48	279	-	-	-	-	2
	1986	247	69	731	597	-	-	-	1
	1987	173	13	413	338	653	569	409	1
South Delta Average		253	43	474	468	653	569	409	4

Notes: Inputs in 1985 : 65kg/ha of "super simple" phosphate with 21% of P_2O_5.
1 treatment of Décis (3.5l/ha) with T15 or ULV
1986 : 40kg/ha of "super triple" phosphate with 45% of P_2O_5.
3 treatments of Décis
1987 : 76kg/ha of "super simple" phosphate with 18% of P_2O_5.
2 treatments of super ED Cymbush (750 ml/ha) with Electrodyn.

Source: Rapport des campagnes 1985, 1986, 1987. Projet conjoint N°.31 de l'OUA-CSTR-SAFGRAD. Programme PRAA-Mali. IER, Bamako.

TABLE 2.7: EFFECT OF A 300 KG/HA APPLICATION OF TRP AT THE BEGINNING OF A THREE YEAR ROTATION (groundnut-millet-groundnut and millet-millet-millet) (1).

AREA	First Series (1979-81)		Second Series (1980-82)		Groundnut-Millet-Groundnut Rotation				Millet-Millet-Millet Rotation	
	Number of Experiment	Average Rainfall (mm)	Number of Experiment	Average Rainfall (mm)	1st Series		2nd Series		1t Series	2nd Series
					Groundnut	Millet	Groundnut	Millet	Millet	Millet
North	0	-	2	313	-	-	170	100	-	619
Center	2	352	8	345	300	804	43	145	1004	456
South	1	443	2	368	327	195	128	116	1389	775
Plateau	0	-	3	292	-	-	456	152	-	438

(1) Cumulative increase in yields (kg/ha) during the three years of tests.

Source: From SAFGRAD data (1979, 1980, 1981, 1982). See Annex C.

is the technology package tested by Action Pilote Mil. The third is the technology package promoted by ORM.

(1) Inorganic fertilizer on improved varieties of early millet.

On-farm tests of early maturing millet varieties (IBV 8001 and HKP) have not shown them to be significantly better than local varieties. SRVCO (Section de Recherche sur les Cultures Vivrieres et Oleagineuses, under DRA) and SAFGRAD nevertheless recommend them for low rainfall zones. However, SAFGRAD's results (1985, 1986, 1987) given in tables 2.8 and 2.9 do not indicate that these improved varieties give better yields than the local varieties when rainfall is low or badly distributed. SAFGRAD estimates that attacks by granivorous birds reduce potential yields by 40%. It is on this basis that SAFGRAD justifies the potential superiority of improved varieties over local varieties. In order to arrive at a better evaluation of these improved varieties the DRSPR could test them systematically and record farmers opinions of them.

Cultivated with the use of inorganic fertilizer (100 kg/ha phosphate of ammonia and 50 kg/ha urea), these improved millet varieties did not yield significantly better than local varieties.

(2) The technology package tested by Action Pilote Mil.

Action Pilote Mil tested a technology package in three villages around the Koporo agronomic research sub-station in the Seno plain (1985-1986). The technology package comprised land preparation with a plow, short and long cycle local millet varieties ("Ningari" and "NBB"), sifting and seed treatment with Thioral (10 g to each 5 kg of seed) and Metalaxyl, planting in rows and on the square (1m by 1m), 100 kg/ha phosphate of ammonia and 50 kg/ha urea at weeding, thinning, three weedings, treatment with Cypermetrine against Rhaguva (headborer), uprooting and burning of plants affected by mildew and wild millet plants (Chibra) and finally a storage treatment of actellic dust.

This intensive care technology package was tested alongside a less intensive package without urea application and manual or chemical phytosanitary treatments with the exception of seed treatment with Thioral. Table 2.10 below compares the profitability of the intensive technology package with that of the semi-intensive and traditional technologies. This comparison was carried out over two seasons, one with mediocre rainfall (360mm in 1985) and the other with average rainfall (550 mm in 1986). The rough estimates of increased net revenues show clearly that these technology packages are not profitable, even without taking into account capital amortization or additional labor.

Matlon (1987) arrived at a similar conclusion. Among cereals such as rice, maize, sorghum and millet, millet responds least to inorganic fertilizer. Considering the sale price of millet and the cost of

TABLE 2.8: TESTS OF EARLY MILLET VARIETIES IN OPERATION MILS MOPTI AREA: SENO, BANDIAGARA PLATEAU AND DOUENTZA.

AREA	YEAR	Rainfall (mm)	Yield in Grain (kg/ha) of the millet varieties w.fertilizer			Yield in Grain (kg/ha) of the millet varieties w/o fertiliz			Number of Experiment
			Local	IBV 8001	HKP	Local	IBV 8001	HKP	
Douentza	1985	199	512	230	-	-	-	-	3
	1986	-	-	-	-	-	-	-	-
	1987	176	527	120	188	436	322	285	1
Douentza Average		187	520	175	188	438	322	285	4
Central Seno	1985	362	739	704	-	-	-	-	8
	1986	452	548	1069	458	355	646	285	8
	1987	273	690	449	414	654	411	329	3
Central Seno Average		362	659	740	436	504	528	307	19
South Seno	1985	-	-	-	-	-	-	-	-
	1986	-	-	-	-	-	-	-	-
	1987	256	737	410	647	440	303	339	2
South Seno Average		256	737	410	647	440	303	339	2
Bandiagara Plateau	1985	415	-	1101	-	-	-	-	1
	1986	258	628	618	290	310	315	429	1
	1987	-	-	-	-	-	-	-	-
Plateau Average		336	628	860	290	310	315	429	2

Notes: Inputs in 1985, 1986, 1987 : 100kg/ha of ammonium phosphate and 50 kg/ha of urea.

Source: Rapport des campagnes 1985, 1986, 1987. Projet Conjoint N°.31 de l'OUA-CSTR-SAFGRAD. Programme PRAA-Mali. IER, Bamako.

TABLE 2.9: TESTS OF EARLY MILLET VARIETIES IN OPERATION MILS MOPTI AREA: THE DELTA ZONES.

AREA	YEAR	Rainfall (mm)	Yield in Grain (kg/ha) of the millet varieties w.fertilizer			Yield in Grain (kg/ha) of the millet varieties w/o fertiliz			Number of Experiment
			Local	IBV 8001	HKP	Local	IBV 8001	HKP	
Central Delta	1985	301	1114	1021	-	-	-	_	2
	1986	266	1249	785	876	1320	888	840	2
	1987	223	225	463	450	375	550	413	1
Central Delta Average		263	863	756	663	848	719	627	5
South Delta	1985	-	-	-	-	-	-	-	-
	1986	373	897	730	856	717	555	421	1
	1987	200	450	325	425	288	188	200	1
South Delta Average		286	674	528	641	503	372	311	2

Notes: Inputs in 1985, 1986, 1987 : 100kg/ha of phosphate of ammonia and 50kg/ha of urea.

Source : Rapport des campagnes 1985, 1986, 1987. Projet Conjoint N°.31 de l'OUA-CSTR-SAFGRAD. Programme PRAA-Mali. IER, Bamako.

TABLE 2.10: CHANGE IN NET REVENUES WITH THE USE OF THREE TECHNOLOGY PACKAGES FOR MILLET.

Comparison of the Technical Packages	Year	Rainfall (mm) (1)	Yield Increase (kg/ha)	Millet Price(F/kg) (F.CFA/ha)	Gross Revenue Increase (F.CFA/ha) (2)	Cost Increase (F.CFA/ha)	Net Revenue Increase
Intensive vs Semi-intensive	1985	360	232	50	11600	10240	1360
	1986	550	346	30	10380	10240	140
Intensive vs Traditional	1985	360	399	50	19550	24240	-4690
	1986	550	657	30	19710	24240	-4530
Semi-intensive vs Traditional	1985	360	167	50	8350	14000	-5650
	1986	550	311	30	9330	14000	-4670

(1) The producer price at harvest, recorded at the weekly markets in the zone, was 30 F/kg in 1986 (a year of average rainfall) and 50 F/kg in 1987 (a year of poor rainfall).

(2) The increase in costs concerns only those agricultural inputs purchased off-farm. The increase is therefore an underestimate since it does not take into account amortization of agricultural equipment and draft animals, or the additional labor necessary. Costs are estimated at the purchase price for inputs in 1987:

100 kg phosphate of ammonia at 140 F/kg = 14000 F/ha.
50 kg urea at 130 F/kg = 6500 F/ha.
2.4 l Cypermetrine at 1500 F/l = 3600 F/ha.
Fungicide = 140 F/ha.

Source: Based on raw data from the 1985 and 1986 Annual Reports. Action Pilote Mopti. Projet de lutte intégrée contre les ravageurs des cultures vivrières dans le Sahel. CILSS. IER. Bamako.

purchasing fertilizer, which never ceases to rise, application of mineral fertilizer to millet is not profitable. However, according to Matlon, the application of TRP on millet is justified if nitrogen is not limiting, rainfall is adequate and the crop is planted early.

(3) The technology package promoted by the Operation Riz Mopti (ORM).

For the cultivated holdings of the flooded areas of the Delta, the falling level of the flood limits the profitability of the technology packages promoted. ORM is promoting a technology package which is potentially superior to traditional practices. The rice variety for the package is Oryza sativa DM 16. This variety is appreciated by rice growers for its earliness (135 days as opposed to 150 days for Khao Gaew), its adaptability to different levels of flooding, its

satisfactory yield and long, fine and better tasting grain than that of Khao Ghew (Dembele, 1986). The other components of the package include an end of season plowing, a seeding density of 70 kg/ha, 100kg/ha phosphate of ammonia at planting and 50 kg/ha urea 10 days after immersion and two hand weedings after emergence. When rainfall is sufficient for development of the seedling and when the flood arrives at the right time and is sufficient, this package can give yields in areas of average flooding in the order of 2,200 to 2,500 kg/ha compared to 1,200 to 1,500 kg/ha for the traditional method (variety Khao Gaew sown on a plowed parcel at a density of 70 kg/ha). With the help of a partial budget provided by Ouedraogo and Coulibaly (1984), the marginal rate of return is estimated at 109% on the basis of 1983-84 prices for inputs and open market price for rice of 183 FM/kg.

Despite this high marginal rate of return the package is not widely adopted by ORM rice cultivators. According to them the recommended fertilizer dose is beyond their means (35,000 FM in 1983[8]) and is risk in view of the uncertain rainfall and hydrological regime (Ouedraogo and Coulibaly, 1984). According to ORM statistics, the fertilized area of the ORM holdings has never exceeded 7%, the maximum being fertilized in 1982-1983. Since then the proportion has dropped between 1% and 2% because of successive drought years. It can be seen from table 2.11 that a peak flood of the Bani river at Mopti approaching 550 cm is necessary for 60% of the cultivated area to be harvested. This level has not been reached in four out of the last ten years (1983, 1984, 1986, 1987). This means that three years out of ten the rice grower risks losing an investment of 67,962 FM[9] over and above his traditional technology. One can understand that this technology package has not been adopted by rice growers on the ORM holdings.

In order to avoid such a risky investment, the Mopti rice research station tested the same type of package, but replacing phosphate of ammonia with TRP, on the holdings of Operation Riz Segou (ORS). First year tests at Konodimini, Tien-konou, Soke and N'gara and second year tests at Konodimini and Soke did not show significant differences across increasing rates of TRP application. For urea, only one test in the first year gave a significant difference at Soke 1 (Diarra et al., 1987; Commission Technique Specialisee des Productions Vivrieres et Oleagineuses, 1988).

c. Promising Technologies for the Future.

In view of the poor response of millet to fertilizer one would anticipate the need to select millet varieties which respond well. However, because of earlier setbacks with tests of varieties that demonstrated high yield potential on station but succumbed to numerous stresses on farm (see section II.3), the research stations of the

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8/ Equivalent to 17,500 F.CFA.

9/ Equivalent to 33,981 F.CFA.

TABLE 2.11: BEHAVIOR OF AREA, PRODUCTION AND YIELDS AT ORM FROM 1977 TO 1986 ACCORDING TO RAINFALL AND FLOOD LEVEL

Agricultural Season	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1986-87
Rainfall in Mopti (1)	-	-	402	546	396	270	433	307	343	454	
Maximum Height of the Flood of the Bani in Mopti in cm (2)	566	620	638	592	628	551	502	440	570	534	
Allotted Area in Ha	21212	21080	18921	21357	29307	29085	30745	30095	29831		27042
Harvested Area in Ha	-	13553	12401	12341	17008	25225	3556	0	18068	7740	1070
Harvested Area in %	-	64	66	58	58	59	12	0	60		4
Production in Ton	-	15528	13395	13445	17819	18334	5334	0	25722	5740	761
Yield (kg/ha) *	1128	1145	1080	1089	1021	728	1500	0	1424	742	711

Note: * Yield for the area harvested.

Sources: Annual Reports and memento ORM, Mopti.
(1) : Rapports Annuels de l'OMM, Mopti.
(2) : Rapport Annuel 1985. Station Régional de Recherche sur le riz flottant et d'immersion profonde. Mopti. CNRA. Avril, 1986.

Sahelian zone have embarked on a selection program for varieties that are more stable, resistant or tolerant to a wider spectrum of physical and biological factors. Having selected earlier maturing varieties which escape end of season drought (IBV 8001 and HKP), commodity research is currently selecting millet varieties which are resistant to Striga and mildew. Drought resistance is more difficult (Matlon, 1987). In Mali, the co-operative program IER-INTSORMIL is screening millet varieties for resistance to drought in the early growth stages and to drought pre and post flowering (Commission Technique Specialisee des Productions Vivrieres et Oleagineuses, 1987). Composites are created from mildew resistant varieties of Indian origin and local varieties (Commission Technique Specialisee des Productions Vivrieres et Oleagineuses, 1988).

There is also intense research activity in the area of intercropping. For the millet-cowpea intercropping pattern which dominates the agriculture of the Fifth Region, researchers are beginning to understand the interactions between plant geometry, spacing, planting date and time of harvest, fertilization and crop protection (S.Traore, 1988). These results, combined with a better understanding of traditional techniques, can provide a point of departure for the

development of on-farm tests. Research has also been carried out on land preparation methods for increasing soil moisture conservation. These methods could be combined with the technologies mentioned above to constitute technology packages. However, they can only be introduced to the farming community on a large scale if a number of other problems are studied and solutions found. These comprise access to appropriate agricultural equipment on the one hand, and on the other the upkeep of draft animals. These two aspects will be taken up in the next section.

Varietal improvement for floating rice is being undertaken. The variety Oryza sativa DM 16 is being used as a check for the selection of higher yielding varieties less susceptible to stemborers. Varietal improvement is sought through varietal performance trials on the one hand, and by hybridization on the other (M.Diarra, Director of the Mopti Rice Research Station, personal communication, August 1987).

From the varietal performance trials two Oryza sativa rice varieties have been carried forward. The variety BKN 6323 is semi early (135 days), photoperiod sensitive, adapted to the average maximum flooding depth (reaching 1.50 m) but its susceptibility to stemborers has not yet been tested. The variety FRRS 43-3 is semi late (150 days), photoperiod sensitive, adapted to the average maximum and minimum depth of flooding (reaching 1.60m) (SRCSS, 1987). Again, susceptibility to stemborers has not been tested up to the present.

In the area of hybridization research is aimed at crossing varieties of floating rice that are well adapted to the region with rice varieties chosen with a view to increasing the productivity of existing floating rice varieties. Results of this hybridization program are expected in four to five years (M.Diarra, Director of the Mopti Rice Research Station, personal communication, August 1987).

The floating rice Oryza sativa is not the only species of rice cultivated in the Delta zones. There is also the floating rice species Oryza glaberrima cultivated under natural submersion outside of the holdings managed by ORM.

The species Oryza glaberrima is a hardy species which has evolved in the ecological conditions of the Delta. It is more resistant to insects, weeds, diseases and drought than the species Oryza sativa. The species Oryza glaberrima is better adapted than Oryza sativa to the different levels of flooding. A number of Oryza glaberrima varieties are early and retain their germination capacity in the event of insufficient moisture. They generally have higher seedling vigor enabling them to compete more effectively against weeds. The principal defects of the Oryza glaberrima varieties is their low yield potential and heavy shattering at maturity of the ears. The species Oryza glaberrima has a more stable level of production than the Oryza sativa species, representing a valuable attribute given the risks of rice cultivation whether under natural or even controlled flooding.

In an attempt to reduce the shattering of the Oryza glaberrima varieties the Mopti rice research station is conducting a program of varietal improvement by screening and by radiation techniques. The radiation techniques practiced by Swiss laboratories has not yet yielded positive results (M. Diarra, Director of the Mopti Rice Research Station, personal communication, August 1987).

d. Conclusion.

This rapid review of available potential technologies which could be tested and adapted to the conditions at farm level by a program of farming systems research, reveals that such technologies are few in number. It appears that improved varieties of cowpea and Tilemsi rock phosphate combined into technology packages are the only technologies currently available which can make a difference to traditional technologies.

In regard to crop storage, low cost chemicals such as actellic dust and phostoxin are available which could reduce post harvest losses. If their supply and utilization should present difficulties one other alternative that could be studied is the improvement of traditional methods of crop storage.

These three technologies, each one integrated into a package, could be tested at farm level from the outset of the DRSPR's work in the Fifth Region. It will also be necessary to continue testing the improved millet varieties IBV 8001 and HKP in order to more accurately determine the benefits of these early varieties.

Technologies that could be available later on include improved varieties of millet, Oryza sativa rice, Oryza glaberrima rice and other varieties currently undergoing development by research. These will emerge during the next decade and could become the subject of on-farm testing.

3. Regional Infrastructure and Institutions.

The infrastructure and institutions of the Fifth Region are important factors affecting technology options and the rate of adoption of technologies being extended. The state of input supply and marketing, pricing policy, the credit system, access to productive resources such as land and family or hired labor have a considerable effect on the diffusion of technology packages. We will see in the following chapters that these constraints are very important in the Fifth Region. The development of technology packages needs to take them into account.

A better understanding and appreciation of these constraints would enable recommendations to be derived for institutional reform or improvement of the Fifth Region's infrastructure. Such reforms and improvements could have a major impact on the productivity of farming

systems, and therefore on the crop and livestock production of the Fifth Region. Studies and surveys to this end could be undertaken by an eventual systems research team. In this kind of study it is important that the potential gains from proposed reforms or infrastructure improvements be stated as clearly as possible in order to facilitate decision making.

4. Coordination between Research and Development.

In his 1980 evaluation report for the research project on the farming systems of southern Mali, Ariza-Niño regretted that systems research constituted a distinct division from that of the Agronomic Research Division (DRA). According to him, the interaction between researchers and producers would have been strengthened by creating a farming systems research unit within the DRA. As far as he is concerned the fact that the DRSPR and DRA come under the overall responsibility of IER does not guarantee good coordination. The annual meetings of the Commission Techniques de la Recherche Agronomique are not sufficient for a detailed discussion of research themes and priorities.

Similarly, eight years later, Cassas (1987) observes that "IER is not so much a unified research institution as a collection of programs". He notes that a number of divisions are studying the same themes but with separate programs, that functions are confounded between the DRSPR (in conducting sectorial research for example) and the DRA (carrying out on-farm trials), and that the DET and the DPE are carrying out applied research without linking up with the DRSPR.

Coordination between commodity and systems research is not the only form desirable. Coordination with the ODR is also very important. In recent years the DRSPR has reaffirmed coordination with CMDT in the pilot extension of a number of promising technology packages (informal survey 7 - 11 June 1988). In 1987, for example, CMDT incorporated into its extension program three areas of research conducted by the DRSPR: advice on management, training of oxen and improved animal enclosures. In 1988, a program to combat erosion was established following the development of techniques by the DRSPR Fonsebougou systems research team. Launching research themes with the extension service involved from the outset in the implementation and monitoring of farm level tests is the approach currently practiced by the OHV section of the DRSPR.

Coordination remains difficult to establish with decision makers in the area of pricing policy, credit policy, and land management policy. The fiscal and customs regimes also have considerable influence on the development of crop and livestock production. These influences are often little understood, however, and consequently are rarely challenged.

5. The Productivity of the Systems Research Team.

Several factors affect the productivity of a multidisciplinary team. Among these factors are the motivation of each team member and the coordination of all members tasks. The theoretical training and accumulated experience of each member are equally important. Finally, the experience accumulated by the research institution within which the team evolves and the financial resources available are also important factors.

A quick method for estimating the productivity of a systems team is to compare the number of researcher man years required for the development of a research theme (from diagnosis to extension) with the product obtained prior to extension. The product developed by systems research can be evaluated in terms of its potential impact on the productivity of farmers' resources. Although it is not valid to project an estimate of the time and resources for systems research to achieve concrete results in one situation to that of another such as the Fifth Region, at least it gives an idea of the time and resources required.

For the Fonsebougou section, counting from the year in which the multidisciplinary team was set up (1980), five out of the twelve research themes studied reached the extension stage after 7 to 8 years of research. This period saw a total investment of approximately 72 researcher man years and 725 million F.CFA in operational budget. The themes reaching the extension phase are the following: management advice, village approach, soil conservation, training of oxen and improved animal enclosures.

For the Bougouni-Sikasso section, counting from the year in which the multidisciplinary team was set up (1979), five out of the seventeen research themes studied also reached the extension stage after 3 to 8 years of research. This period saw a total investment of approximately 50 researcher man years with a more limited budget than that of the Fonsebougou section. The themes reaching the extension phase are the following: introduction of maize with reduction in labor through animal traction, improvement of maize-millet intercropping, improvement of rainfed rice cultivation, compost with TRP on maize and the training of oxen.

In addition to the time required for the general reconnaissance survey, the majority of the themes developed by these two sections followed the sequence and duration of activities set out below:

- diagnosis	1 year
- testing	2 to 4 years
- pilot extension	0 to 2 years
- TOTAL	3 to 7 years.

E. CONCLUSION.

This chapter has discussed why and how systems research has evolved in Mali. Much hope has been placed on this approach and it has attracted significant external funds. In terms of operational budget, external support amounted to 272 million F.CFA[10] in 1987, coming from the Dutch government, USAID and IDRC, compared to 68 million F.CFA[11] in 1981. This represents a quadrupling of external support in seven years. The national contribution has followed the same trend, increasing from 9.5 million F.CFA[12] in 1981 to 38 million in 1987[13]. In 1981, the total budget for systems research (DRSPR) represented 10% of that for commodity research (DRA). In 1987, this proportion exceeded 31% (Commission Financiere, 1988).

The role of the DRSPR according to the protocol of agreement between IER and USAID was presented next. The establishment of a research strategy based on systems research poses some difficulties however. Three difficulties have been underlined.

These three difficulties of the systems approach led to the identification of four factors which can particularly influence the results of the DRSPR in the Fifth Region. The first factor is the small stock of available technologies at station level from which the DRSPR can draw with a view to adapting and transferring them to producers in the Fifth Region. However, it is reasonable to hope that this stock of technologies appropriate to the agroclimatic conditions of the Fifth Region will increase in the course of the next decade.

The second factor is the low level of development of infrastructure and institutions in the Fifth Region. This low level of development further reduces the stock of technologies appropriate not only to the agroclimatic conditions of the Fifth Region, but also to the socio-economic and institutional conditions which producers in the Fifth Region experience. Systems research can also serve as a source of information and proposals for guiding the reforms necessary in the Fifth Region.

The third factor concerns coordination between commodity and systems research. In this regard, the structure of research, i.e., its organigram, and the formal and informal opportunities for meeting between station and systems team researchers, are important elements to consider in order that the systems research, with the support of

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10/ Equivalent to 971,000 US dollars at 1$ = 280 CFA.

11/ Equivalent to 243,000 US dollars at 1$ = 280 CFA.

12/ Equivalent to 34,000 US dollars at 1$ = 280 CFA.

13/ Equivalent to 135,000 US dollars at 1$ = 280 CFA.

commodity research, can have an impact on the productivity of natural resources.

Finally, the fourth important factor is the productivity of the research team, on which the results of systems research largely result. The two systems research teams which have worked in a zone of Mali more favorable than the Fifth Region took 3 to 7 years in order to obtain results ready for extension.

The agroclimatic, socio-economic and institutional constraints will be presented in the following chapter, according to the major farming systems of the Fifth Region. Chapter four will then propose research themes for an expansion of the DRSPR into the Fifth Region, taking account of these constraints and technologies available at the level of station research or technologies which will become available in the near future.

III. FARMING SYSTEMS IN THE FIFTH REGION.

A. BACKGROUND INFORMATION ON THE FIFTH REGION OF MALI.

The Fifth Region covers an area of 77,800 km2 between the 14th and 16th parallels north ("Recensement Administratif et Fiscal du 2 mai 1986", Ministere de l'Administration Territoriale et du Developpement a la Base). To the north east lie the sixth (Tombouctou) and seventh (Gao) regions, and to the north west Mauritania. To the south west lies the fourth region (Segou), and to the south east Burkina Faso (see map of Mali, fig. 3.1).

In the southern part the climate is sudano-sahelian with more than 600mm of rainfall annually at Djenne. It becomes sahelian to the north, with rainfall between 200mm and 400mm. In table A.1 in annex A the rainfall records show a significant fall in rainfall during the period 1977 to 1987 compared to the long run average.

The soils of the Niger Delta are clay, silty clay, and clayey silt; those of the Seno plain and plateau plains of Bandiagara sandy and sandy loam.

The Fifth Region is administratively divided into 8 circles, which are further subdivided into districts. According to the general population and housing census of April 1987, the Fifth Region has approximately 1,261,000 inhabitants, giving rise to an average population density of 16 persons/km2. Table A.2 in annex 2 gives the area, population and density for each circle in the region.

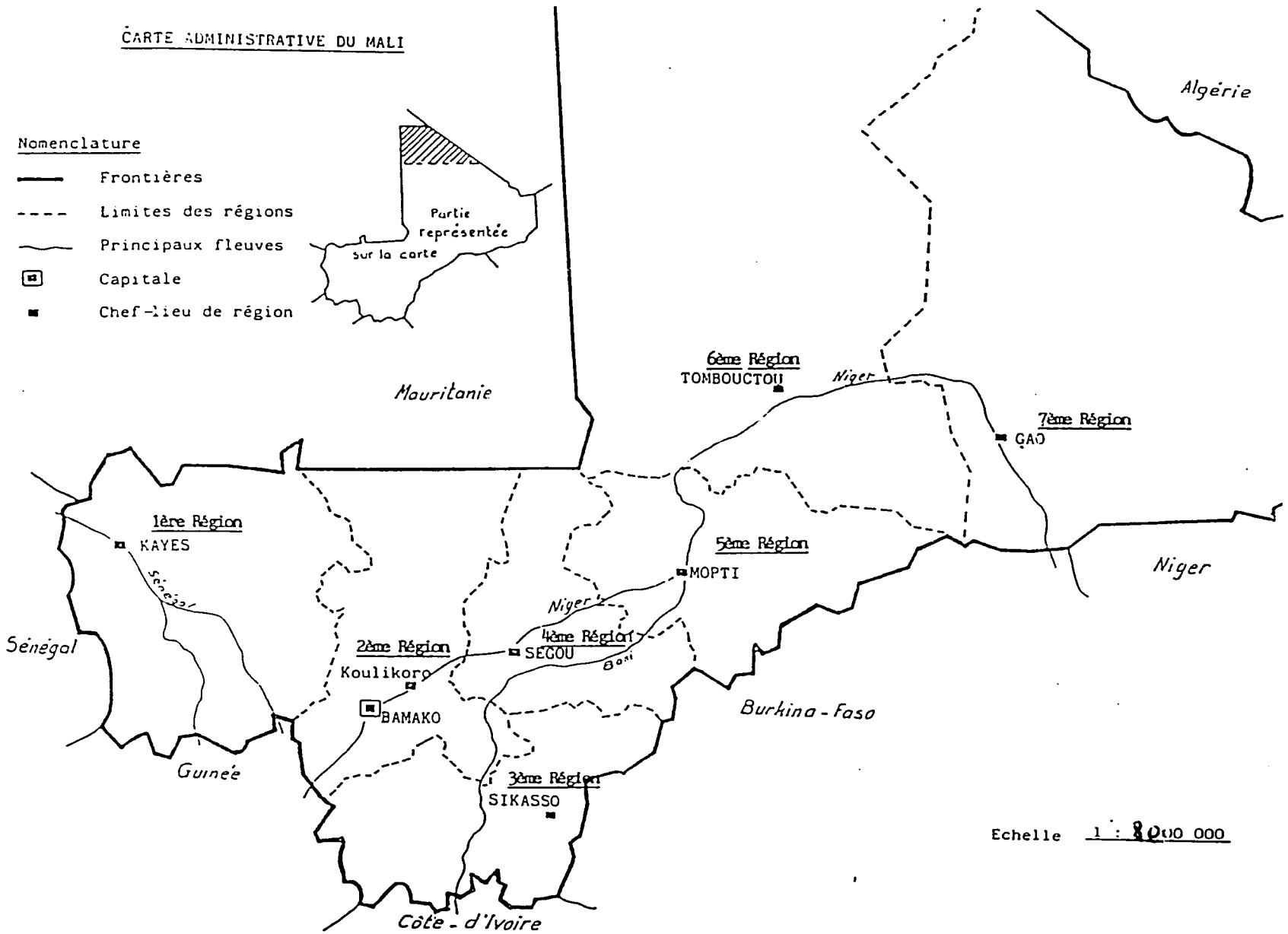
Economic activities in the Fifth Region of Mali comprise mainly those in the primary and tertiary sectors. Primary sector activities are principally crop production, herding and fishing. Trade is the principal tertiary sector activity, both with other regions of Mali and with neighboring countries. This study focuses on the primary sector of the Fifth Region.

1. Principal Components of the Primary Sector in the Fifth Region.

Primary sector activities in the Fifth Region have been the concern of four specialized rural development programs:

1. ODEM : Operation de Developpement de l'Elevage dans la region de Mopti (Mopti Livestock Development Program).
2. ORM : Operation Riz de Mopti (Mopti Rice Program).
3. OMM : Operation Mils de Mopti (Mopti Millet Program).
4. OPM : Operation Peche de Mopti (Mopti Fish Program).

FIGURE 3.1: ADMINISTRATIVE MAP OF MALI



Two of the four Operations de Developpement Rural (ODR) are fully operational with external funding. The Operation Riz Mopti (ORM) and Operation de Developpement de l'Elevage dans la Region de Mopti (ODEM) benefit from CCCE and WB funding. The Operation Peche Mopti operates with a remaining EDF funds. The Operation Mils Mopti (OMM) has been recently restructured into a Direction Regionale d'Agriculture (DRA) with no external funding since USAID ceased its financial and technical assistance in 1984. The Fifth Region benefits from two agronomic research stations depending under IER: the deep water and floating rice research station based in Mopti (previously under WARDA) and the Point d'Appui de Recherche (PAR), a station located in the rainfed Seno plain which conducts trials under the supervision of the Cinzana agronomic research station. Since 1979 SAFGRAD has been conducting on farm tests on technologies recommended by the Division de Recherche Agronomique (DRA/IER). In Mopti there is also based a hydrobiological laboratory under technical assistance of ORSTOM. The Banque Nationale de Developpement Agricole (BNDA) has a branch based in Sevare which provides credit to village groups through the ODRs or the Direction Nationale de la Cooperation (DNACOOP).

a. Crop production.

Statistics for cereal production from the Office Statistique des Communautes Europeennes (OSCE) are presented in tables A.3, A.4, A.5, A.6, A.7 in annex A. Cereal production in the Fifth Region is principally composed of rice, millet, sorghum, fonio, and finally maize. During the period 1974-86 the region accounted for 40% of the average area cultivated in rice nationally, and 26% of total rice production. For millet, sorghum and fonio over the same period, the region accounted for an average of 24% of the area cultivated nationally, and 16% of production. Regional production of maize contributed only 1% of the national harvest, from 5% of the total area cultivated. By implication, cereal yields in the Fifth Region are lower than the national average. Rice production is dependent on flooding by the Niger River and its tributary the Bani. Rainfed crops (millet, sorghum, fonio and maize) are dependent on the erratic sub-saharan rainfall. Agriculture in the Fifth Region is extensive in nature.

The regional area devoted to rice decreased at a rate of 4% annually between 1974 and 1986, while production was maintained (trends estimated from the OSCE statistics, table A.3 in annex A). Nationally, area and production stayed at the same level between 1974 and 1986. Whereas national production of millet, sorghum and fonio was increasing at a rate of 5.6% per annum during the period 1974-86[1], and national

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1/ This estimated rate is surprisingly high compared to other statistics which generally indicate a 3% increase over the same period. These statistics should be interpreted with caution given that they are based on rough estimates of area and yield. They only indicate a trend.

area cultivated was increasing at a rate of 3.4% per annum, regional production of and area cultivated in sorghum, millet and fonio stayed the same (trends estimated from OSCE statistics, see table A.4 in annex A). Consequently, the regional contribution to millet, sorghum and fonio production has diminished.

Legume production is equally important for the region. Cowpea is generally intercropped with millet. Groundnuts and wandzou are generally cultivated in pure stands on small plots. Dah, sesame and Guinean sorrel are also cultivated.

The Bandiagara plateau is a major producer of vegetables. Onions from the dogon area can be found in every market in Mali and in surrounding countries.

b. Livestock.

Tables A.8, A.9, A.10, and A.11 in annex A provide statistics on livestock in the Fifth Region of Mali. Cattle on the hoof represent an important stock of capital in the Fifth Region. According to OSCE statistics, cattle accounted for 23% of the national livestock total during the period 1977-87. No significant change was observed, either at the national or regional level. Two periods of reduction in the livestock population of the Fifth Region have been observed, corresponding to drought years; 1978 and 1983-85. At a national level, the drought of 1983-85 had a more marked effect on cattle and sheep and goat numbers than the drought of 1978.

The Fifth Region is a major exporter of cattle on the hoof to Burkina Faso and coastal countries (principally Ivory Coast). At the beginning of the 80's these exports could cover imports of both agricultural products and manufactured goods into the region. According to the annual reports of ODEM (see statistics in table A.11 in annex A), the numbers of cattle and sheep/goats exported tended to decrease during the period 1980 - 1986.

c. Fishing.

The fisheries sub-sector is very important for the Mopti region, specifically the Central Delta, South Delta and North Delta. Fishing is practiced by the Bozo and Somono ethnic groups. Two types of fishing can be distinguished according to the degree of movement of the fishermen: nomadic and semi-nomadic. A tendency for marketed production to fall over time can be observed in table A.12 in annex A.

d. Conclusion.

The Fifth Region has important production potential. According to a recent study financed by the World Bank (Stryker et al., 1987), Mali possesses comparative advantage[2] in the production of cotton and livestock for export, and in cereal and rice production for local consumption. Of these four areas of comparative advantage, the Fifth Region possesses three: livestock, cereal production (with the exception of maize) and rice. The contribution of the Fifth Region to national production is (OSCE, 1988):

- 16% for millet, sorghum and fonio (average for the period 1974 to 1986),
- 26% for rice (average for the period 1977 to 1986),
- 23% for cattle and 10% for small ruminants (average for the period 1977 to 1987).

2. The Three Natural Zones of the Fifth Region.

In 1978, IER identified and described eight natural regions in the Fifth Region, taking account of the rainfall pattern, flooding pattern and soil characteristics. Table B.1 in annex B presents the principal characteristics of these eight natural regions. Instead of grouping these natural regions into one flooded zone for the four natural regions of the delta and one non-flooded zone for the remaining natural zones as the authors of the present study have done[3], these regions are in this case grouped into three large zones, specifically the Delta, Dogon Plateau (or Bandiagara Plateau) and the Seno Plain with South Gourma. This grouping in three large zones is carried out in order to take account of distinct hydrological, soil and population characteristics. These three large natural zones are described accordingly:

a. The Delta.

The Delta is a partially inundated plain, flooded by the Niger floods and its tributary the Bani. This natural zone has a relatively flat topography varying between 260 and 280 meters in altitude. To the north lie the large lakes which provide reservoirs during the dry season.

2/ The theory of comparative advantage says that a country should produce and export those goods for which it has higher relative productivity and import those for which it does not have this advantage.

3/ This distinction is set aside since the flooded and non-flooded parts cover the four natural regions of the delta.

The Delta extends over the circles of Djenne, Mopti, Tenenkou and Youwarou and the lakeside part of the Douentza circle (arrondissement of Bore and NGouma). This natural zone is separated from the other two natural zones by the San-Gao road.

The Delta covers an area of 35,889 km2 with a population of around 606,000 inhabitants, representing 46% of the land area and 48% of the population of the region. The population density of 17 people per km2 is slightly higher than the regional average of 16/km2 ("Recensement General de la Population et de l'Habitat", July 1987)

The principal economic activities of the Delta are crop production (primarily millet and rice), livestock and fishing. The town of Mopti is an important commercial and administrative center. An ancient activity, rice cultivation is practiced with either natural or controlled flooding. The rainfed crops, primarily millet, sorghum and groundnut, are cultivated on the elevated land of the Delta. Flood recession agriculture is found in the northern, low lying part of the Delta, which is also an excellent pastoral zone by virtue of its dry season pastures. These pastures are made up of an herbaceous forage plant, the "bourgou"[4] (Echinochloa Stagnina) which has given the name "bourgoutiere" to the pasture zone of the Delta. During the Niger and Bani floods the herdsmen migrate to the non-flooded zones. Following the recession, the herdsmen return to the Bourgoutieres. Fishing is principally practiced in the middle and upper delta.

b. <u>The Seno Plain.</u>

The Seno[5] plain essentially covers the Bankass circle, the Koro circle and the south east part of the Douentza circle (the arrondissement of Mondoro and the southern part of the Boni, Hombori and Douentza central arrondissements).

The Seno is a vast plain ranging from 250m to 300m in altitude. To the north it is bordered by South Gourma, characterized by rocky outcrops ringed with dunes. The Bandiagara escarpment constitutes its north western limit and Burkina Faso its south eastern limit. From north to south the Seno Plain appears as a parallel succession of smooth dunes followed by sandy-silt plains. The Seno plain and South Gourma extend over 33,695 km2 representing 43% of the area of the Fifth Region. These two zones are inhabited by a population in the order of 473,000, a density of 14 persons per km2, lower than the regional average of 16 persons per km2 ("Recensement General de la Population et de l'Habitat", July 1987). This represents 37% of the total population of the Fifth Region.

4/ Peul word meaning flooded plain.

5/ Peul word meaning non-flooded plain.

Administratively, South Gourma comprises the north of the arrondissements of Douentza central, Boni and Hombori in Douentza circle. South Gourma is primarily dedicated to pastoralism.

Within the Seno plain it is possible to distinguish two sub-regions as follows:

(1) The Seno-Mango[6] covers the arrondissement of Mondoro, the southern part of the arrondissements of Boni, Hombori and Douentza central in the Douentza circle, and the arrondissements of Dinangourou and Dioungani in the Koro circle. The Seno-Mango region is essentially agro-pastoral, with rainfall between 200mm and 400mm annually for the period 1977 to 1986. The rainfed crops cultivated include millet, cowpea, groundnut, fonio and wandzou. During the dry season, the Seno-Mango also serves as a transhumance zone for the animals of the Delta and the animals from the cultivated parts of Seno-Mango and Seno-Gondo.

The Seno-Mango and South Gourma extend over an area of approximately 17,551 km2 with a population in the order of 192,000, a density of 11 people per km2 ("Recensement General de la Population et de l'Habitat", July 1987).

(2) The Seno-Gondo[7] covers the entire Bankass circle, and that of Koro with the exception of the Dinangourou and Dioungani arrondissements, which come under Seno-Mango. The area is in the order of 16,144 km2 with a population of 326,000, a density of 20 people per km2, higher than that of the Delta ("Recensement General de la Population et de l'Habitat", July 1987). Like the Seno-Mango this region is essentially one of mixed farming. However, it enjoys a higher level of rainfall, ranging from 400mm in the north to 700mm in the south during the period 1977 to 1986. The principal crops are millet, cowpea, groundnut, fonio and wandzou. Despite its limitations of soil and hydrology, the Seno-Gondo region is considered the millet granary of the northern part of the country, primarily supplying the markets of Bandiagara, Mopti, Gao and Tombouctou. Sheep and goats take priority over cattle raising.

c. <u>The Dogon or Bandiagara Plateau.</u>

The plateau essentially extends over the circle of Bandiagara at an elevation generally between 300m and 600m, with some valleys situated between 150m and 300m and rocky peaks rising to 800m. The plateau covers an area of 8,219 km2 with a population in the order of 183,000, a density of 22 people per km2, the highest density in the region with the exception of that of the commune of Mopti ("Recensement General de la

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6/ Peul word meaning large plain.

7/ Peul word meaning Gondo plain.

Population et de l'Habitat", July 1987). The area of the plateau represents 11% of the Fifth Region, and is home to 15% of the region's population.

The cultivable land of the plateau is limited to 22% of the total available (Chef de Secteur de Developpement Rural de Bandiagara, personal communication, July 1987). The land is cultivated with millet, cowpea, groundnut, fonio and wandzou. The Yame river crosses the plateau from south east to north west. The tributaries of the Yame and the flooded depressions provide numerous opportunities for dry season vegetable gardens. Rearing small ruminants predominates over cattle.

B. AGROCLIMATIC ZONES.

1. Agroclimatic zones of the Delta.

The agroclimatic characteristics of the Delta are given in tables B.2 and B.3 in annex B. Crop, livestock and fishing activities depend on the physical environment. In order to identify the relationships between the physical environment and rural activities, and to identify the potential and constraints to production, the Delta has been divided into four agroclimatic zones according to the following criteria:

- r infall regime,
- hydrological regime,
- soil potential and limiting factors.

Figure 3.2 shows schematically the agroclimatic zones for the delta.

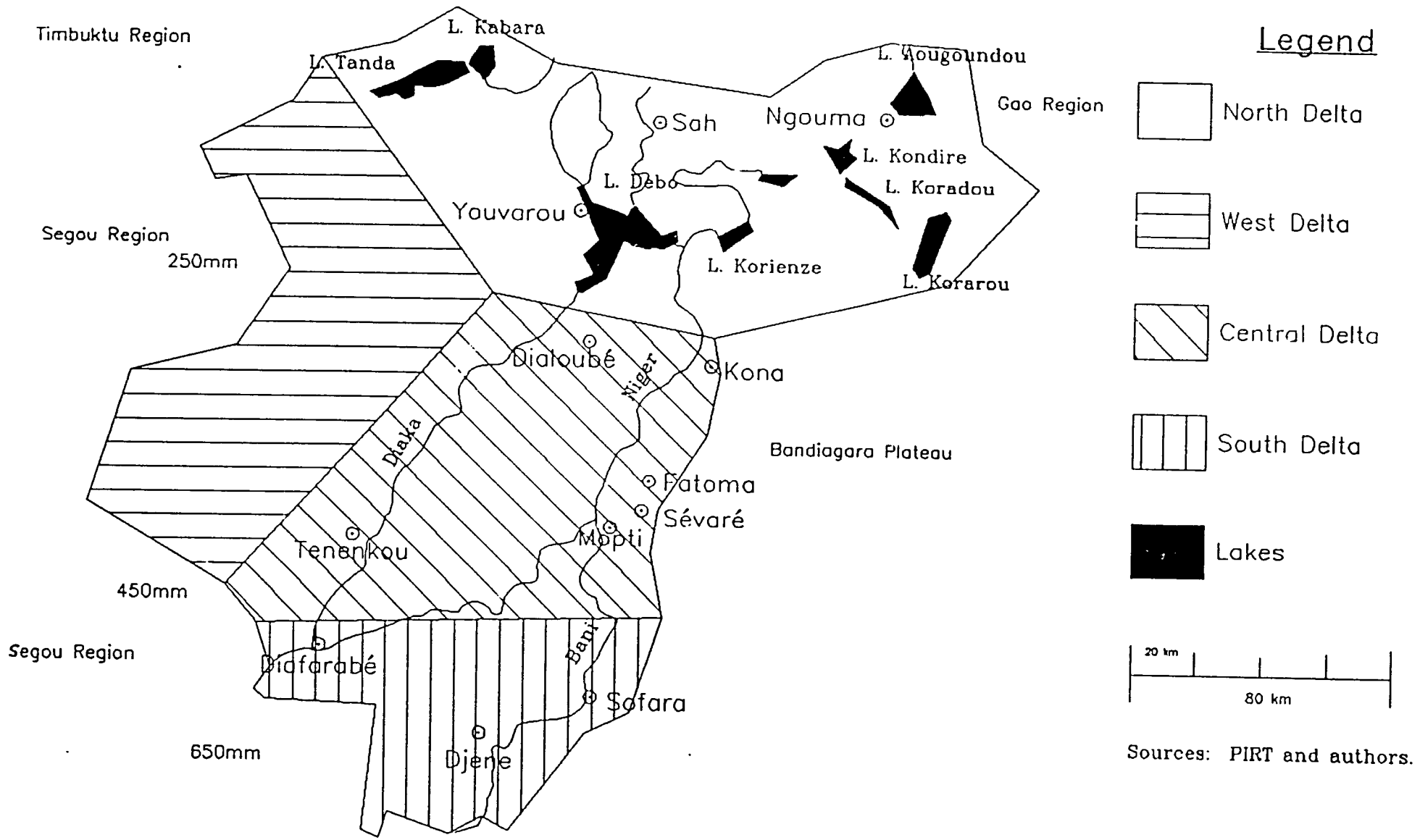
a. The South Delta.

(1) Administrative boundaries, area and population.

The South Delta covers the Djenne circle, the southern part of the Mopti circle (arrondissement of Soye) and the southern part of the circle of Tenenkou (arrondissement of Diafarabe). The extreme south of this zone belongs to the mid Niger-Bani (PIRT,1986). The South Delta covers an area of 6,286 km2 (18% of the area of that part of the Delta in the Fifth Region) with a population of 153,480, a density of 25 people per km2 (25% of the total population of that part of the Delta in the Fifth Region).

The population is composed of Bambara, Bozo, Peul and some Dogon who came from Seno and the Plateau.

FIGURE 3.2: THE AGROCLIMATIC ZONES of the Niger Delta in the Fifth Region



Sources: PIRT and authors.

(2) The rainfall regime and pressure on the land.

Rainfall varies between 350mm and 600mm annually. The historical average for the period 1926 to 1975 at the Djenne station is around 600mm as opposed to 440mm for the last decade, a decline of roughly 160mm. As a consequence of this decline in rainfall the length of the agricultural season has shortened considerably.

According to PIRT (1986), pressure on the land is high around the rice polders where 50 to 75% of the arable land is under cultivation. On the plains it is moderate with around 50% of the arable land used for rainfed crops.

(3) The hydrological regime.

A large part of the South Delta is inundated by flooding from the Niger and the Bani. The height of the floods has decreased considerably. At the Sofara station, for example, the average maximum height of the flood was 422cm for the period 1981 to 1986 as opposed to 672cm for the period 1968 to 1971. The vast bourgoutieres such as Pondori (flooded by the Bani), Yongari and Mangari (flooded by the Niger and its tributaries), are currently flooded only to a minor extent.

(4) Potential of soils and their limiting factors.

According to the distribution of soil/vegetation units in the Delta zones (PIRT, 1986), the South Delta is dominated by clayey and silty clay soils. Flooded soils are important, but less so compared to the Central Delta. However, the hydromorphic behavior of the soils is temporary because the soils are deep (more than 100cm) and well drained.

Despite the fact that the South Delta belongs to the sudanian zone, and is currently experiencing rapid ecological degradation, the vegetation still remains quite abundant. On the non-flooded areas the Acacia Albida and Acacia Seyal are dominant. The flooded areas, on the other hand, are occupied by Vetiveria Nigritata, Biflorus and Andropogon Gayanus.

Assuming that the flooded soils are highly suitable land, it could be said that the South Delta presents few obstacles to crop, livestock, or forestry production. The soils are deep (more than 100cm), well drained and temporarily hydromorphic. The soils lend themselves equally well to irrigated or rainfed crops. The decline in rainfall, however, represents the limiting factor for crop production.

b. The Central Delta.

(1) Administrative boundaries, area and population.

Covering the Mopti circle (apart from the arrondissements of Sandogue, Korientze and Soye) and the Tenenkou (apart from the arrondissements of Diafarabe, Dioura, and the western part of the arrondissement of Toguere Kumbe), the Central Delta has an area of 11,348 km2 (31% of the total area of the Delta in the Fifth Region) with a population of 290,724, resulting in a population density of 26 people per km2 (48% of the total population of the Delta in the Fifth Region). The population is mainly composed of Rimaibe, Bambara, Peul and Bozo. There are a few Dogon and Marka.

(2) The rainfall regime.

At the Mopti station, the average rainfall for the last decade was 390mm as opposed to an historical average of 530mm for the period 1926 to 1975. The Central Delta is currently located between the 250mm isohyet north of Konna and 300-350mm south of Mopti. The Central Delta is in the northern sahel zone with an arid climate and short growing season.

(3) The hydrological regime.

As for the South Delta, a considerable decline in the flooding regime has occurred in the Central Delta. For example, the maximum height of the Bani floods at the Mopti station was 538cm for the period 1981 to 1986 as opposed to 700cm for the period 1968 to 1971. This zone is entirely located in the active Delta, resulting in flooding over 60-74% (PIRT, 1986). This explains the importance of rice land with natural and controlled flooding. The zone has little pasture such as that provided by the bourgoutieres.

(4) Potential of soils and their limiting factors.

According to PIRT (1986) the soils of the Central Delta are mainly flooded, more or less hydromorphic, silty clays and sandy clays. These soils are of average depth (50 to 100cm) and well drained.

The eastern border forms a narrow sandy band running from Somadougou to Konna and is generally cultivated to millet.

The flora of the active delta is determined by the level and duration of the floods. Ligneous species predominate on the non-flooded areas.

c. The West Delta or the Mema.

(1) Administrative boundaries, area and population.

The West Delta covers the west and north western parts of Tenenkou circle, specifically the arrondisement of Dioura and the western part of the arrondissement of Toguere Kumbe. In order to facilitate estimates of area and population the Delta West zone has been compared to the arrondisement of Dioura, thus covering an area of 4,246 km2 (12% of that part of the total area of the delta in the Fifth Region) with a population of 3,396 (2% of that part of the total population of the delta in the Fifth Region) and a density of 3 persons/km2. The population is composed of Bambara, Marka (mixed farmers) and Peul (herders).

(2) The rainfall regime.

Rainfall presently varies between 200mm and 450mm with an annual average of 328mm over the last decade. It is a particularly dry zone, having a very arid climate without the benefit of any flooding at the present time. The growing season has been considerably reduced, ranging from 25 to 45 days as opposed to 45 to 90 days in a normal year in earlier times.

(3) The Hydrological regime.

The West Delta has been a flooded part of the Niger basin since ancient times. However, there are some ravines which carry the outflow from the Office du Niger's irrigated perimeters. This water is used for vegetable production and watering animals. Aside from this water source there also exist depressions which accumulate rainwater. A number of these are currently being deepened by ODEM in order to provide reservoirs in Mema for the cattle herds while they are waiting to move into the bourgoutieres. Mema is primarily a dry season pasture and cattle waiting zone, complementary to Farimake (the northern part of Nampala in the fourth region) and the Mauritanian sahel. Overall, the limiting factor for the West Delta is inadequate and unfavorably distributed rainfall. To this should be added the problem of wind erosion.

(4) Potential of soils and their limiting factors.

According to the soil map of PIRT (1986), the Delta West comprises eroded dunes (42%), sandy silt plains (49%) and stable dunes (10%). PIRT estimate that 45% of the total land of Delta West is cultivable and of average natural fertility. The non-arable lands are mainly the sandy soils and dunes, constituting more than 53% of the area in this zone.

d. The North Delta.

(1) Administrative boundaries, area and population.

The North Delta extends over the circle of Youwarou, the north of Mopti circle (the arrondissements of Korientze and Sendegue), and the west of Douentza circle (the arrondissements of N'Gouma and Bore). The North Delta covers an area of approximately 14,000 km2 (39% of the total area of the delta in the Fifth Region) with an estimated population of 148,400 (20% of the total population of the delta in the Fifth Region) with a density of 11 people per km2. The population comprises Peul, Touareg, Tamachek, and some Sonrai herders, some Bambara and Rimaibe agropastoralists and some Sorko (Somono) fishermen.

The lakeside zone is characterized by the presence of lakes and ponds around which the population is engaged in a range of economic activities, particularly recession agriculture, herding and fishing. It should also be noted that when water levels are high the lakes and ponds, and the water courses that supply them, are navigable for part of the year. Currently, with the low level of the floods, all these economic activities have declined in importance because of the reduction in the available flooded areas. The economic potential of the lakes and ponds located in the extreme northern part of the zone (i.e. the lakes of the zones bordering Gourma) has greatly declined compared to the potential of those situated in the south.

(2) The rainfall regime.

Rainfall is very low in this zone. The recent average annual total is in the order of 222mm at Korientze and 218mm at Sendegue, as opposed to a historical average of 400mm for the period 1929 to 1980. This reduction in rainfall has resulted in a considerable shortening of the length of the agricultural season, which is now in the order of 25 days as opposed to 45 days in a normal year. Pressure on the land is only high around the lakes and bourgoutieres.

(3) The hydrological regime.

The North Delta is principally a zone of lakes, from which it derives its name as the "lakeside zone". The Niger flows into the large topographical depressions which are natural ravines. These depressions (lakes and ponds), provide large reservoirs of water in the dry season. As a result of the low level of flooding, however, few of the lakes are flooded nowadays and many are filling up with sand.

The principal lakes of the region are: the Debo lakes, Tanda, Kabara, Korientze, Koraru, Aougoundou and a part of the Niangay lake. In this section, however, the focus will be on certain lakes in the arrondissements of Korientze (Mopti circle) and N'Gouma (Douentza circle) which were visited by the evaluation team for the expansion of DRSPR activities in the Fifth Region in April 1988. According to the head of the Secteur de Developpement Agricole de Douentza, the Niangay

lake has received no water since 1982. In addition to Niangay lake numerous other lakes in the arrondissement of N'Gouma received no water during the 1987-1988 agricultural campaign, including the Belambi, Oradu and Koraru lakes. Only the beds of the Aougoundou and Sao lakes received a little water during this period. In the arrondissement of Korientze, farmers also reported a decrease in the cultivable area for recession crops. According to the farmers of N'gorodia (arrondissement of Korientze) the Samakiri lake, which used to provide many opportunities for flood recession agriculture, has received no water since 1980. Currently , the farmers in this locality only farm the cultivable land of the Kodie pond where the weed growth poses serious difficulties. According to farmers in Korientze, rice cultivation is no longer possible on the Kaira plain because of the low level of floods.

(4) Potential of soils and their limiting factors.

The soils of the North Delta are hydromorphic with little or no drainage. These are brown sub-arid soils with eroded stable dunes on the surface. The base of these soils is impermeable, which results in their hydromorphic properties. The high water retention and capillarity of these soils makes flood recession cropping possible in the lake basins. The North Delta, because its bourgoutieres are flooded from August to December, provides excellent dry season pasture.

2. Agroclimatic Zones of the Seno plain and the Cultivable Plains of the Bandiagara plateau.

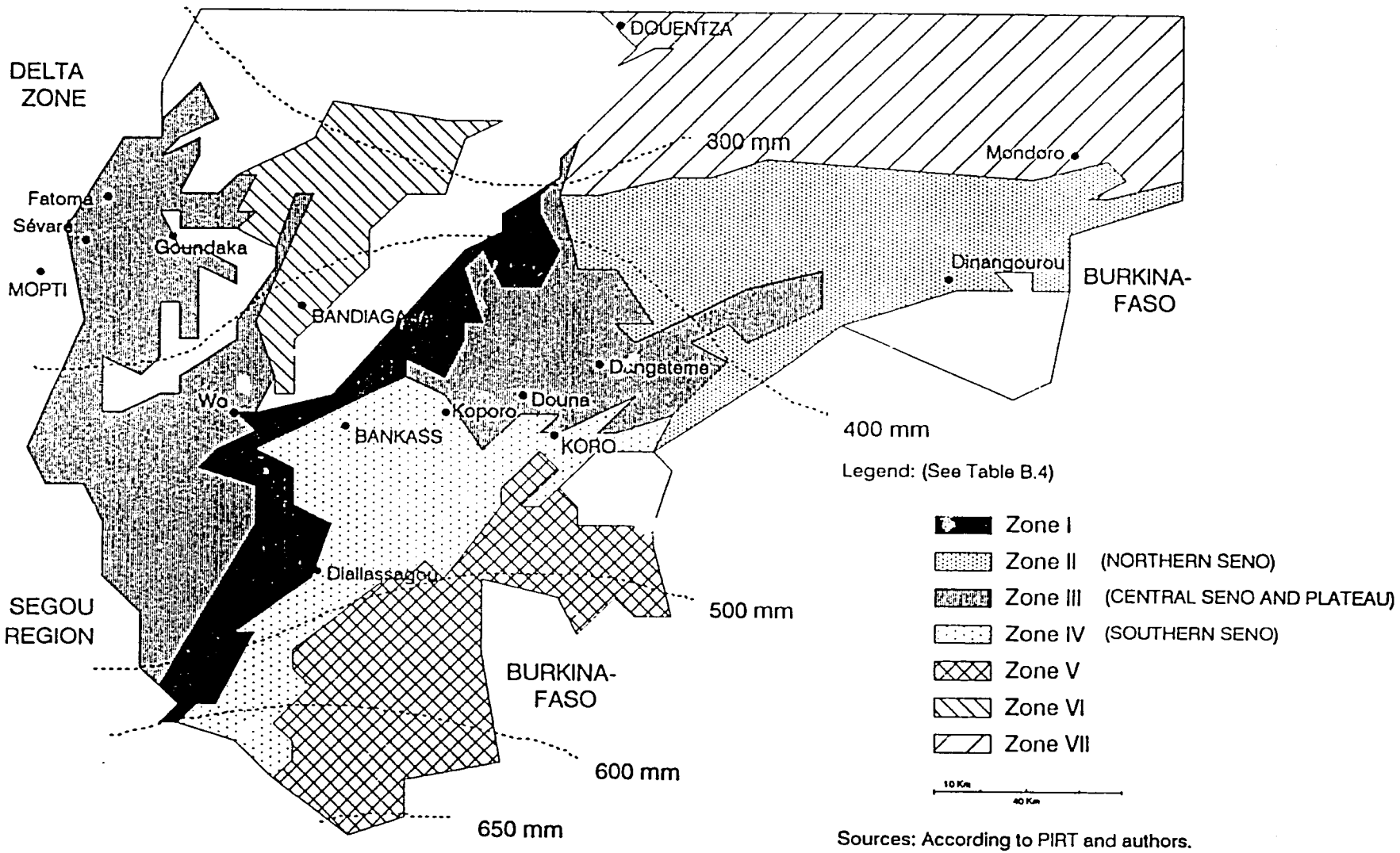
Table B.4 in annex B presents the agroclimatic zones of the Seno plain and the cultivable plains of the Bandiagara plateau. This division into zones has been presented in Henry de Frahan and Diarra (1987). It is based on soil mapping by the land resources inventory project (PIRT, 1983). Soils with similar characteristics have been grouped together to simplify the division into zones. Two other criteria have been added to that of soil characteristics. These are rainfall and population pressure on the arable land. Figure 3.3 presents a schematic map of the agroclimatic zones of the Seno plain and Bandiagara plateau.

Among the seven zones identified (see table B.4 in annex B), three have been included in this study on the basis of size, population density and production potential:

- zone 2 or North Seno,
- zone 3 or Central Seno and Plateau,
- zone 4 or South Seno.

These three zones are briefly described below. For greater detail the reader is referred to Henry de Frahan and Diarra (1987).

FIGURE 3.3: AGROCLIMATIC ZONES
Of The Seno Plain And The Bandiagara Plateau



Sources: According to PIRT and authors.

a. North Seno.

North Seno covers the eastern part of the arrondisement of Diankabou and the Dinangourou and Dioungani arrondissements of Koro circle. These are eroded dunes comprising primarily red-brown sub-arid soils in transition to ferruginous and little leached ferruginous soils. Herding and crop production are both practiced on the eroded dunes which provide both pasture and areas suitable for millet cultivation with long periods of fallow. Climatic constraints are serious and tend to restrain the choice of plant species. Rainfall recorded for the period 1977 to 1986 varies between 300mm to 400mm annually.

b. Central Seno and the cultivable land of the Bandiagara Plateau.

These two zones cover roughly the arrondissements of Madougou, Koporo Na and the north of the central Koro arrondissement in Koro circle and the arrondissement of Goundaka and a part of the arrondissement of Wo in the Bandiagara circle. It is a plain of loamy material. It is made up of leached ferruginous soil for crop production with a short period of fallow. The eastern border of this plain, corresponding to the north eastern and south western parts of Dioungani, is composed of fine silty materials. It comprises leached brown tropical soils which are used for herding.

The agricultural production potential of this region is average. The climatic constraints are very serious. Rainfall recorded for the period 1977 to 1986 varies between 400mm and 450mm annually.

c. South Seno.

South Seno covers the arrondissement of Toroli and the south of the central Koro arrondissement in the Koro circle, the central Bankass arrondissement, the eastern parts of the arrondissements of Kani Bonzon, Diallassagou and Sokoura and the central part of Ouenkoro arrondissement in Bankass circle. These are eroded dunes with little leached ferruginous soils used for crop production. Agricultural production potential is average and is subject to serious climatic and, in some locations, hydromorphic constraints. For the period 1977 to 1986, the annual average rainfall varied between 450mm and 600mm.

C. FARMING SYSTEMS IN THE FIFTH REGION OF MALI.

1. Introduction.

Through the process of adaptation to conditions of the natural, socio-economic and political environment, and to the objectives of rural people, more or less distinct farming systems have evolved. Systems or sub-systems with similar characteristics can be grouped together in the same class of homogeneous system (Norman, 1980; Hildebrand, 1981). These classes or homogeneous systems constitute recommendation domains (Byerlee et al., 1982) which can serve as a basis for the development of local specific techniques. Byerlee et al. (1980) define recommendation domains as being groups of producers for whom the same recommendations apply.

Okigbo (1981) suggests that rural production systems comprise one or more sub-systems. Each sub-system can be distinguished from the others by the following elements.

- Physical or chemical: climate, soils, nutrients, etc.
- Biological: cultivated plants, livestock species, insects, diseases, etc.
- Socio-economic: labor force, markets, preferences, religious beliefs, etc.
- Level of technology: tools, machines, practices, etc.
- Management: level of education, decision making, etc.

These elements mentioned above interact with each other and affect the production process. Other no less important elements affect farming systems. Among them are the following:

- Storage and utilization of vegetable and animal products and by-products.
- Institutional factors.
- Population.
- Local industries and off-farm activities, etc.

2. Principal Farming Systems in the Delta.

Table B.5 in Annex B presents the principal Delta farming systems and their sub-systems encountered in the Fifth Region. This section presents the agropastoral and pastoral systems, and fishing in the Delta.

a. Summary description of the agro-pastoral system.

The agropastoral system represents one of the principal farming systems in the Delta. Examples of a purely crop based farming systems are rare. The agropastoral system effectively comprises three sub-systems; the rainfed crop sub-system, the flood recession crop sub-system, and the sub-system of crops irrigated either naturally, or through controlled water flow or with motorized pumps as in the small village irrigated perimeters (PPIV).

In the agropastoral system, crop production has always been given priority over livestock production. The majority of agropastoral system farmers (Bambara, Marka and Rimaibe) own some ruminants (cattle, sheep, goats) and donkeys for transport. Cattle are herded or used as draft animals. In the former case, cattle represent a form of savings or investment for the farmer. The sheep and goats represent a bank account for the household since they are easily slaughtered for home consumption or sold to meet urgent financial problems.

In the agropastoral system, harvest residues and kitchen leftovers are used for fattening castrated rams known as "mouton de case". Poultry rearing is less developed and limited to local breeds of cocks, hens and pullets. The manure produced by the animals is transported to the millet and sorghum fields, and vegetable crops. Chemical fertilizers are rarely used by farmers on millet and sorghum fields, but are used, however, on the ORM rice polders. The use of Tilemsi rock phosphate (TRP) has encountered several problems. The majority of farmers do not have experience of TRP, and those who do dislike its powdery and dirty appearance and slow effect. Many farmers use fungicides for treating sorghum and millet seed.

In the agropastoral system one observes both individual and family fields. The family fields receive priority in the use of family and outside labor, which farm households can call upon either as a form of mutual help, or pay for in cash or kind. Generally, payments in cash or kind arising either from agricultural tasks performed outside of the farm household, or from migration, do not belong to the individual but come under the patrimony of the farm household. The predominance of the household over the individual testifies to the continuing presence of patriarchal forms of labor organization.

(1) The rainfed crop sub-system.

The rainfed crop sub-system is much more widespread in the South Delta than in the other Delta zones. It gradually diminishes in importance as one travels westward, finally becoming of marginal importance in the Center and North. The rainfed crop sub-system is essentially based on millet and sorghum, which are often intercropped with other crops.

The most widespread form of intercropping is millet and cowpea. Other intercrops which can be observed are millet-sorghum, millet-groundnut, millet-dah, millet-tobacco, millet-tomato, millet-cowpea-wandzou. Intercrops with maize include maize-squash, maize-watermelon, rainfed rice-maize, in the last case with maize being the secondary crop. Fonio, sweet potato and potato are grown as sole crops. The intercrops with millet, maize and rainfed rice are primarily for home consumption. For mechanized farms, intercropping of cowpea and groundnut with millet makes weeding operations difficult. Consequently, for these farms there is a tendency for groundnut and cowpea to be cultivated in pure stands.

As a result of climatic risks, areas formerly reserved for rice cultivation are more and more frequently used by farmers for the cultivation of sorghum and millet on ridges. Some farmers no longer follow the practice of making mounds of organic material as is still widespread in the Seno Plain. For the cultivation of sorghum, the mounds have been replaced by holes dug in non-sandy spots which are filled with manure. The sorghum is then sown after the first useful rain. Millet is cultivated in the sandy areas. Early millet varieties (3 month cycle) are generally cultivated in the fields around the house which are rich in manure. Late varieties of sorghum and millet (4 months) are cultivated on the outlying fields. The disappearance of certain long cycle varieties of millet, sorghum and groundnut has been noted, as they have difficulty in adapting to the decline in rainfall observed in the course of the last decade.

Rainfed agriculture is largely dependent on the quantity, distribution and duration of the rainy season. As a general rule, plowing begins in May or June, after two good rains, when it is possible to turn the soil. Sowing does not begin on any fixed date, but rather when the soil has sufficient moisture to permit germination of the seed, usually in July. In the Delta, the first useful rains currently do not fall until the first ten days of June. As for the final showers, they tend to fall in the second ten days of September rather than the first ten days of October.

The Operation Mils Mopti (OMM) carried out tests of improved millet varieties (IBV 8001, HKP, M2D2), sorghum (CE90) and cowpea (TN 88-63, Gorom-Gorom) along the Kona-Mopti-Djenne axis. OMM reports that IBV 8001, due to its earliness, has given good results under unfavorable rainfall conditions. However, this variety is highly susceptible to

bird attack. The variety IBV 8001 is at the stage of pilot extension to farmers.

(2) The flooded crop sub-system.

The flooded crop sub-system involves three main methods of irrigation as follows: natural flooding, controlled flooding and the small village irrigated perimeters (PPIV) using motorized pumps. Rice cultivation with natural flooding is a marginal practice in the northern zone and non-existent in the West Delta. In the South Delta, natural flooding of rice is common. It is even more so in the Central Niger Delta where there is also a heavy concentration of rice cultivation with controlled flooding. The latter is also widespread in the South Delta but non-existent in the North and West Delta. The small village irrigated perimeters are found in the Central Delta where pump installation has been concentrated. The PPIV are few in the South and North Delta and non-existent in the West Delta.

Natural flooding is entirely dependent on hydrological and climatic fluctuations. Rice is sown at the beginning of the rainy season. The early rains provide moisture for the plants until the arrival of the annual floods which enable growth to continue. The timing of the arrival of the floods can result in either too early or late flooding. The water can rise too rapidly (more than 5cm per day) for the floating rice (Oryza glaberrima), drowning the plants. The traditional use of dikes around the rice fields only partially controls fluctuations of the floods.

Controlled flooding enables the rise in the flood to be managed after germination, and the polders to be drained by means of dikes, canals and gates. As the polders are not usually levelled, the topography of the plain and the height of the water determine the technique of irrigated rice production employed. Controlled flooding on the rice polders managed by ORM is practised both by farmers whose principal activity is agriculture ("paysan direct" in French) and by civil servants and merchants using hired labor ("paysan indirect" in French). Only improved varieties of Oryza sativa are cultivated in the ORM rice polders.

Neither controlled or natural flooding provide a guarantee against insufficient flooding. For the inner Niger Delta the climatic changes have taken the form of a reduction in rainfall and the level of flooding from the Niger and its tributary the Bani. These disturbances have led the ORM to adopt a program of reducing water levels from 1.80m to 1.20m. ORM also attaches importance to research aimed at identifying improved varieties of rice that can adapt the different threshold water levels.

The management of small perimeters (20 to 30 hectares) in some villages, irrigated from the river by pumps, is another program adopted by ORM to counter the climatic changes. ORM recommends the rice varieties IR 15-29 and IR 15-61 with transplanting in the irrigated plots. The cultivation of rice by pump irrigation is a new approach to

rice cultivation which requires rigorous management on the part of ORM and the farmers, who have no prior experience with it.

(3) The flood recession crop sub-system[8].

In the Fifth Region, the flood recession crop sub-system is found exclusively in the North Niger Delta. During a part or all of their growth cycle the crops benefit from residual moisture in the sandy clay soils around the ponds and lakes. Crops grown include sorghum, cassava, sweet potato, cowpea, sorrel, tomato, eggplant and onion. The pattern of different crops around the ponds and lakes is linked to the recession of the floodwater. Often, sorghum is planted on the areas uncovered by the earliest retreat of the floodwater. With the next retreat millet is cultivated, but may be replaced by other crops such as cassava, sweet potato, etc. Often cassava is intercropped with sorghum. The intercropping pattern
sorghum-cassava-cowpea can also be found. In the pond and lake beds some farmers cultivate rice. It should be borne in mind that before the climatic changes rice was often cultivated on the fringes of ponds and lakes. As for millet, while presently cultivated in some ponds, when rainfall conditions are normal it is much more commonly cultivated in the non-flooded areas (sandy plains).

The climatic and hydrological hazards (low level of rainfall or floodwater) have led to many changes in the usual practices for cultural operations. For example, sharecropping used to be the common institution for bringing land into cultivation in the lakes and ponds but is rarely practised in the zone nowadays because of the reduction in cultivable area and low level of yields.

According to farmers from N'Gouma and Korientze, floating rice was the most widespread crop before the climatic changes (prior to 1973). At that time the cultivation of millet, sorghum and cowpea was reserved for the sandy zones. Presently, with the decline in rainfall levels, the cultivation of floating rice has virtually disappeared, yielding its place to the cultivation of upright rice varieties in some Korientze lakes. Sorghum and millet, which constitute the major crops, are cultivated in all the lakes visited. The cultivation of tubers (cassava, potato) is also popular around the lakes.

The cultivation of millet or sorghum around the lakes requires land preparation at the beginning of the cycle. This is generally carried out with the daba (short handled hoe) or by plough where draft animals and implements are available. Farmers sow by making a shallow hole with a pointed stick, then digging another smaller hole inside the first into which the seed is dropped. The seed is usually covered with fine sand.

8/ More detail is given in this section because the flood recession technique has not been introduced in the previous evaluation team reports and is not well known by researchers and people.

Some Goue farmers (N'Gouma arrondissement) prepare millet and sorghum nurseries. The young plants are transplanted after the water has receded. The techniques for sowing and transplanting prevent bird damage to the seeds and seedlings following germination. Millet and sorghum are most often sown in mixtures with other crops such as cassava, cowpea, potato, etc. The varieties of sorghum and millet cultivated around the lakes are generally photoperiod sensitive varieties with a 9 to 10 month cycle. Plantings which used to be carried out in December and January in some lakes are presently delayed until March and April because of the late arrival of the floods.

The frequency of weeding is lake specific. In the Sao lake for example, farmers generally carry out three manual weedings. The first two weedings are carried out during the dry season and the third takes place during the rainy season. According to farmers in this area the third weeding constitutes a labor bottleneck because of the high level of weed infestation and the difficult working conditions with the rains.

The harvest of recession millet and sorghum takes place generally in September. All crops are harvested before the arrival of the new floods.

b. Summary description of the pastoral farming system.

Like the agro-pastoral system, the pastoral system is one of the principal farming systems of the Niger Delta. The pastoral system comprises two sub-systems: the nomadic sub-system and the transhumant sub-system. In the Delta, the feeding of herds requires constant movement over variable distances in order to benefit from annual forage production. The search for wet and dry season pastures follows a regular pattern which forms the basis for transhumance and nomadism.

Nomadism is practised in a marginal manner to the west and north of the Delta. Nomadic herders have no permanent home. They move with their entire family in search of pasture, water and salt for the animals. Nomads do not cultivate crops. They draw nourishment and income entirely from raising cattle, sheep, goats and camels, and from trade.

Transhumance is common in all the Delta zones. It is practised by the Peul according to a definite pattern. The animals move away from the Delta during the rainy season in order to take advantage of the Sahelian wet season pastures, then return to the inner Niger Delta towards November to enter the bourgoutieres as the waters recede. According to the Dina code instituted by Sekou Amadou in the nineteenth century, the flooded pastures are divided into units of different size called "leydi". In each of these a traditional social structure is charged with the responsibility of allocating pasture rights, to decide on access to the pastures and modalities of their use, to fix payment for the rights to be distributed and identify the individuals entitled

to them, and finally to determine the dates and order in which herds will access the pastures. A special statute governs the village pastures destined for the part of the herd producing milk, the transhumance routes, and the temporary shades where herds crossing the "leydi" rest. Outside the flooded zone, the use of rainfed pastures is not controlled but the main transhumance routes are recognized and in principal protected from encroachment by crop production.

The herd is traditionally divided into smaller groups which are managed according to the method of organization developed in the Dina code. The bulk of the herd, known as the "garti", comprises the majority of dry and pregnant cows, the majority of the bulls and heifers, some older steers and a limited number of mating bulls. A small percentage of lactating cows and their calves accompany the "garti", their principal role being to provide milk for the herdsmen. The "garti" is the only unit which fully participates in transhumance. The majority of lactating cows, their calves, some heifers, steers and mating bulls, form that part of the herd known as the "bendi". This part of the herd provides milk for sale or domestic consumption. Another part of the herd is known as the "dumpti" and comprises two or three suckling cows for each family. These animals are only separated from the rest of the "bendi" during the rains (August to October), joining the "bendi" when it migrates to the rainfed pastures. Being few in number, the "dumpti" animals can easily benefit from a supplement of millet bran, cotton seed and salt. The "dumpti" cows are among the best milkers in the herd. They are kept apart from the mating bulls to avoid untimely conception.

To these two sub-groups of animals identified during the informal survey must be added two other sub-groups identified and described by the International Livestock Center for Africa (ILCA). These two groups are the "tjipi" and the "aladji". The "tjipi" is a part of the "bendi" and includes cows. During the period January to March it is lead to various villages in the flooded zone in order to trade milk for rice. The "aladji" is composed primarily of oxen for transport which accompany the "tjipi" cows on commercial expeditions or take part in transhumance within the garti and bendi. The "aladji" is also a small group of draft oxen belonging to absentee farmers or to Peul who also cultivate rice. For the majority of the dry season the "aladji" is kept close to the villages, in order to help plough the rice fields immediately after harvest (February-March) and when the first rains come (May-July). The "aladji" rejoins the garti when it departs for the arid land pastures.

The Dina pastoral code was recognized by the Malian government. The Malian administration was responsible for enforcing decisions on the use of grazing areas, taken jointly with representatives of the herders and local administration. However, the Dina pastoral code has become inadequate due to a variety of factors, particularly:

- anarchic use of resources,

- increasing conflicts (social and land related) between individuals, families, village groups and between crop producers, herders and fishermen,

- acceleration of environmental degradation, particularly during drought years.

c. Summary description of fishing.

In the Niger Delta fishing is an important activity, practised by the Bozo ethnic group. Two main types of fishing can be distinguished according to the extent of movement of the fishermen: nomadic and semi-nomadic. These two types are practised marginally in the South and Central Delta. Fishing is widely practised in the North Delta and non-existent in the West Delta.

The semi-nomadic fishermen are those who practice agriculture in the wet season. They are different from farmers who occasionally go fishing to supplement the family diet. The semi-nomadic fishermen fish primarily in order to earn money and secondly for family consumption. Like the farmer fishermen the semi-nomadic fishermen are permit holders. However, they have more fishing tackle than the farmer fishermen and move from site to site according to information received as to the abundance of fish at different fishing locations within the area.

The movements begin with the recession in November and December and continue until the months of January and May (duration of the flood recession). The semi-nomadic fishermen organize collective fishing days in the Niger, the Bani, the Diaka, the lakes and the ponds. Before the collective fishing day decisions are made as to how much will be paid in rights and taxes to the administrative and traditional authorities. Fishermen from other circles in the region always pay more than the locals. According to the latter, the visitors always have more effective fishing tackle. Fish caught at the collective fishing point authorized by the Service des Eaux et Forets belong to the families or individuals owning the fishing tackle. The catch is often dried or smoked for sale to wholesale merchants from Mopti. Some semi-nomadic fishermen are organized in cooperatives and groups attached to Operation Peche de Mopti.

Nomadic fishermen are those only practicing fishing. They are constantly moving along the water courses in search of fish. Nomadic fishermen, in addition to paddle canoes used for fishing, possess motorized canoes for transporting family members and baggage.

Fishing tackle differs according to the period and type of fisherman. Items of fishing tackle include: hooks, harpoons, nets, hoop nets, seine nets, fishing lines with many hooks, and casting nets. Farmer fishermen use primarily the net, harpoon and hooks. Semi-nomadic fishermen use the other items of tackle, enabling them to catch large

numbers of fish. The majority of the fishing tackle used by semi-nomadic fishermen is in the process of being banned (e.g. casting nets) in order to enable fish populations to recover. Many other problems aggravate the growth of fishing in the Delta.

3. Presentation of the Major Farming Systems in the Seno and Cultivable Areas of the Bandiagara Plateau.

Two main types of farming system can be distinguished in these zones:

- The agropastoral system which is intermingled with the Dogon production system.
- The pastoral system which is intermingled with the Peul production system.

The Seno Plain and Bandiagara Plateau are primarily inhabited by the Dogon and secondly by the Peul. While one can meet Peul all over the plain and plateau, their villages of origin are principally concentrated in the north of the plain (the Diankabou, Dioungani and Dinangourou arrondissements of Koro circle[9]) and in the southern part of the plain (the Diallassagou and Sokoura arrondissements of Bankass circle). The central part of the plain, which has the highest population density, is almost exclusively inhabited by Dogon. This is also observed on the Bandiagara Plateau.

Other ethnic groups are also present: the Mossi close to the border with Burkina Faso and the Daffin or Marka in the southern part of the Seno Plain.

The Dogon, as well as minority groups such as the Mossi and Daffin, are farmers by tradition. However, they have two types of livestock enterprise: one is fattening of a few animals at the homestead (primarily sheep), the other is herding, the management of which is traditionally confided to the Peul.

The Peul are traditionally transhumant herders, moving from pasture to pasture according to the season. As a result of successive droughts over the last fifteen years they have increasingly moved into crop production. This diversification in their activities is a way of reducing the risk from climatic variability. In the event of a bad season the terms of trade between millet and livestock become less favorable for livestock. During such times the harvest of a little millet becomes important for family subsistence.

9/ The Koro circle comprises 80% Dogon and 15% Peul (Koro circle Commandant, November 1987).

On the Seno Plain and Bandiagara plateau, cropping systems have experienced little in the way of modernization. Millet is the most important crop enterprise and continues to be traditionally cultivated, often intercropped with cowpea. Where crop production is no longer entirely manual, modern techniques such as the use of the plough are integrated into the traditional husbandry practices without fundamentally changing them.

The traditional system does not involve land preparation, with the exception of clearing before planting. With the first rains, a few grains of millet are sown in pockets at the top of small mounds of earth. These small mounds of earth, commonly called organic mounds, date from the previous season. At the time of the first and second weeding, the weeds are uprooted, gathered between the millet plants and finally buried under earth gathered between the plants. These mounds containing decomposed weeds give rise to the name "organic mounds". The benefits of this ancient practice are threefold: 1) burial of green material, 2) protection of young seedlings from windblown sand, 3) capturing run-off water for better retention. Cowpea is sown between the millet plants during the first weeding, on a few recently made organic mounds. Manure is brought to the fields when available and sometimes spread around the base of the millet plants. The harvest of millet is performed by uprooting the plants and laying them down flat.

Variations in husbandry practices exist according to the location of the field. Fields close to the village (the "laras" in Dogon) receive greater care than those located further away (the "baracou"). Cunard (1983) notes these differences. In terms of restoring organic matter to the fields, those around the homestead receive more organic matter while those further away are periodically fallowed (for shorter and shorter periods as a result of population pressure) and benefit from the tethering of animals during the dry season. The fields around the homestead are mainly cultivated with millet-cowpea intercrop while those further away also have small areas of secondary crops. In regard to plant spacing the density of millet and cowpea is generally higher on the fields around the homestead. Also, the varieties sown around the homestead are earlier. The fields around the homestead receive priority in first weeding.

Besides cowpea, secondary crops are groundnut, wandzou, fonio, sesame and dah. These secondary crops are cultivated either on land which has already been cropped for several years with the principal millet-cowpea crop, when the land begins to show signs of exhaustion, or else as the first crop after fallow. Millet always receives priority over the secondary crops in husbandry care. Sowing and weeding are first carried out for millet.

The modern system differs from the traditional system in the practice of plowing before planting (above all in the South Seno zone where the soil is loamier and the rainy season longer), by the treatment of seed with fungicide (practised by the majority of farmers) and by mechanical weeding (typically in loamy and sandy loam zones). Chemical

fertilizer is rarely used because of its low and uncertain profitability. The cost of fertilizer is high relative to the sale price for millet. The productivity of fertilizer is as variable as the rainfall regime and the attacks of caterpillars or grasshoppers.

The agropastoral system of the Dogon and the pastoral system of the Peul are two production systems which complement each other at different levels: at the level of exchange of goods and services between the two communities and in the use of the area. The Dogon are specialized in the production of millet intercropped with cowpea. Their surplus production tends to be invested in small and large ruminants, the care and keeping of which is traditionally entrusted to Peul herdsmen. The Peul are specialized in extensive herding of small and large ruminants with transhumance. They concentrate their efforts on the management of herds, interested both in the growth and increase in cattle, and in the production of milk. Milk is exchanged for millet or other agricultural products. Following the recent droughts, the Peul diversified into crop production. A number of them have even obtained ploughs.

These two main farming systems are subject to the effect of their physical, institutional and socio-economic environment. Within each farming system the producers can be grouped according to the effect of this environment on their farming system. For example, the rainfall regime or access to the market can be more or less serious constraints to the farming system according to location. Distinguishing between groups of producers according to the importance of any given constraint posed by the environment on the farming system is a means of identifying recommendation domains.

For each of these two farming systems three distinguishing criteria have been used. The first criterion relates to agroclimatology. The second criterion is access to markets and supply infrastructure. The third criteria is population pressure on the available land.

On the basis of these three criteria five groups of producers can be distinguished, three of them belonging to the agropastoral system and to the pastoral system (see table B.6 in annex B).

a. Agroclimatology.

The agroclimatic environment has a major influence on the conduct of agricultural activities. The use of the plough for land preparation and weeding, for example, depends heavily on the agroclimatic zone. Recommendations on the use of Telemsi rock phosphate depend on the rainfall. Recommendations for the development and extension of a given variety of millet or cowpea also depend on rainfall. In view of the influence of the agroclimatic factor on agricultural activities, it is used as the first criterion for distinguishing groups of producers with

the same farming system. The three most important agroclimatic zones in terms of area and population have been included: the North, Central and South Seno zones. The cultivable plains of the Plateau, termed Plateau zone, have been included in the Central Seno zone as they have similar soil and rainfall characteristics.

b. Access to markets and input supply facilities.

Access to markets and input supply facilities is the second criterion for distinguishing groups of farmers with the same farming system. Access to markets is relatively easier for the Plateau and Central Seno zones than for the North and South Seno Plain zones. For the Plateau zone, although the feeder roads are rocky and not maintained they lead to the Mopti-Bandiagara-Sangha highway. For the Central Seno Plain, Bankass and Koro (circle capitals) are accessible from the Somadougou road. The North and South Seno Plain zones, on the other hand, are much more isolated. They are located away from the main highways and cannot access any important markets besides those of Douna in the North and Diallassagou in the South zone. Consequently, two zones have been included: an isolated zone for the North and South Seno zones and a relatively accessible zone for the Central Seno and Plateau zone.

c. Population pressure on the arable land.

Population pressure is the third criterion for distinguishing between groups of producers with the same farming system. This criterion helps to identify which type of technology is most appropriate. According to PIRT (1986), the North zone has a lower population pressure than the Center, Plateau and South zones. Technologies for intensification are therefore relatively less appropriate, and the farmers in this zone have a tendency to increase the area cultivated. Their justification for this strategy is that it reduces the risk of total failure in the event of insufficient rainfall, as has frequently occurred during the last fifteen years.

Two degrees of population pressure, borrowed from PIRT (1986), have been included. The first level is termed "very high population pressure" and corresponds to the North zone, while the second level is termed "excessive population pressure" and corresponds to the Central, Plateau and South zones.

The identification of these groups of farmers experiencing the same external influences is summarized in table B.6 in annex B. Based on the three criteria of identification the agropastoral system can be characterized by three groups of farmers (I, II, III). The pastoral system can be characterized by only two groups of herders (IV and V) since there are few Peul villages in the Central and Plateau zones.

The five groups of producers include a population of 393,000, representing 31% of the population of the Fifth Region.

D. GENERAL CONSTRAINTS ON FARMING SYSTEMS.

The constraints to farming systems in the fifth region can be classified into two main groups:

- Physical and agrobiological constraints.

The components of this group are rainfall, hydrology, soil characteristics, water and forage resources, cultivated plants, crop pests (insects, weeds, diseases), and animals.

- Technical, socio-economic and institutional constraints.

The components of this group include techniques used, costs and supply of agricultural inputs and equipment, capacities and approaches of rural development agencies, markets for crop and livestock products and fiscal, monetary and commercial policies.

These different constraints are discussed according to the two major farming systems of the region and by agroclimatic zone when necessary.

1. The Agropastoral System.

The constraints to the agropastoral system have been discussed in the working document "Resultats de l'Enquete Preliminaire en Cinquieme Region du Mali. I. La Plaine du Seno et le Plateau de Bandiagara." (Henry de Frahan and Diarra, 1987) and in the information notes "Etude de la Traction Animale dans le Seno." (S. Traore, 1988), "Les Principaux Resultats de la Recherche sur les Cultures Associees Mil-Niebe au Mali" (S. Traore, 1988) and "Enquete Informelle sur les Cultures Maraicheres du Plateau de Bandiagara." (S. Traore, 1988). The constraints discussed briefly below are developed further in chapter IV of this report where the research subjects for the expansion of DRSPR in the Fifth Region are proposed.

a. The major physical and agronomic constraints.

(1) The deterioration in the rainfall regime.

Since 1973 and 1974 the rainfall regime has deteriorated in the Fifth Region. This deterioration has taken the form of a reduction in rainfall in the order of 20% and a poor distribution of rainfall over

the course of the vegetative cycle of the principal crops of the region. In the North and Central zones of the Seno Plain, the Bandiagara Plateau zone, the North, West and Central Delta zones, the present rainfall regimes do not allow local millet and cowpea varieties, even the earliest, to complete their cycle in some years. This deterioration in the rainfall also prevents varieties of Oryza sativa rice to develop sufficiently before the arrival of the flood.

(2) The deterioration in the flooding regime.

In the Delta zones, the late arrival and weakness of the floods prevents varieties of Oryza sativa rice and, to a lesser extent, varieties of Oryza glaberrima rice from developing in some years. This deterioration also affects the productivity of the recession crops (rice, sorghum and millet).

(3) Low soil fertility.

The soils of the Fifth Region, like those in the rest of the country, are generally poor in nitrogen and phosphorous (OECD and CILLS, 1987). The level of organic matter in these soils is also low. The poverty of the soils is a factor which severely limits biomass production. Any significant increase in productivity requires the use of chemical fertilizer or manure. The condition of draft animals also depends on the improvement of soil fertility in order to increase forage availability, whether in the form of forage crops or crop residues.

For the rainfed crop zone, the loamy soils have adequate depth and infiltration characteristics. By contrast, the Bandiagara Plateau is characterized by snallow, rocky soils which prevent any form of cultivation in some places.

(4) Violent winds and run-off.

The violent winds on the Seno Plain at the time when cereal crops are germinating results in seedlings being covered in sand. At the edges of the Delta the violent winds fill some lakes with sand where ten years ago recession cropping was still very productive. On the Bandiagara Plateau and the Center and South Delta zones, run-off water erodes the arable land and removes fertile elements.

(5) Harmful insects and other crop predators.

The principal rainfed crops such as millet and cowpea are subject to insect attack both in the field and in storage. Raghuva headborer in particular frequently attacks millet, and other insects inflict serious damage on cowpea in storage. Borers are also very frequent on millet and Oryza sativa rice. Termites, mice, rats and granivorous birds are important and active pests on all crops.

On the rainfed crops weeds are a serious pest, particularly Striga in the millet crop and wild rice species (Oryza bartii and Oryza longistaminata) in the rice crop.

b. The principal socio-economic and institutional constraints.

(1) The unfavorable ratio between input and agricultural product prices.

The high cost of modern agricultural inputs (primarily pesticides and chemical fertilizers) in relation to the selling price for cereals discourages intensification of rainfed agriculture. Besides the unfavorable terms of trade for agriculture in regard to external inputs, the climatic and hydrological uncertainties limit the intensive use of agricultural inputs whether for rainfed, flooded or recession agriculture. The absence of any truly profitable crops limits the financial resources of agropastoral enterprise, and consequently the intensification of agriculture.

(2) Thinness of agricultural product markets.

The thinness of the market for such products as groundnut, the small degree of transformation of agricultural products (low value added) and the weak purchasing power of potential consumers limits the outlets for agricultural products and further serves to discourage the intensification of agriculture.

(3) Taxes.

The taxes levied during the post harvest period increase sales of agricultural products at a time when sale prices are relatively low. The over commercialization of agricultural products during this period, the lack of organization of producers in dealing with the better organized merchants, and the difficulties of preserving large quantities of agricultural products (particularly cowpea) reinforce seasonal price fluctuations to the disadvantage of producers.

(4) Isolation of areas of production.

The inaccessibility of some producing areas during the rainy season (e.g. Koro) and during the flood period (Tenenkou and Youwarou) as well as the bad state of the rural roads has resulted in zones becoming isolated. This isolation limits the supply of agricultural inputs and outlets for agricultural and livestock products.

(5) The inadequate distribution network for agricultural inputs and credit.

The inadequacy of credit and input supply facilities for inputs and agricultural equipment, particularly for rainfed agriculture, limits

the use of these inputs and consequently discourages the intensification of rainfed agriculture.

(6) The weakness of techniques for water management.

The water management structures set up to control flooding of crops can only delay the arrival or recession of flooding on the managed polders. Consequently, crop production with controlled flooding remains dependent on rainfall to begin rice cultivation, and dependent on the hydrological regime for continued growth.

The small village irrigated perimeters have been established in order to have full control over flooding of crops. However, because of a lack of technical studies and sufficient finance, some of these small perimeters have been located on porous soils or poorly levelled areas.

The weak producers' organization responsible for the profitable management of water and maintenance of irrigation canals prevents the optimal management of these facilities in some cases.

(7) Land use conflicts.

A poorly defined land tenure system gives rise to different interpretations among crop producers, livestock herders and the administration, and constrains the optimal use of land resources. It has been shown (OECD and CILLS, 1987), for example, that the income obtained from rice cultivation under controlled irrigation is not necessarily superior to that obtained if the area was allocated to dry season pasture. According to OECD and CILSS (1987, p 135), each hectare of dry season pasture, i.e. each hectare of bourgoutiere, taken away from transhumance represents elsewhere, particularly in the North sahel zone, 2 to 20 hectares of rainy season pasture which can no longer be efficiently utilized. The value of the best dry season pastures is estimated at between 30,000 and 40,000 F.CFA/ha while the Delta rice polders provide a net income of 20,900 F.CFA/ha, based on a yield of 900 kg paddy rice which is possible only in years with favorable rainfall and hydrological conditions.

2. The Pastoral System.

The constraints to the pastoral system have been discussed in the working documents "Resultats de l'Enquete Preliminaire en Cinquieme Region du Mali. I. La Plaine du Seno et le Plateau de Bandiagara." (Henry de Frahan and Diarra, 1987) and "L'Elevage en Cinquieme Region: Contraintes et Actions Pioritaires d'Intervention et de Recherche Appliquee." (Diakite and Keita, 1988). These constraints will be discussed more specifically in chapter IV of this report according to the research subjects proposed for the expansion of the DRSPR in the Fifth Region. This section presents the principal physical and

biological constraints of the pastoral system and then the main socio-economic and institutional constraints.

a. Physical and biological constraints.

(1) Inadequate nutrition.

Nutrition is generally considered as the first constraint to livestock production in the Fifth Region. This constraint is not linked to the method of rearing animals. The report of OECD and CILLS (1987) shows that extensive herding, with transhumance between the dry and rainy season pastures, is the most appropriate and effective type for the Fifth Region. However, the availability of forage is limited by low soil fertility (particularly in regard to phosphorous), the expansion of the cultivated area and the small quantity of crop residues.

(2) The deterioration of the rainfall and hydrological regime.

The deterioration of the rainfall and hydrological regime over the last decade has reduced the possibilities for biomass regeneration. This rapidly translates into deterioration of the grazing areas in regard to both perennial grasses and ligneous species This climatological deterioration has only exacerbated the disequilibrium which already existed between cattle and carrying capacity.

(3) Parasitic diseases.

Parasitic diseases persist among transhumant cattle and principally among small ruminants.

b. Principal socio-economic and institutional constraints.

(1) Population pressure on the arable land.

Population pressure on the arable land reduces the grazing area and provokes conflicts between crop producers and herders over their use. In the face of uncertain rainfall and hydrological regimes, crop production tends to become more extensive and diversified. This results in a progressive loss of control over the grazing area to the det iment of the herders.

(2) Ambiguities in the land tenure system.

Regulations for the productive use of natural resources established by the Malian administration are poorly defined and far removed from reality. In conflict with the still active traditional socio-political structures, the regulations resolve few conflicts either between herders and crop producers or between groups of herders. Because of this legislative vagueness, numerous conflicts over the use of land, wells and ponds are solved in an arbitrary and partial manner.

(3) The thinness of the market for livestock products.

The thinness of the market for livestock products is due to reduction in market outlets to neighboring countries and to the fall in purchasing power. The overvaluation of the CFA franc in Mali and the fiscal and administrative charges do not encourage exports.

(4) Inadequacy of pastoral infrastructure.

The lack of wells, boreholes and ponds in the waiting zones encourage degradation of the dry season pastures. The lack of mineral supplements from ODEM results in mineral deficiencies and encourages some illnesses.

(5) The lack of alternative investment opportunities to livestock.

Besides the social prestige attached to being the owner of a large herd, there exist few opportunities for investment apart from livestock. This is also true for mixed farmers as well as purely livestock farmers.

Following a background on the Fifth Region, this chapter has presented the agroclimatic zones, the major farming systems and the major production constraints for these farming systems. This has been done to understand the agroclimatic, socio-economic and institutional environment of the farming systems. With uch an understanding, the next chapter proposes a research program which includes a series of research subjects addressing the key production constraints.

IV. PLAN OF RESEARCH

In view of the main agro-climatical, socio-economical and institutional constraints found in the Fifth Region, a research plan is suggested in the first section of this chapter. This plan contains fifteen research subjects and takes into account both current and expected technologies available to the on-going research. Each subject is expanded along the same outline and contains four parts. The first part introduces the theme and gives its context in Mali and in the Fifth Region. The second part identifies and defines the research objectives. The third part presents the main elements justifying each research subject. The information comprising the third part was either collected in formal and informal surveys and from available documents, or was compiled and analyzed from this data. The fourth part explains how the research team might approach the topic more concretely, both qualitatively and quantitatively, depending on the available data and the expected results.

The first section is more detailed than the other sections. In order to ensure the validity of the suggested research subjects, it was necessary to detail possible constraints (either agroclimatic, agrotechnical, zootechnical, socioeconomical or institutional) and to see if solutions exist in the technologies developed by the on-going research or in institutional or political reforms. The proposed research subjects are therefore based on technological, institutional and political considerations.

The second section of this chapter recommends a schedule of research activities for the Fifth Region. This schedule takes into consideration the human and financial resources allocated to the extension of the DRSPR in the Fifth Region, the priority of some research subjects over others, and the expected results.

The third section of this chapter presents a research strategy based on production problems in the Fifth Region at both the micro and macro levels, and on a strict collaboration and coordination between the research system on the one hand, and on the other; applied research, extension services, other public services, the private sector and decision-makers.

A. RESEARCH SUBJECTS.

1. Study of Input Factor Markets and Agricultural Credit.

a. Introduction.

There are numerous constraints linked to growth in agricultural production. In the agricultural sector review for Mali (Ministry of Agriculture, 1987, pp. 76-77), the lack of inputs, seeds and varieties adapted to the ecological conditions are listed among the main factors inhibiting this growth.

(1) Supply of inputs.

(a) Supply of agricultural inputs.

Since the Agricultural Credit and Farming Equipment Union (S.C.A.E.R.) was dissolved, the Operations du Developpement Rural (ODR) have been furnishing and delivering inputs to villages and establishing transfer prices (through a request for international funding for the CMDT). This system's performance depends upon the ODR's means, its efficiency and the constraints found in each area. For example, if the input supply level is sufficient in the CMDT zone, it is lacking at the Office du Niger. At the OHV, the ODIPAC and the ORS, after previous failures, the supply of inputs currently remains less than the demand. In the more arid areas of the country like the Fifth Region, the supply of agricultural inputs is sufficient only in the case of punctual, limited, and specific programs. There, the extra capacity to absorb these inputs is, however, very limited economically due to financial risks and the suspension of input subsidies, especially for fertilizers. It could be said that, in Mali, the CMDT operates the only satisfactory supply of agricultural inputs.

In addition, there are significant price differences among zones for agricultural input transfer prices to producers such as those between the OHV and CMDT zones. For non-subsidized fertilizers such as the cotton fertilizer, urea acid and ammonium-phosphate, villagers in the CMDT pay 15% less than those in the OHV zone (official OHV and CMDT prices for 1988). This difference in price is even more marked for Tilemsi rock phosphate (41% more expensive through the OHV). Also, producers in the CMDT region of San receive a 50% subsidy on fertilizer. This example illustrates that a better purchasing policy with the suppliers (for example, a call for international funding as did the CMDT) would create a lower price for producers without instituting subsidies. It should be noted that no import tax is levied on imported fertilizers except a 5% Contribution for Payment of Services (CPS) rendered at the time of import.

In the Fifth Region, particularly in the Seno plain area, the demand for inputs such as plows, carts and fungicides (Thioral) remains unmet (Henry de Frahan and Diarra, 1987). In the area where the Operation Riz Mopti (ORM) operates, most rice growers have expressed a preference for the Oryza sativa DM 16 variety which is an earlier germinating and hardier strain than the Kao Gaew currently distributed by the ORM. Nevertheless, 23 years after its development in 1965 (Goita, 1986,) and 10 years after the first field tests (M. Dembele, 1986,) the O. sativa variety is still not available to rice growers in the ORM region.

(b) Supply of inputs for animal breeding.

Traditionally, mineral supplements necessary to livestock grazing (nomadic and seasonal herding) are obtained from salt deposits found in the soils of the northern area of the Fifth Region. The more recent introduction of mineral blocks by the Operation pour le Developpement de

l'Elevage a Mopti (ODEM) has not been as successful as was planned because traditional livestock grazing practices make the distribution of mineral supplements difficult. Furthermore, ODEM technicians were disappointed in the first white KNZ compound marketed because it lacked sufficient calcium and phosphorus (the assistant director at ODEM, personal communication, October, 1988). Therefore, since the pastureland in the Fifth Region is also lacking in calcium and phosphorus, any mineral block not containing these elements is of little use.

(2) Supply of agricultural credit.

Agricultural credit in Mali, which appears to be a source of input supplies, is dependent upon the ODR since the Banque Nationale de Developpement Agricole (BNDA) has not yet taken over all the credit programs and intervenes only in underwriting credit with other agencies. Credit underwritten in this manner represents 90% of the total value of credit accorded to the ODR by the BNDA. Underwriting is carried out under an agreement between the BNDA; the grantor, regulator, director and loan collector, and development organizations (DNACOOP, for example) which receive the requests for loans and are responsible for their administration and follow-up ("La Revue du Secteur Agricole du Mali", 1987, p. 182). In addition to underwriting credit, the BNDA grants loans to individual borrowers and agribusiness companies. The interest rate is set by the Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO) according to an established scale. The parameters defining the interest rate are the following: 1) the cost of financial resources (purchase of currency), 2) administrative costs, 3) the risk involved and 4) realization costs (Diallo, BNDA agricultural credit agency, personal correspondence, September 1988). The current interest rate established by the BNDA for an intermediate time period is 9% for 4 years. The BNDA is not subsidized by the state, but is supported by several financing organizations such as the CCCE and the DEG.

The BNDA has opened a branch in Sevare (10 km. from Mopti) in the ORM region, to finance agricultural development activities but despite a line of credit from the CCCE, it has had virtually no success because of unstable agricultural production. The BNDA has 3 branches and 5 offices in the CMDT region, however, and is well-established. The CMDT area alone absorbs 50% of all underwritten credit. Most of this credit, in the form of intermediate-term loans, goes to villages which have been organized into village associations. This credit has currently attained an equilibrium point and the recovery rates have been satisfactory ("La Revue du Secteur Agricole du Mali", 1987, p. 183).

According to the aforementioned agricultural sector review (1987), an expansion in the BNDA's financial activities is subject to several conditions:

- The future growth of the BNDA's intervention, necessary given the magnitude of the needs yet to be addressed in the targeted zones, can only be achieved when accompanied by an extension of the

administrative capacity of regional services and the village organizations receiving the credit.

- An extension of the BNDA into other areas of intervention calls for an extension of the bank's network of offices. This can occur only in the initial phase, and with the assistance of other projects operating in these areas, since the BNDA itself could not finance the start-up in areas with low service volume.

b. Objectives.

The specific objectives for this research subject are to:

- Identify the constraints and potentialities linked to the supply of credit and agricultural inputs (fertilizer, agricultural equipment, pesticides).

- Identify and analyze the constraints linked to the use of a mineral block for livestock.

- Propose and test methods of organizing the supply and distribution of credit and agricultural inputs.

c. Purpose.

The identification of constraints and potentialities linked to the supply of credit, agricultural and husbandry inputs implies finding solutions to problems encountered by the rural producer (for example, seed treatments, transportation of manure or agricultural products, field cultivation, etc.). The study of credit and agricultural input supply systems will facilitate the transfer of technologies developed by the farming system research team. In fact, the identification of market constraints for agricultural inputs is important not only to solve the current problems faced by producers at the beginning of each season, but to foresee any problems that might arise after the development of technical packages during their extension. It is for this reason that the evaluation team recommends that this research topic receive as much attention as the others. The research project should be understood on a larger scale. Its aim should be not only to develop technologies adapted to production systems, but also to seek and propose solutions to constraints found in the physical and institutional environment of these production systems.

In the Seno area, emphasis should be placed upon removing the constraints hindering the availability of adequate fungicide supplies, such as Thioral, for seed treatment. From 1976 to 1984, the supply of Thioral fell dramatically. In 1976, approximately 30% of the area cultivated under the Operation du Mil Mopti (OMM) was treated (Berthe, 1977), and the OMM was the largest buyer of Thioral (4,755 kg. in 1979 , the peak year). In 1984, however, the area treated was approximately 5% (estimate based on the amount of fungicide purchased by OMM). Berthe (1977, p.9) reports that the OMM's recommendations for fungicide use are

well-known and accepted by farmers for the following reasons: 1) its immediate effect on seed, 2) ease of application, and 3) relatively low price.

Since 1982, USAID no longer funds the OMM and village organizations must order Thioral through the DNACOOP, local NGOs, catholic mission and political organizations. Thus, during the 1987-88 and 1988-89 growing seasons, the Societe Malienne des Produits Chimiques (SMPC) delivered 1, 407 kg. of Thioral in 1987, and 780 kg. in 1988 to the Service National de Protection des Vegetaux (SNPV) in Mopti, who then sold this stock to the village groups that had ordered it. The amount of Thioral sold for cash to the village organizations in 1988 was sufficient only to treat 31,200 ha., or 12% of the area grown in millet. Each bag of Thioral weighs 25 gr., costs 60 FCFA and will treat 10 kg. of millet seed, enough to plant one hectare.

Henry de Frahan and Diarra (1987) report that the demand for plows and carts goes unmet in the Seno area. This demand was verified in a formal survey. Table 4.1 below shows, by producer stratum, the percentage of plow and cart owner-user operations, and also the percentage of farmers wishing to own the equipment.

As one can see in Table 4.1, of the agropastoralists and pastoralists interviewed who do not have equipment, 75 to 100% wish to have an ox or donkey plow. Among those who already have one plow, there is an expressed demand to own a second one. It should also be noted that, with the exception of the pastoralists in the northern area, those groups of producers who own a plow also own a cart.

Henry de Frahan and Diarra (1987) report that the problem of supplying rural producers with a plow and cart stems from production. The same may be said for supplies of the Oryza sativa DM 16 variety of rice where production and propagation of the seed constitute the main constraints. As for Thioral, there is practically no private channel of supply and distribution to rural areas. The review of the agricultural sector in Mali (1987,p. 189), however, advises caution in linking the private sector to input distribution outside of the CMDT area and the Office du Niger. According to this review, the private sector can only operate in a market endowed with an effective, foreseeable and solvent demand, conditions which are not met outside the CMDT area, except perhaps that which concerns vegetable production at the Office du Niger. Nevertheless, according to the survey in the Seno, it seems that there is a significant demand in the Fifth Region and that there could be solutions linked to the private sector to facilitate supplying the rural areas with the desired inputs for which there is a willingness to pay.

As for inputs to animal breeding, the future orientation of the ODEM (Diakite and Keita, 1988,) is toward local production of mineral mixtures at reasonable prices, adapted to and supported by more dynamic extension practices. The target livestock sector will be primarily the sedentarized herds of the agropastoral system and the milk cows and calves of pastoralists (Bendi herds).

TABLE 4.1 : LOCATION OF AGRICULTURAL EQUIPMENT IN THE SENO PLAIN AND THE BANDIAGARA PLATEAU BY PRODUCER TYPE (%).

EQUIPMENT	Oxen plow		Donkey plow		Cart	
STRATUM	Owner and user	Wants to own	Owner and user	Wants to own	Owner and user	Wants to own
North agro-pastoralists w/o equip.	-	83.8	-	94.6	21.6	75.7
N. agropast. w/ equip.	33.3	61.9	61.9	19.0	52.4	47.7
Central and Plateau agropastor. w/o equip.	-	78.9	-	74.6	19.7	69
Central and Plateau agro pastoralists w/ equipment	28.8	38.8	67.5	10.0	70.0	23.8
South agro-pastoralists w/o equip.	-	96.8	-	96.8	58.1	42
S. agropast. w/ equip.	32.1	67.9	71.4	25.0	89.3	10.7
Northern pastoralists w/o equip.	-	77.8	-	83.4	-	88.9
N. pastoral. w/ equip.	44.4	55.6	55.6	44.4	33.3	55.6
Southern pastoral.w/ & w/o equip.	-	100	19.0	81.0	47.6	47.6

Source: Survey implemented from December 1987 to March 1988. IER-USAID-MSU project.

d. Outline of reforms and solutions.

Since the problem of agricultural input supplies has been brought to light, action has been taken to solve some of these problems. Several of these measures have been reforms to existing institutions such as the seed multiplication and production program. Other timely effects have been in the removal of particular problems which might, however, arise again.

The seed multiplication and production program currently under design proposes the restructuring of the agencies involved and the reinforcement of their means of production ("La Revue du Secteur Agricole du Mali," November 1987 p. 178). The PNUD project MLI/86/005/B/01/12, in effect for a period of four and one half years, focuses on the production and propagation of improved varieties of millet, sorghum, maize and

cowpea seed. At the same time, the production and propagation of the rice variety Oryza sativa are not a part of its program.

The World Bank proposed to the Ministry of Planning support for a long-term improvement program in agricultural support services, starting with the extension service. The first part of this program would be carried out during the 1988-89 agricultural season in four areas, three of which have been named: ORM, ORS and the Office du Niger (ON). An evaluation following this step will decide the content and scope of the next part of the program (World Bank, undated). The introduction of the Training and Visit System, similar to the research system approach, was decided upon during initial discussions between the Ministries of Agriculture, Natural Resources and Animal Breeding, and the World Bank (CCCE, 1988).

An order placed in 1986 by the Koro and Bankass area village farmer groups (Tons) was finally delivered. The order consisted of 754 carts (of which 172 were for 8 Tons in the Bankass circle) and 344 donkey plows (of which 86 donkey plows and 32 TOM brand plows were for 8 Tons in the Bankass circle) on which 20% of the credit value was paid. The Societe Malienne d'Etude et de Construction de Materiel Agricole (SMECMA) could not provide tires for the cart frames, and DNACOOP, acting in the name of the village Tons, imported them from a merchant in Bamako. The donkey plows were purchased from the OMM who, at the end of the 1986-87 season, had 550 donkey plows and 210 TOM plows in unsold stock (OMM, March 1987). This equipment was sold on credit for 56,235 F CFA per set of cart frames and 48,335 F CFA per donkey plow. Subtracting the initial investment of 20%, the annual payments come to 13,856 F CFA and 11,910 F CFA respectively, over a period of 4 years at 9% interest.

SMECMA underwent a severe financial crisis in 1986 and 1987. As a result of this crisis and its use of out-dated production equipment, orders for agricultural materials could not be filled. Currently, SMECMA claims that it is able to honor its agreements. It should be noted, however, that SMECMA's costs of production are 8% higher than the average price of its product. As an extreme example: SMECMA takes a 30% loss on the selling price of a grain drill (correspondence from the assistant director at SMECMA, August 1988). Consequently, the production of agricultural equipment in Mali is subsidized. In addition, there are no taxes on imported materials except for a 5% CPS. These particular advantages limit private competition for SMECMA, despite a strong unmet domestic demand for agricultural equipment.

Furthermore, the equipment manufactured by SMECMA is not always well-adapted to the soil and climatic conditions around Seno where, for example, crop spacing is greater than in other areas (see the research subject on the improvement of cropping techniques).

One solution would be to manufacture and assemble certain equipment parts regionally. This could increase adaptability of use and supply local conditions. The Dutch project ADAMA (Association Des Ateliers de Materiels Agricoles) has similar objectives.

Lutheran World Relief (undated), in collaboration with the CAC of Bankass, financed a 45-day training seminar (May and June, 1988) for 10 blacksmiths from several districts in the Bankass circle (Central Bankass, Baye, Kaw, Bozon and Diallassagou) and those from the central training workshop. Five of these blacksmiths formed a cooperative which just received a 9 million FCFA loan from the BNDA to purchase materials to make 200 carts. The assembled carts will be sold for 90,000 FCFA (the added value nears the value of the materials).

e. Proposals.

Zone: The entire Fifth Region

Production systems: Agropastoral and pastoral.

Collaborating services: DNACOOP, BNDA, ORM, ODEM, Direction Regionale de l'Agriculture (Mopti).

Proposals:

(1) Study of private and public sector agricultural input distribution networks, accompanied by the identification of existing constraints, potentialities and viable alternatives.

This study would be carried out through periodic surveys on the input production and distribution channels (manufacturers, importers, distributers, users, ODR, etc). Inputs studied would be fungicides (Thioral, for example), fertilizers, including Tilemsi rock phosphate (TRP), improved seed varieties and draught animals.

It would be interesting to answer the following questions: Why don't merchants purchase Thioral at the SMPC for resale at weekly markets? Why aren't fertilizers and TRP marketed? What are commercial profit margins? Are they high or low? What should be suggested to producers in the Fifth Region, and particularly to those producers who have access to improved seed varieties produced by the OPSS but are in areas not covered by any service or agency? What is the commercial network for draft animals (from production areas to usage areas)?

Regular surveys should also be carried out to identify constraints linked to mineral block use for livestock.

(2) Study and testing of input supply and credit services in villages not yet included in an extension program under the DSPR project.

These studies and tests should be carried out on the inputs included in the technological packages proposed by the DRSPR such as improved seed varieties, insecticides, fertilizers and agricultural equipment. Village farmer groups (Tons) could be intermediaries in carrying out these tests.

2. Study of Agricultural Product and Livestock Markets and Transactions.

a. Introduction.

The Fifth Region comprises two ecological zones (flood and non-flood areas) and has therefore, multiple resources in animal breeding; agriculture and fishing. According to the National Bureau of Statistics (DNSI), cereal production in the Fifth Region consists primarily of rice, millet, sorghum and fonio. Legumes such as peanuts and wandzou are monocropped in small plots. Cowpeas and millet are usually intercropped, and dah, sesame and sorrel are also grown. For the period 1974 to 1986, the regional contribution of millet, sorghum and fonio to the national production was 16%. For the same period, the regional contribution of rice was 26%. Market gardening, especially onions, is practiced widely on the Bandiagara plateau. Animal breeding in the Fifth Region, in spite of drought periods, plays an important role economically. In fact, in Mali, the livestock sub-sector contributes to approximately 18% of domestic product and is the second most important source of export revenue (Stryker, 1987). According to DNSI statistics, cattle herds in the Fifth Region represented 23% of the national total of herds for the period 1977-1987 and sheep and goat represented 20%. The fishing sub-sector is also important economically in the Fifth Region, especially in the Mopti (central Delta), Diafarabe (south Delta) and lake Debo (north Delta) circles.

Marketing of agricultural, fishing and animal breeding products takes place in the interior as well as the exterior of the Fifth Region. Furthermore, Mopti is located between grain producing (Sikasso, Segou and Seno) and grain consuming zones (Mopti, Gao, and Tombouctou). In this central location, Mopti is an important national, and even international, commercial axis. However, the overvaluation of the CFA franc, import taxation and export disincentives do not facilitate trade and do not allow the region to benefit completely from its comparative advantage in the areas of agriculture, livestock, and fisheries.

(1) Market for cereals and legumes.

(a) Demand for cereals and legumes.

According to the agricultural sector review for Mali (November 1987, p. 87), on a national scale, the demand for rice will continue to increase. This increase will probably surpass potential growth in local production since production should increase at a rate of 7% annually to satisfy a 2.5% population growth increase by the year 2010. On the other hand, the demand for millet, sorghum and maize is expected to increase at an annual rate of 2.6%, and will be in line with anticipated local

production growth[1]. Otherwise stated, it will be necessary to diversify processing technologies for coarse grains (millet and sorghum processed into flour, couscous, etc.) in order to facilitate grain sales in the long run.

Currently, groundnut production meets domestic demand at 40,000 tons nationally. Because of a depressed world price for groundnuts and Mali's landlocked position, the short and intermediate term market for groundnuts will remain domestically based. The current policy advocates protecting the national market against often illegal imports from neighboring countries (Africa, July-August 1988). The 1986 crop has not yet been refined and the 1987 crop not yet ground and pressed. Peanut by-products consist of oil produced for the local markets, as well as peanut butter and flour produced for local and exterior markets if the quality is satisfactory (director of ODIPAC, personal correspondence, August 1988).

Sesame is not normally exported because the world market price is not high enough to induce increased production or to cover transportation costs. The CMDT, however, is interested in sesame cultivation for agricultural diversification in its zone (director of ODIPAC, personal correspondence, August 1988).

Traditionally, cowpeas were consumed seasonally and particularly during the rainy season. Since the drought, cowpea consumption has increased significantly. The possibility of developing cowpea and wandzou production is realistic for domestic markets and perhaps also for export. Marketing of these products still needs to be coordinated (O. Coulibaly, 1987). Farmer organizations are not yet capable of serving more than the local market and merchants are not yet willing to take the risks of unstable and dispersed supply, high transportation costs and export taxes[2]. As in the case of peanuts, research should be undertaken on cowpea technology to meet consumption demands and provide the possibility of a diversifying crop in the Sahel areas ("La Revue du Secteur Agricole du Mali," November, 1987, p. 69).

(b) Price levels for grains and legumes.

According to the Review of the Agricultural Sector for Mali (November 1987, p.97), prices for millet and sorghum essentially depend on supply and therefore on production. After a good harvest, prices decrease not only because urban demand for millet and sorghum is stable

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1/ The annual increase in production rates for millet, sorghum and fonio for the period from 1971 to 1987 was 3.3% according to the DNSI and 2.1% according to the DNA (OSCE, 1988).

2/ The export tax for oil seeds and fruits other than peanuts is 5% and the Contribution for Payment of Services rendered at the time of export (CPS) is 3% (Stryker et al., 1987).

but also because, after a good season, rural producers have a surplus and their demand is relatively low. After a poor harvest, however, the urban demand compounds the rural demand for the scarce commodity. In sum, coarse grain prices are unstable from one year to the next.

The Review (November 1987, p.97) states that the price of rice on the national market is contingent upon import policies and the world market price. In order to align the price of locally produced rice with that of imported rice, rice projects received subsidies during the 1986-87 season amounting to 28 F CFA/kg at the Office du Niger, 21 F CFA/kg at the ORS and at the ORM, the highest subsidy, 44 F CFA/kg ("La Revue du Secteur Agricole du Mali," November 1987, p. 99). There was no such subsidy for the 1987-88 season. During both of these seasons, the price of paddy rice was fixed by the rice projects at 70 F CFA/kg.

The price of an 80 kg. sack of rice for producers in markets around the delta fluctuated between 4,000 and 7,500 F CFA, or 50 to 90 F CFA/kg against the official price of 70 F CFA/kg for the 1987-88 season. Prices vary depending on good and bad years for production, the time of year (whether harvest or hungry period) and the markets.

For the Malian people rice, millet and sorghum constitute the staple foods. It seems, however, that there is no direct correlation between the price of rice and that of millet and sorghum. Cross-price elasticity measures the effects that a change in price for one food product has on the amount consumed of another. In an interim report from their study on prices and food products consumption in Mali, Rogers and Lowdermilk (1988, pp. 19-20) show that the cross-price elasticity for rice and millet/sorghum is low. In other words, when the price of millet and sorghum increases, there is little tendency for consumers to switch to rice consumption or vice versa. The authors explain why rice and millet/sorghum are not substitutes, contrary to expectations, in a price margin observed in Bamako, Koulikoro, Sikasso, Segou and Mopti.

These same authors estimated price elasticities of demand for rice, millet and sorghum, peanut butter and beef from a sample of consumers in Bamako, Koulikoro, Sikasso, Segou and Mopti. As staple cereals, the demands for rice and millet/sorghum are relatively elastic with respect to price (-0.8 and -0.66, respectively). Such price elasticities are higher than those observed in India (-0.6) or in the United States (-0.1 to -0.2). These data signify that a shift of the supply of a commodity on the market (for example, as a result of increased rice imports or increased millet/sorghum production following the adoption of a new technology) will decrease gross revenue only slightly for importers or sellers.

A relatively high price elasticity of demand for a commodity does not, however, guarantee diffusion of a new technology designed to shift the supply of this commodity. The producer will respond to the change in profitability and not to the change in gross revenue generated by the new technology. The most important consideration for the producer is the amount by which one can reduce the unit cost of production with respect

to the eventual decrease in sale price of the commodity due to the supply shift at the time of new technology diffusion. In addition, in the case where the marketing margin between the final product (peanut butter, for example) and the raw product (peanuts, for example) is large, the producer does not face the market demand but a derived market demand. If this margin is large, the derived demand for the raw product from the producer will be relatively price inelastic, even if the price for the final product is relatively price elastic (Tomek and Robinson, 1985).

Since peanut butter has a high price elasticity of demand (-1.86 for the urban consumer according to Rogers and Lowdermilk, 1988, pp. 20-21), peanuts would be an attractive investment if, on the one hand, processing and marketing margins aren't too high and, if, the decrease in unit cost is relatively greater with respect to a possible price decrease in the market. Marketing margins are analyzed in the following section, and savings in unit cost obtained through improved technology are estimated in the section on establishing budgets per operation in the following chapter.

(c) Marketing margins.

Several marketing aspects of the Fifth Region lead one to think that marketing margins may be high. First, there are high transportation costs due to poor road maintenance, high collection costs due to supply dispersal, the risk associated with any commercial undertaking (uncertain demand, official and unofficial taxes, etc.), and information costs. Second, there is the oligopolistic behavior inherent to assembly markets (markets characterized by a few buyers and many sellers) and overmarketing of agricultural products after harvest. These elements can be the source of a significant price differential between the price the producer receives and the price the consumer pays.

Since marketing margins are not available for peanuts, those for millet are used in order to estimate the gross margins found between the assembly market in Seno and the consumption market in Mopti. The BECIS (1982, pp. 89-90) provides an estimate for 1981 of the gross margins for millet between the Bankass, Koro and Diallassagou producers (Diallassagou, the largest millet assembly market in the Seno area, lies 50 km. south of Bankass) and the suppliers in Mopti. These gross margins have fluctuated between 10 and 50 FM/kg., or 10-30 % of the price in Mopti, depending on the particular market and the season. Gross margins are highest immediately following the harvest in the Diallassagou market which is more isolated and has a higher grain supply than other markets. The lowest gross margins were observed in the Koro market during the rainy season. During this period it is hard to reach the Koro market from Mopti and exchanges take place through Burkina Faso. From August to October 1987, gross margins for millet of 10 F CFA/kg for Koro, 15 F CFA/kg. for Bankass and 25 F CFA/kg. for Diallassagou were recorded at the assembly market in Seno and in Mopti (Henry de Frahan and Diarra, 1987). These margins represent 15%, 20% and 35%, respectively, of the sale price for millet in Mopti. The same significance was observed for prices recorded from July 1986 to September 1988 by the Systeme d'Alerte

Precoce (see Table E.2 in Annex E). Furthermore, in August 1987, the gross margin for peanuts in the shell was 30 F CFA/kg. between Bankass and Mopti, representing approximately 40% of the selling price of peanuts in Mopti (results of an informal survey).

(d) The marketing network.

Millet from the Seno plain, Bandiagara plateau areas (Henry de Frahan and Diarra, 1987) and also the Koutiala zone (Dione and Dembele, 1986) supplies the Mopti market. Paddy rice comes from the delta and the Office du Niger area ("La Revue du Secteur Agricole du Mali," November, 1987, p.90). Mopti is both a consumption market and a redistribution market for grain deficit areas to the north (Dione and Dembele, 1986; Steffen and Kone, 1988).

The "La Revue du Secteur Agricole du Mali" (November 1987, p.95) reports regional prices variations limited to 10 F CFA/kg. between surplus (Sikasso) and deficit areas (Kayes).

In surveys carried out by the CESA-USAID-MSU project, regional price variations of 10 to 15 F CFA were observed between the Sikasso and Koutiala markets, and the market at Mopti during the marketing periods 1985-86, 1986-87 and 1987-88. Looking at the correlation coefficients calculated for the Bamako, Koutiala, Mopti and Sikasso markets, the market at Mopti appears to be well-integrated with the markets at Koutiala (0.88) and Bamako (0.83), but less with that of Sikasso (0.71). The correlation matrix is found in Table 4.2.

TABLE 4.2 : Correlation matrix for millet prices recorded in the Bamako, Koutiala, Mopti, Sikasso markets.

Markets	Bamako	Koutiala	Mopti	Sikasso
Bamako	1.00			
Koutiala	.86	1.00		
Mopti	.83	.88	1.00	
Sikasso	.79	.81	.71	1.00

Source: Mehta, Publication forthcoming.

Moreover, the markets in the principal towns of the Fifth Region seem to be very highly integrated with respect to millet prices. The correlation matrix for millet prices recorded monthly by the Systeme d'Alerte Precoce for the period of July 1986 to September 1988 shows

4.3). The market at Gao appears to be well-integrated with the markets in the Fifth Region while the market at Tombouctou seems much less so. This can be explained by the fact that Tombouctou is less accessible than other markets.

The peanut supply for the market in Mopti comes primarily from surplus supply in Bamako, whose supply comes from the Kayes region (Kita and Kolokani districts). ODIPAC prices, available only to Village Associations, have decreased since 1986 as follows: 75 F CFA/kg. for 1986-87, 60 F CFA/kg. for 1987-88 and 50 F CFA/kg. for 1988-89 (ODIPAC director, personal correspondence, August 1988).

(e) Seasonal price variations.

At the beginning of each seasonal cycle the price of millet depends on the harvest ("La Revue du Secteur Agricole du Mali," November 19987, pp. 95-96). In 1987, the price of millet in the Seno assembly markets at the beginning of the marketing period was approximately double that of last year's price (now 60 F CFA/kg., formerly 30 F CFA/kg.). Prices increase from 50-100% until the period right before the next harvest (Henry de Frahan and Diarra, 1987).

The same evolution can be seen in the monthly prices for millet recorded by the Systeme d'Alerte Precoce for the markets in the Fifth Region (see Table E.1 in Annex E). Using this data, the variation coefficient was calculated for the period from October 1986 to September 1988. A value of 50% signifies that the price of millet is 50% higher than the average in at least one month out of three. most of the price time series have a variation coefficient between 30 and 50%.

Theoretically, in a competitive environment price increases from one month to another should not exceed storage costs for that same period (Dione and Dembele, 1986). In the Fifth Region, however, in spite of the liberalization of millet and sorghum markets in 1981, there is little competition, and as a result, seasonal price variations would not reflect storage costs. Several organized buyers deal with a large number of producers who are not really organized and who have significant financial obligations during the assembly period. In towns also, there are several wholesalers who have an apparent monopoly on sales. According to the market studies conducted under the CESA-USAID-MSU project, there are only six grain wholesalers in Mopti and about thirty semi-wholesalers[3]. During the marketing seasons for 1985-86, 1986-87 and 1987-88, the average volume of grain sold by wholesalers was 1,445 tons, 1,736 tons and 572 tons, respectively. The average volume of grain sold by semi-wholesalers during these same periods was 203 tons, 348 tons and 88 tons, respectively (Mona Mehta, forthcoming).

3/ Semi-wholesalers are different from wholesalers in that they also engage in retail sales.

TABLE 4.3 : CORRELATION MATRIX FOR MILLET PRICES RECORDED BETWEEN JULY 1986 AND SEPTEMBER 1988 FOR MARKETS IN THE FIFTH REGION, TOMBOUCTOU AND GAO.

Markets	MOPTI	BANDIAGARA	BANKASS	DJENNE	DOUENTZA	KORO	TENENKOU	YOUWAROU	TOMBOUCTOU	GAO
MOPTI	1.0000									
BANDIAGARA	.9356**	1.0000								
BANKASS	.9528**	.9284**	1.0000							
DJENNE	.9623**	.9788**	.9571**	1.0000						
DOUENTZA	.9370**	.9265**	.9097**	.9451**	1.0000					
KORO	.9685**	.9735**	.9559**	.9896**	.9705**	1.0000				
TENENKOU	.9221**	.9617**	.9287**	.9560**	.9489**	.9581**	1.0000			
YOUWAROU	.9348**	.8909**	.9502**	.9283**	.9537**	.9544**	.9248**	1.0000		
TOMBOUCTOU	.6819*	.7083*	.6335*	.6541*	.7367**	.7226**	.6959*	.6795*	1.0000	
GAO	.9264**	.9242**	.9278**	.9442**	.9617**	.9696**	.9224**	.9635**	.7729**	1.0000

Degrees of freedom: 16

* : significant at the 0.01 level.

** : significant at the 0.001 level.

Source : Matrix calculated from prices recorded by the Système d'Alerte Précoce (see Table 1 in Annex E).

There are other factors which increase the costs of storage. These include 1) financial constraints faced by merchants which hinder them from maintaining large stocks, 2) administrative and taxation complications, 3) social and family obligations and 4) uncertainty pertaining to the flow of OPAM stocks and food aid distributions.

At the producer level, temporary village storage with the goal of spreading out supply to receive the best price is limited to wealthier operations producing a cash crop. Other farmers are in a hurry to sell regardless of the price in order to repay loans and pay taxes ("La Revue du Secteur Agricole du Mali", November 1987, p. 101; D'Agostino, 1988).

This favors the development of secondary cash crops to provide another source of income, as well as improvement of village storage conditions. The tax burden is relatively high for farming operations. The minimum tax is between 800 and 1,300 F CFA per taxable citizen, depending on the administrative circle in the Fifth Region. A regional and local development tax of 1,400 F CFA is levied in addition to the minimum tax (regional tax inspector, personal communication, August 1988). It seems probable that this tax pressure exacerbates the surplus-marketing that occurs right after the harvest, and consequently, seasonal price variations.

In an effort to decrease seasonal variations in millet and sorghum prices, the Programme de Restructuration du Marche Cerealier (PRMC) launched a storage credit initiative aimed at merchants (500 million F CFA at an 8% interest rate, 7,500 tons stored) beginning during the 1986-87 season. During this same period a similar program, directed at regrouped villages, was enacted through the BNDA (of 16,500 tons stored, 10,000 tons were sold to OPAM at 55 F CFA/kg., the market price being 30 F CFA/kg). The objective of this credit program extended to PRMC village groups was to channel cash to the poorest producers at the end of the harvest so that they could reserve their stocks for sale at a later date.

Since 1987 the PRMC has chosen a new direction. The PRMC has maintained its objective of regulating production prices from year to year, but using more flexible methods than those of OPAM. In particular, the PRMC wants to promote appropriate financing, village-level storage and adjustment storage by merchants. Official prices are suppressed except for the price of paddy rice which will remain at 70 F CFA/kg. for 3 years. Also, OPAM's role will be limited to managing the buffer stock, supplying deficit and distant areas ("La Revue du Secteur Agricole du Mali", November 1987, p.108) and installing a market information system (Steffen,1988). If this last direction is successful, Mopti's role as a distribution center for the northern deficit regions might be disrupted. Likewise, the assembly markets in Seno and income to producers selling grains might also be affected.

(2) The market for vegetables.

One can identify three types of market-gardening, each having different marketing outlets. The first type comprises village gardens in lowlands, or those bordering streams and perennial rivers, which are watered by hand during the dry season, and more recently those near village water sources with hand pumps (installed by the Operation Puits in the Fifth Region, financed by the EDF). Village gardens are a source of income, particularly for women and youth. Produce is marketed locally.

The second type of market-gardening comprises the green belts which supply vegetables to large urban centers. An example is the green belt near Bamako. Market-gardeners operating near urban areas are in direct contact with the market and services. They are able to organize the flow of their products and their supply of inputs and agricultural credit (as does the market gardeners' cooperative in Bamako).

The third type of market-gardening is the gardening plots in the large areas (ON), the moderate-sized areas (ODIB) or small gardening areas (the small irrigated areas in Kayes, Tombouctou and Gao, etc.). Almost all of the market-gardening areas have had to confront different problems, and among those; marketing problems. For example, on the Bandiagara plateau onion marketing encounters both structural and organizational problems. The annual estimated onion production on the plateau is approximately 20,000 tons. Home consumption represents only a small portion of this production. The remainder of the production is sold at local markets where the supply is generally greater than the demand.

Henry de Frahan and Diarra (1987) report that in August 1987 the price per kilo of onions was 250 F CFA in Bandiagara while the price in Bamako was 500 F CFA. Prices are the lowest during the production season. For example, from December 1986 to February 1987 the price per kilo of onions in Bandiagara was between 65 and 100 F CFA. A lack of organization on the part of the producers and a lack of appropriate storage structures or transportation to other markets is conducive to merchants fixing their own prices. The Centre d'Action Cooperative (CAC) in Bandiagara proposes to restore the producer cooperative of Bandiagara in order to resolve some of these problems.

(3) The market for livestock products.

(a) Animal production marketing in Mali.

According to Delgado and Staatz (1981, p. 294), there are four fundamental objectives in the official malian animal production policy to be applied at the national level:

- maximize cattle exports,

- export fattened cattle and meat rather than forage or young and underweight cattle,

- satisfy domestic protein needs by using culled cattle, small ruminants and fowl rather than animals which could be exported,

- promote animal production by encouraging the northern region to become a reproduction zone and the south a grazing zone.

In spite of the emphasis that development programs place on animal breeding, it has developed very slowly. Aside from drought and natural resource depletion problems, animal breeding in Mali is also affected by occurrences and trends in the sub-region and in the world. The magnitude of these crises is reported in numerous documents on cattle mortality rates, the migration of Malian herding families to neighboring countries, the privation of herding families nourishing themselves and their cattle on food aid, the degradation of resources throughout the country, and the animal breeding sector's decreasing contribution to the national economy.

Domestic markets for livestock products are narrow and scattered and the consumer's limited buying power is decreasing (OCDE and CILSS, 1987). The expansion of exterior markets for cattle is restrained by movements in other markets such as those in the Ivory Coast and Niger. In fact, even if Nigeria has a potentially large market for small cattle on the hoof in overland and for small ruminants, Burkina Faso, Niger and Chad offer strong competition for Malian cattle exporters who are considerably disadvantaged by distance from the Nigerian markets.

As for the Ivory Coast, it has modified its internal economic policy to ensure the supply of meat to urban consumers. First, the government launched a massive effort to develop animal breeding in the northern part of the country in order to supply an increasing portion of its demand for meat. Then it bought stocks of frozen meat and other products from South America and Europe on the international market. These market modifications led to a decline in the Malian and Burkinabe markets, the primary suppliers of cattle on the hoof in the Sahel. Consequently, hopes of maintaining a market among these countries for meat and meat-products have been almost completely eliminated. These modifications have also contributed to decreased interest on the part of the Ivory Coast in developing regional transportation networks or other infrastructure which would result in a comparative advantage for exporters in the Sahel, to the detriment of meat producers in the Ivory Coast. The organization of the export market requires marketing policies and solid agreements not only among countries but also among the countries' individuals and institutions. Programs involved in livestock operations should also be included in research on marketing channels.

Market organization must also involve reducing cattle marketing costs which currently are 25,000 to 30,000 F CFA per head for export toward Abidjan by truck (Diakite and Keita, 1988). According to

merchants in the Fifth Region, it is not the level of official taxes and duties[4], considered acceptable, that represent the huge costs of marketing but the unauthorized and hidden taxes. According to Diakite and Keita (1988), these unofficial charges come to about 10,000 to 15,000 F CFA per head, or approximately two thirds of the necessary costs in transportation and official charges to go from Mopti to Abidjan. A sensible reduction in marketing costs, followed by an increase in the competitiveness of livestock products, particularly in the Fifth Region, would come through strict application of tax and customs laws.

(b) Marketing of animal products in the Mopti region.

Concerning animal breeding in the Sahel, the Fifth Region represents a special case because the grazing land that lies in flood recession areas during the dry season and that is used during the rainy season are in adjacent zones. However, this particularity does not insulate the livestock sector from the primary constraints to animal production in the Sahel as described by the OCDE and the CILSS (1987). Certain factors specific to the Fifth Region limit, or in fact block, the current level of animal production. These factors are physical, human, socio-economical and historical (Diakite and Keita, 1988).

According to directors at the ODEM, the rational exploitation of cattle in the Fifth Region calls for decreasing livestock herds. Animals withdrawn from the herd for sale generally follow two distinct routes: official and unofficial. In fact, a certain proportion of the animals to be sold goes through the official channel and is sent in a caravan toward Bamako and other destinations to the south. Outside the official channel are the itinerant animal merchants. As indicated by their name, these merchants travel from place to place buying animals for resale in an urban area, which are eventually sent to the south or south-west. Aside from the cattle marketing network toward the exterior of the region, there are significant local markets where herders sell different categories and breeds of animals such as draught cattle, grazing cattle, donkeys, camels, goats and sheep. Animals can be bought by investors who then deliver them to their original owners or to other herders.

Henry de Frahan and Diarra (1987), showed through an informal survey in the Fifth Region that cattle marketing takes place in the following markets:

- the Fatoma and Somadougou markets for animals from the Mopti and Bandiagara circles,

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4/ The export tax is fixed at 200 F CFA per head of cattle and at 500 F CFA per sheep or goat. To this, one adds 3% for the CPS (Stryker et al., 1987).

- the Douentza, Boni, Hombori and N'Gouma markets for animals from the Douentza and Seno-Nango circles,

- the Koro and Douna markets for animals from Seno-Gondo.

Outside of these main markets, animals (especially small ruminants) are sold everywhere in weekly village markets.

According to the regional ODEM administrator in Koro, there are two marketing routes for animals originating in the Seno plain area and sent outside the region (mainly to the Ivory Coast). The first route is from Koro or Douna toward Tougan in Burkina Faso. From Tougan, the animals are then sent to Bobo-Dioulasso (cattle are herded overland, goats and sheep are sent by truck) where they are sent by train to Abidjan. The second route goes to Koudougou in Burkina Faso where cattle are sent by train to Abidjan, while goats and sheep are herded overland to Tiou in Burkina Faso. From Tiou, goats and sheep are then sent by train to Abidjan. According to administrative statistics, 6,000 head of cattle, 21,000 sheep and 7,000 goats were exported in this manner in 1984. In 1985, livestock exports amounted to 4,000 head of cattle, 22,000 sheep and 6,000 goats (the regional ODEM administrator of Koro, personal correspondence, July 1987).

It seems that prices in local livestock markets in the Fifth Region are established by a minority of merchants. As animals pass through the official channel, prices and quantities sold are recorded. The absence of government instituted arrangements to control the price of cattle on the hoof is noted. Only the price and quantity of meat are supervised at butchers and at slaughterhouses. It should be noted, however, that in the Fatoma and Sofara markets the ODEM levies a fee on each animal brought to market (100 F CFA per head of cattle and 50 F CFA per small ruminant).

(c) Groups of animal herders.

To relieve the pressure of the influx of animals on waiting zones and grazing land in flooded areas, the ODEM initiated a well-digging project near the flood recession areas favorable to extensive animal breeding (Mema and Seno-Mango). Such a project would slow down the arrival of animals in holding zones, and consequently limit overgrazing in these areas. The equipment for these boreholes is obtained through credit allocated to the groups of herders.

The organization of these groups would create a unity of herders managing their own herds and with a bore-hole or well. These groups are currently located in a grazing area that is allocated to them preferentially. In return for the ODEM's support, the herding groups agree to provide the financing and material for the bore-hole or to the construction of a well or reserve well. They must also agree to the management terms; in other words, supervision of the area, respect for this responsibility, and of exploitation and restricted usage periods, etc., and respect of the habits and customs of the area.

For these groups of herders, the most important problems seem to be not only in finding mineral supplements, livestock and milk marketing, but also in managing water sources and grazing land.

(4) Markets for fish products.

The fishing sub-sector represents one of the primary economic activities in Mali and has an important role in exterior trade. According to the document entitled "Etat d'Execution Technique et Financiere du Projet de Developpement de la Peche au Mali" (Operation Peche Mopti, undated), this sub-sector represents approximately 3% of the gross domestic product and 8% of total value of exports. Fishing is fourth in importance after cotton, groundnuts and livestock products. Annual production is not known precisely but is estimated at over 100,000 tons of fresh fish, which ranks Mali as the tenth largest producer in Africa, and among the largest producers of fish in the Sahel. Fishing in Mali is mainly concentrated in the central Niger delta and great lakes areas and affects over 300,000 people either through income earned or home-consumption. Ninety percent of the marketed production is in the form of either dried or smoked fish, some of which is marketed domestically but a large amount of which is exported to Burkina Faso, Ghana and the Ivory Coast (8 million tons exported from a total of 35.7 million tons produced from 1972 to 1985). Unfortunately, during the 1960's a lot of resources were wasted in production, processing and marketing. Also, the Malian government has drawn up an enormous fisheries development plan for the country. To carry out this program, an integrated development project was created called "Operation Peche Mopti" (OPM). According to the above-mentioned document (OPM, undated), the objectives of this project are the following:

- an increase in the amount of fish caught,
- improvement of fish smoking and drying,
- organization and management of fish markets,
- processing and marketing of fish in various ways,
- encouragement and organization of fishing groups in collaboration with cooperative services.

The OPM also has the goal of encouraging fish production in its operating area, primarily by the:

- development of fresh-water fish culture,
- restocking of ponds,
- improvement of fisheries techniques,
- improvement of processing and storage techniques (drying, smoking, storage and packaging of fish products),

- organization and management of fishermen,
- organization of marketing centers,
- encouragement and organization of fisheries groups in collaboration with other agencies.

The OPM is collaborating with the hydrobiology laboratory on a study to identify the impact of fishing practices on the fish ecosystem in the Diafarabe, Aka, Mopti and other zones. Furthermore, the hydrobiology lab is also collaborating with ORSTOM on a multi-disciplinary study of fishermen. This laboratory envisions the eventual installation of a permanent team of researchers to follow the development of fish culture. It is for this reason that any intervention made by the DRSPR in the fisheries sub-sector should be identified and carried in collaboration with laboratory and with the other agencies concerned with the development of fish culture in Mali.

(b) Objectives.

The primary objectives for this subject of research are the following:

- to identify supply constraints for agricultural products on the Mopti market in the Fifth Region so that producers in the region can better compete on the Mopti market with other areas,
- to identify potential marketing channels in order to orient and support intensification and diversification of agriculture,
- to identify constraints in reducing cattle herds for sale, making animal management more rational and profitable,
- to identify the possible effects of measures taken by the PRMC and the OPAM in markets, and concerning transactions and production in the Fifth Region, and to notify the CESA, the PRMC and the OPAM of the observations and analyses of these effects.

(c) Purpose.

(1) Agricultural products.

According to data collected during an informal survey in the Fifth Region, the Sevare and Mopti markets obtain supplies of agricultural products, except millet, from other areas in the region. Products like groundnuts, cowpeas, etc., come from the southern regions. More data should be collected in order to determine why this situation exists and for what reasons when, ecologically, these products could be grown in the Fifth Region. An answer to this question would determine if the

Fifth Region could compete with other regions in the consumption and redistribution market in Mopti and perhaps increase its market share.

The sale of secondary cash crops and small ruminants should decrease the transaction rate for millet, and consequently, have a positive effect on family food security and on income. According to a formal study, the transaction rate for millet is high. Among the farmers interviewed during this study, 67% report that the sale of millet constitutes their largest sales of agricultural products (11% cited groundnuts). Furthermore, 92% report that buying millet is their greatest expenditure on agricultural products. Also, transaction rates for small ruminants are high. For 60% of the farmers interviewed, small ruminants comprised their largest sales of animal products. A lesser percentage are buyers, approximately 23%. That there are more sales than purchases leads one to surmise that those who raise small ruminants in the Seno and Plateau areas derive a marketing surplus.

The possibility of selling secondary crops should also promote intensification in agriculture by furnishing the necessary income to buy inputs (refer to the research subject on the development of secondary and minor crops).

The study of cereals, legume and small ruminant transactions (rate and period by category of farming/herding or herding operation and by the type of product bought or sold) as well as the study of assembly, consumption and redistribution markets (with estimated actual prices and quantities sold in these markets) should:

- clarify producers' motivations for buying and selling, and consequently, identify positive measures that could be taken by the PRMC and the OPAM to ensure food security for all producer types and, for example, to decrease seasonal price variations by promoting village-level storage;

- identify potential marketing channels for secondary crops and small ruminants in order to insure a solid basis for the intensification of these investments;

- clarify the position of secondary cash crops and small animal raising in the family food security strategy and as a source of income in order to ensure that the development of these investments can contribute to family food security, an increase in available income and finally, to the intensification of agriculture.

(2) Market gardening products.

Vegetable marketing on the Plateau, particularly for onions, is without a doubt the most difficult problem to be dealt within this subsector. Currently, there are plans to approach this problem through the establishment of local development groups, supported by the GTZ and the Catholic mission. DRSPR activities in this area should be determined in coordination with these organizations.

(3) Livestock products.

The sale of livestock as a form of management is, for the ODEM, the basis and the optimal method of raising livestock in the region (Diakite and Keita, 1988). The ODEM's approach to herding systems is of four types:

- extension of information to breeders on the damages caused by extensive animal breeding,
- construction and supervision of cattle markets (secured markets for unrestricted transactions),
- promotion and support of socio-professional groups in the beef-cattle sub-sector,
- application of agricultural credit to livestock consumption.

According to Keita and Diakite (1988), the results obtained to present indicate a clear change of perception about the problem of selling off herds. The composition of herds is progressively changing as desired. Cattle markets have been established and the socio-professional individuals (cattle merchants, intermediaries, butchers and part-time breeders) are trying to organize their efforts to access investments and credit.

Constraining the expansion of this action are the prices offered to the primary breeder and his ability to market his product, and the investment possibilities in other areas of animal breeding. On this latter point, Diakite and Keita (1988, p. 16) point out that the areas in which breeders could invest surplus production are complex and not well defined. They suggest that the problem is economic, institutional and sociological. Generally speaking, it is a question of creating other consumption and investment demands among breeders, stressing their role in the financial and economic network. This depends much upon the education, awareness of responsibility and security of the breeder. In this manner, the breeder would have better access to credit and would invest in the improvement of his production and his lifestyle (technical development and equipment, housing, etc.). ODEM's previous experience with animal breeders illustrates that the breeder can invest in equipment (e.g. water pump) as soon as use rights are accorded to him.

In developing alternative investment strategies for animal breeding, the administrators at ODEM suggest an in-depth study of the existing systems, their relationship and connections, and their evolution according to peak and trough periods in production. Shortage and change-inducing elements should also be identified in order to retain a positive production system within the general dynamic development system.

Nevertheless, given current knowledge, the following investments should be encouraged in the region:

- livestock trade and fattening,
- milk production,
- the processing industry.

Regarding livestock trade and fattening, it seems that traditional livestock trade has reached its adaptive limits to new market conditions. Parallel to the traditional practice of buying and selling, peasant livestock fattening and semi-intensive fattening of cattle and sheep produce added value and a better quality product. For example, sheep fattening is a well-adapted production activity where essential feed inputs are found locally and any services needed are those necessary to animal care (vaccinations, parasite treatments,etc.). Peasant livestock fattening is done primarily by women and is an activity that draws on local production systems (green forage, acacia pods, agricultural by-products, etc.). Sheep fattening (domestic breed) is practiced widely on the Bandiagara plateau with the livestock market in Fatoma drawing its production. However, since 1984 this market has been saturated with fattening animals. A complete study of the marketing network, especially for exports, is necessary to update legislation in this area. There are many taxes levied on livestock. First, there is an annual tax of 250 F CFA per cow, 100 F CFA per donkey and 50 F CFA per goat or sheep. Second, there are taxes levied on slaughter and market profit. Finally, there are license fees, trade dues and health inspection fees. These numerous taxes and administrative complications discourage legal exports of live animals to neighboring countries (Stryker et al., 1987).

In addition to marketing, the research plan should also investigate the intercropping of certain forage crops with other crops in this zone. Results obtained at this level would contribute to a reduction in production costs and, therefore, to an increase in marketing.

Intensifying milk production appears to be the only solution possible to compete with the enormous imports of milk products. This will involve a certain intensification and selection in breeding, in both the intermediate and long run. In the Fifth Region, milk production differs according to the time of year, the zone, and even the breeding method. Milk is sold on the spot, traded for grain, processed into butter or sold elsewhere. Prices fluctuate depending on the time of year and on supply and demand. In the Mopti district, prices range from 75 to 150 F CFA/liter in extreme cases. In areas with a large amount of production and weak demand, milk is sold at 10 to 50 F CFA/liter, and only by virtue of making butter is there a variable profit. This is especially the case in Boni, Mondoro, Ouo, Dialloube, Wallado-Debo, Yongari, etc., during certain periods (Diakite and Keita, 1988).

Poultry farming, the poor second to livestock breeding, should be carefully researched, especially in the Bandiagara plateau area. Poultry is an important consumption item for urban as well as rural dwellers.

Processing of animal products and by-products serves as an indispensable support to increasing these endeavors in the future. In any case, the socioeconomic importance of animal breeding in the region remains a major advantage in this undertaking.

The problems linked to organizing groups of animal breeders described above as environmental management, land tenure legislation, etc., are also important and call for the ODEM's expertise in all research areas. The desired objective is to motivate herders into organizing and achieving the goal of rational management of fattening land resources and the exploitation of water sources. According to Diakite and Keita (1988), 30 water sources are present in the flood zones in Mema and Seno-Mango.

(4) The importance of this research subject.

The development of this subject is ambitious. It will probably demand the full-time aid of an agricultural economist, two supervisors and four to six survey-takers. These results are important to enumerate and orient the possibilities for expansion in agriculture and livestock, without which it would be difficult for producers to increase current output given the traditional methods they use. This research proposal is, in a manner of speaking, the impetus for other proposals, and consequently, for agricultural and livestock development in the Fifth Region. This subject also allows for a better appreciation of the economic and institutional environment of production systems in the Fifth Region. In addition, it will permit from the initial expansion of the DRSPR in the Fifth Region, the micro and macroeconomic linkages that are so often missing in research projects. In fact, this evaluation team surmises that the constraints found at the market level and in agricultural product and livestock transactions could limit the expected effects of development and appropriate technology transfer on increasing production. The presence of a lucrative market is a motivating factor which drives farmers to accept technological innovations capable of increasing production (Cunard, DRSPR, personal communication, November 1988).

d. Proposals.

Zone: The entire Fifth Region.

Production system: Agropastoral and pastoral.

Collaborating services: Direction Regionale de l'Agriculture (Mopti), ORM, ODEM, Food Security Project (CESA-USAID-MSU), OPAM and PRMC.

Proposals: (1) Study of assembly, consumption and redistribution markets for agricultural and livestock products in the Fifth Region.

This study should be accompanied by a price survey, and identification of trade periods, and a follow-up of merchants' activities. Several organizations already collect market prices (ODEM, SAP, CESA-USAID-MSU, PADEM). To identify potential marketing outlets, this study along with the study on potential groundnut, cowpea and sesame production (see the research subject concerning the development of secondary and minor crops) and the study on the integration of agriculture and livestock, should point out possibilities of developing both secondary crops and small ruminant breeding.

(2) Study of cereal and small ruminant transactions at the producer level and in the generation of farm and nonfarm income.

The CESA-USAID-MSU Food Security Project and CIPEA are already carrying out this type of study in the CMDT and OHV zones. In conjunction with the previously mentioned study, this particular study will furnish a more precise idea of the type of cereal market restructuring and the specific actions (credit for storage, marketing, cereal banks, etc.) that would increase cereal production and diminish seasonal price fluctuations and also those fluctuations lasting several years.

(3) Follow-up on groups of animal breeders.

(a) Study of the composition and exploitation of herds.

This study should suggest measures that promote selling-off herds and alternative investments that are better adapted to the current situation rather than perpetuating the extensive animal breeding system.

(b) Study of water sources and grazing lands.

This study should suggest ways of managing water sources and grazing lands with the goal of improving seasonal herding operations.

3. Intensification of Millet-Cowpea Intercropping.

a. Introduction.

Intercropping is most frequently used by farmers in semi-arid areas (Shetty et al., 1987). Areas cultivated using intercropping techniques are estimated at 80% of the total land area in cultivation in Mali (Keita, 1977).

Intercropping of millet and cowpeas is also widely practiced on the Seno plain and the Bandiagara plateau. Despite relatively low output (about 400 to 600 kg/ha of millet and 50 to 200 kg/ha of cowpeas; results of an informal survey), this cultivation method is still the

best adapted to the severe environmental conditions (sporadic rainfall, wind erosion, poor soils) and producer purposes (food self-sufficiency, risk minimization of total loss, optimization of cultivation and labor, etc.). Research programs, however, have long ignored intercropping because it interferes with the extension of mechanization processes, fertilizer use, plant protection products and herbicides. Also, millet and cowpea genotypes were usually selected for use in monocropping systems, and therefore, their performance in intercropping systems has been limited. Moreover, agricultural factors (planting periods, cropping patterns, density of seeding and fertilization) that influence the growth of species are not always easy to overcome, even during research, because of their complexity.

According to the results obtained during experimentation (Ntare et al., 1987; Traore and Martine, 1987; Sawadogo, 1985), it is possible to increase the millet-sorghum intercropping yields appreciably by slightly increasing the planting density of the traditional system, using an early variety of cowpea suitable for intercropping, applying a mineral fertilizer on the two crops and insecticide treatments on cowpeas in the field and in storage. Traore and Martine (1987) actually obtained yields of 1014 kg/ha for millet and 141 kg/ha for cowpeas in Koporo (Mali) in 1986 where planting densities were 52,000 and 26,000 plants/ha for millet and cowpeas, respectively. Even though the selling price for cowpeas was relatively high (60 to 100 F/kg), the profitability of such a system is still marginal due to the high price of mineral fertilizer, low millet prices and a higher demand for labor.

b. Objectives.

The main objectives of this subject of research are to:

- maintain, and if possible, increase millet yields,
- increase yields for cowpeas as a secondary crop.

These two objectives contribute to satisfying food needs and increasing agricultural incomes.

c. Purpose.

(1) The relative importance of millet-cowpea intercropping.

Intercropping plays an important role in the Seno and Bandiagara plateau production systems. In this area of the Fifth Region, 88% of the farmers use this system in the family fields (results from a formal survey, 1988). Millet and cowpea intercropping is done mainly by men in their individual plots (50%). Women are less likely to use this system (22%, results from a formal survey).

According to OMM statistics (monthly reports, January and February, 1987),land areas on which millet and sorghum are grown regionally (mainly intercropped with cowpeas, either planted in the same hole or every other hole) cover 238,450 ha, or 88% of the area grown in rainy season crops in the OMM zone.

(2) Benefits of millet-cowpea intercropping.

(a) Technical benefits (agricultural).

Many authors have reported the advantages of intercropping over monocropping. The earliest results indicate that, in general, intercropping gives higher yields than monocropping (Willey 1979a, 1979b). In the field, millet yields obtained through intercropping reach 60 to 90% of the yields from obtained from monoculture (Ntare et al., 1987). Fussel and Serafini (1985) found that intercropping systems based on millet and cowpeas usually improve and stabilize the overall yield in semi-arid areas of West Africa. Intercropping does not only increase yields; it plays an important role in soil conservation, in supporting the system and in propagation (Norman, 1974; Finlay, 1976; Beets, 1982).

The use of an early cowpea variety grown together with millet is not a traditional practice. It seems promising, however, in semi-arid areas where millet is widely spaced at planting (2000 to 9000 holes seeded/ha). Planting the early cowpea variety can absorb a lot of moisture from the soil and competes little with the millet. In fact, a substantial amount of moisture in soil (up to 40% of the evapotranspiration) is lost because of evaporation. The loss of evapotranspiration is especially important during the first month of growth when the millet offers little vegetative cover for the soil (Ntare et al., 1987).

Results from the research center's study on planting dates show that it is possible to improve cowpea yields without affecting millet performance. Studies have shown that planting cowpeas at the same time as millet, or shortly thereafter, allows the cowpeas to develop during the initial growth stage without shade from the millet plants. On the other hand, cowpeas planted 25 days after millet result in almost total failure (Ntare et al., 1987). Elsewhere, when cowpeas are harvested before the millet flowers, yield increases of approximately 60% have been reported. These studies illustrate the potential for intercropping an early cowpea variety with millet.

The results obtained by Ntare et al. in 1987 show that millet yields are not noticeably reduced when cowpeas are planted more densely, given that soil moisture and fertility are sufficient. A 22-51% increase in cowpea yields is possible without compromising millet yields when cowpeas are sown at 6,250 to 25,000 plants/ha (Serafini and associates, 1982).

(b) Economic benefits.

Norman (1971, 1974) showed that intercropping increases total income and reduces labor and the possibility of total crop loss. Studies carried out on millet-cowpea intercropping systems in 1983 and 1984 by Sawadogo et al. in Burkina Faso showed that the greatest constraints concerning intercropping are primarily soil moisture and fertility. Economic analysis of this system has revealed that the net income obtained from the two crops is greater than that obtained from growing only millet. Likewise, the millet-cowpea intercropping systems have all shown a positive hourly income for the additional labor needed above that necessary for growing only millet (given favorable rainfall and fertility conditions). Sawadogo et al. (1985) conclude that with favorable moisture and fertility conditions (from a test in Dissankuy in 1983 and in Bangasse in 1984, Burkina Faso) it is more profitable for farmers to increase the planting density for cowpeas in their intercropping systems. However, with unfavorable conditions (from tests in Bangasse in 1983 and in Nedogo in 1984, Burkina Faso) the farmers' traditional practice seems the most certain and profitable. With improved management, increasing cowpea planting densities slightly above that which is currently practiced by farmers appears to be economically worthwhile.

In Mali, studies emphasizing the benefits of millet-cowpea intercropping are rare. Serafini and associates (1982), recommending the planting of cowpeas between rows of millet, state that they did not carry out an economic evaluation to see if the increase in yield derived from this practice offsets the necessary investment. Traore et al. (1987) tested the aforementioned improved system; two rows of millet for every row of cowpeas, against the traditional system in seven areas in the Segou region. Economic analysis revealed an insignificant difference between the two systems. It appears that additional research (thematic and applied) would be necessary to improve millet-cowpea intercropping and make it profitable in Mali. Socioeconomic studies are also important in investigating the profitability and acceptability by farmers of the current intercropping systems suggested by the research team.

Furthermore, the demand for inputs creates a greater dependence on the part of the farmer on agricultural services, on the markets for improved cowpea varieties, fertilizers, insecticides (for use in the field and during storage) and on marketing outlets for their production. In addition, the purchase of agricultural inputs requires significant financial resources and an appropriate credit system.

(3) Analysis of limiting factors.

According to the results of a formal survey (Table 4.4), the surface area of family fields is still increasing in the survey area for 49% of the farmers interviewed. This development is generally at the expense of fallow periods. In fact, 51% of the farmers increased the size of their family fields in this manner. However, the individual fields of the heads of households, dependent males and women, have not

increased as much in size. Only 23% (women's individual fields) to 38% (separate fields of dependent males) of these individual fields have increased in area.

As for the fields which remained unchanged or had decreased in size, labor seems to be the foremost limiting factor to the expansion of cereal crops. Lack of available field space is given as the second limiting factor (Table 4.5).

TABLE 4.4 : Change in area cultivated in Seno and the Bandiagara plateau (Given in % of people interviewed).

Change	Family fields	Individual fields		
		Head	Men	Women
Positive	49	32	38	23
Constant	27	49	46	53
Negative	24	18	17	24

Source: Survey: December 1987-March 1988. IER-USAID-MSU project.

TABLE 4.5 : Factors limiting the expansion of area cultivated in Seno and the Bandiagara plateau (Given in % of people interviewed).

Limiting factors	Family fields	Individual fields		
		Head	Men	Women
Labor	33	30	40	52
Land	-	-	15	14

Source: Survey: December 1987-March 1988. IER-USAID-MSU project.

It appears that the productivity of labor in farming operations must be increased, particularly for millet-cowpea intercropping which is widely practiced. According to those interviewed, the first weeding in this system is the most labor-intensive (68%), followed by planting (14%) and harvesting (10%).

Animal traction facilitates weeding and is cited as making the work less tiring by 44% of those interviewed, as leading to increased planting area for crops for 22%, and as having a beneficial effect against drought for 10%.

Improvement of millet-cowpea intercropping should, therefore, focus on increasing labor and/or land productivity. On the other hand, since the availability of capital is very limited due to a lack of cash crops, poor livestock marketing outlets and few nonfarm activities, an increase in the productivity of labor and/or land can not be achieved at a very large financial cost.

(4) Analysis of production objectives.

Cereal-cowpea intercropping responds well to food security needs given the presence of unfavorable physical conditions. Also, increasing yields while employing few inputs outside of farm allows for increased farm incomes, particularly for the crop grown with the cowpeas. Given the importance of millet-cowpea intercropping in the Fifth Region and the results obtained by the on-station research, a budgetary study will be drawn up in order to analyze the financial and economic profitability of this system in the Seno and Bandiagara plateau areas (see Chapter V).

Producer prices for cowpeas are high during the harvest (60 to 100 F CFA) and even more so during the hungry season. With appropriate storage techniques producers could benefit from the higher prices, and consequently, diversify and spread out their sources of income.

The technical packages suggested below will incorporate the identified production objectives and constraints.

d. Proposals.

Zone: North, central and south Seno, the plateau, the west delta, and the flood recession area of the delta.

Production system: Agropastoral and pastoral.

Collaborating agencies: SRCVO/DRA, Direction Regionale de l'Agriculture (Mopti).

Material and Methods:

With regard to the intensification of millet-cowpea intercropping, we have combined various components that have been tested in experiments in many areas and in pre-extension trials. This technological package is adapted for recommendation domains in the Fifth Region: the north, central and south Seno, the plateau, the west delta, and the flood

recession areas of the delta (refer to Table F.1 in Annex F). The primary components of the package are summarized as follows:

(1) Varietal selection.

The variety of millet chosen is NKK, a local improved variety from Seno. This variety produced high yields in tests in different areas and in pre-extension trials. It will be used in areas receiving sufficient rainfall (south and central Seno, and the plateau). In the north Seno area the early IBV 8001 variety will be used. The variety of cowpea Gorom-Gorom was chosen for its yield, early maturity, resistance to Striga and uses (mixed variety for grain and fodder).

(2) Selection of cropping methods.

Ridging and planting in ridges allow better plant establishment and higher survival rates (Renard et al., 1987). This type of technique will be used in areas where rainfall and soil conditions permit it.

Using animal traction for weeding reduces labor time significantly (Renard et al., 1987). Animal traction for this use is recommended for all areas.

(3) Selection of planting arrangement and density.

Planting cowpeas in between rows of millet was recommended by Serafini and associates (1982). According to them, planting "two rows of millet for every row of cowpeas" appears to be the most productive. A density of 26,500 holes seeded/ha (75 cm x 50 cm) for millet and of 13,300 holes seeded/ha (150 cm x 50 cm) for cowpeas in the aforementioned arrangement was tested on station by Traore and Martine (1987). Currently, another arrangement is being tested; one row of millet per row of cowpeas with 15,625 holes seeded/ha (160 cm x 40 cm) for millet and 25,000 holes seeded/ha (160 cm x 25 cm) for cowpeas, and 80 cm between the rows which facilitates mechanization of planting and maintenance operations (Coulibaly et al., October 1988). Planting cowpeas approximately two weeks later than millet allows the millet, the principal crop, to development properly.

(4) Selection of mineral fertilizer.

Soluble mineral fertilizers like ammonium phosphate and urea are suitable for the poor soils found in the Seno and Bandiagara plateau areas. However, due to their price at cost and the low selling price for millet, it is difficult for these fertilizers to be profitable. For this reason, Tilemsi rock phosphate could be tested in areas where the rainfall is adequate enough to dissolve it (the central and south areas of Seno and the Bandiagara plateau). Since, however, ammonium phosphate

and urea have already been tested, these fertilizers at low application rates will be used in drawing up the farm budget for this subject of research.

(5) Selection of plant treatments.

Millet seed will be treated with APRON+, a fungicide and insecticide produced by CIBA-Geigy. Metalaxyl, one of three components in this mixture, is effective against mildew. When used at a rate of 1 gr per kilo of seed during an experiment at Koporo (in the central Seno zone), Metalaxyl increased millet yields by 10%; from 861 kg to 951 kg/ha (Vuong and Selvaraj, October 1988). The cost of treating 10 kg of seed/ha is approximately 250 to 300 F CFA. Even though it is five times more expensive than Thioral, APRON+ is still profitable.

Cowpeas are not affected by mildew and will be treated with Thioral.

The first experiments with intercropping in Mali did not foresee treatments for cowpeas, and without these treatments yields from improved varieties would not be comparable to the local varieties. Two treatments with Decis will be tested at a rate of 1 liter/ha for each treatment. Phostoxin is recommended for protecting stored cowpeas.

e. Experimental results obtained at the research center and those expected in the field.

At the research center (Traore and Martine, 1987), 50 kg/ha of ammonium phosphate (18-46-0) and 50 kg/ha of urea (46-0-0) were used to obtain a 67% yield increase for millet over that of the control crop receiving no fertilizer application (1,131 kg/ha compared to 678 kg/ha for the control crop). On the other hand, cowpea yields decreased 46% as compared to the control crop (115 kg/ha compared to 213 kg/ha for the control).

One expects yield increases from the technological package recommended for the south Seno area of 60% above those resulting from traditional methods for millet[5] (800 kg/ha compared to 500 kg/ha for the control), and 450% for cowpeas[6] (180 kg/ha compared to 40 kg/ha for the control) using 50kg/ha of ammonium phosphate and 25 kg/ha of urea on the two crops.

5/ Equivalent to 70% of the yields obtained on station, taking into consideration the decreases in yield generally observed in the field and a lesser application of urea (25 instead of 50 kg/ha).

6/ The expected yield for cowpeas on the farm is higher than that obtained experimentally. Such an increase is expected from the methods that are currently used on station and that will be used in multilocational tests to optimize spacing and planting and harvest dates (Coulibaly et al., October 1988).

For the central Seno and the plateau areas, expected yield increases above those obtained from traditional methods are 63% for millet (650 kg/ha compared to 400 kg/ha for the control) and 220% for cowpeas (160 kg/ha compared to 50 kg/ha for the control), using 50 kg of ammonium phosphate alone. For the north Seno area, expected yield increases are 60% for millet and 300% for cowpeas (120 kg/ha compared to 40 kg/ha for the control), using 25 kg of ammonium phosphate alone.

4. Intensification of the Millet-Cowpea cropping Pattern and Storage of Cowpeas.

a. Introduction.

Millet-cowpea intercropping is the traditional practice among farmers in the Fifth Region. However, even in years with adequate rainfall, yields are relatively low; approximately 400 to 600 kg/ha of millet and 50 kg/ha of cowpeas. In years with insufficient rainfall, cowpea yields are insignificant. Low yields are due to the following principal factors:

- the soils are poor in phosphorus and nitrogen (OCDE and CILSS, 1987),
- the rains end too early to accommodate the complete 3 to 4 month cycle of the traditional cowpea crop (Henry de Frahan and Diarra, 1987; Kodio, 1988),
- the low yields of local cowpea varieties limit its contribution to household food supplies.

Increasing millet-cowpea intercropping faces certain technical constraints such as the difficulty in mechanizing cropping operations, and in obtaining the optimal densities and planting dates for the two crops, the lack of appropriate cowpea genotypes for intercropping,and problems in treating cowpeas and in fertilizing both crops ("Les cultures associees au Mali", IER-ICRISAT, 1987).

It is still difficult to make millet-cowpea intercropping economically profitable (Serafini and associates, 1982). However, interesting results have been obtained from millet and cowpeas grown as monocultures. With the appropriate treatment, yields of 1500 to 1800 kg/ha are possible for single cowpea crops (Hats and Raheja, 1975). O. Coulibaly reports that the agronomy research station in Cinzana, in the Segou region, obtained average yields of 1,255 kg/ha with new varieties of cowpeas. In onfarm trials, not far from the Cinzana station, yields from new cowpea varieties (mainly KN1 and TN 8863 varieties) increased to 760 kg/ha when the crop was treated in the field, from 50 to 100 kg/ha for traditional, untreated varieties.

More specifically in the Fifth Region, SAFGRAD (1985, 1986, 1987) was able to double cowpea yields in onfarm trials using the early

varieties TN 8863 and Gorom-Gorom (see Tables 5 and 6 in Chapter II). As for millet, SAFGRAD (1979, 1980, 1981, 1982) obtained an additional 700 to 1000 kg/ha of millet during a three-year rotation period (millet-millet-millet) by applying 300 kg/ha of Tilemsi rock phosphate (TRP) at the beginning of the rotation (see Table 7 in Chapter II). Such yield increases, as well as the early varieties used in the tests, led to the proposal of a research subject on increasing millet and cowpea monoculture systems. This subject will integrate many elements which have already been tested in a decentralized manner, either at the research station or in onfarm trials.

There are several constraints limiting the adoption of this technological package during extension; primarily the supply of and credit for inputs and treatment equipment, as well as marketing outlets for cowpea production (O. Coulibaly, 1987).

b. Objectives.

The two primary objectives of this subject of research are the following:

(1) to increase millet and cowpea yields in order to satisfy demands for food and to increase agricultural incomes.

(2) to store cowpeas with the goal of increasing household food security and optimizing selling periods.

c. Purpose.

Even though millet-cowpea intercropping is widely practiced among farmers, recent studies have shown that farmers in the north tend to grow cowpeas as a single crop, instead of cereal crops, because of increasingly lower yields due to drought.

According to the results of a formal survey in the Seno plain and Bandiagara plateau areas, 10% of the heads of farms, 16% of the women and 15% of the men interviewed with individual fields grow millet as a single crop. An informal study carried out in 1988 by Ousmane Coulibaly and Moussa Bore Diarra identified several areas where cowpeas are grown in monoculture: the villages of Dounde in the Bankass circle, Pomorododjou in the Koro circle, and the Bandiougou plain in the Bandiagara circle.

As compared to millet-cowpea intercropping, growing these crops in monoculture is easier technically because cropping operations like mechanization, mineral fertilization and treatments on plants are more simple to carry out.

SAFGRAD results (1979 to 1982) obtained in the Fifth Region for a three-year rotation (millet-millet-millet), treated initially with TRP at a rate of 300 kg/ha are presented in Table 4.6 below.

TABLE 4.6 : Yield increases for millet treated with an initial application of TRP (%).

Zone	1st test sequence (1979, 1980, 1981)	2nd test sequence (1980, 1981, 1982)
North Seno	-	52%
Central Seno	87%	35%
South Seno	89%	60%
Plateau	-	54%

Source: Synthesis of tables in Annex C.

SAFGRAD (1985, 1986, 1987) obtained significant yield increases using the improved cowpea varieties TN 88-63 and Gorom-Gorom, and administering 65 kg of phosphate[7] and one to three treatments of Decis and Cymbush. Treatment results are presented below in Table 4.7.

TABLE 4.7: Yield increases for cowpeas subject to fertilizer and plant protection treatment (%).

Zones	Gorom-Gorom	TN88-63
Central Seno	205%	138%
South Seno	262%	263%
Central Delta	106%	107%
South Delta	1000%	988%

Source: Synthesis of Tables 5 and 6 in chapter II.

The Gorom-Gorom variety meets a certain number of criteria as a preferable selection for the Fifth Region. Its cycle is short; 50 days from planting to flowering and 70 days from planting to maturity. Its semi-creeping growth produces fodder for draught animals as well as grain. Gorom-Gorom is drought- and Striga-resistant and is adapted for cultivation in those areas receiving between 400 and 600 mm of rain. The average experimental yield is between 1000 and 1500 kg/ha ("Catalogue Officiel des Especes Vivrieres", SRCSS, 1987).

Improved varieties, however, need effective protective treatment. The incidence of disease and parasites (for example, Striga) can be reduced through a three-year rotation of cereal-cowpeas-cereal (Kodio, 1987).

Traditional storage techniques cannot protect a large quantity of cowpeas from bruchid attack (Henry de Frahan and Diarra, 1987; Kodio,

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7/ According to Kodio (1988), only phosphate has a significant effect on cowpea yields.

1987). Nevertheless, the producer price for cowpeas becomes lucrative during the period June to September. In August 1988, cowpeas were sold for 250 F CFA/kg at the Sevare market (Tangara, assistant director at OMM, personal communication, August 1988).

Improved on-farm storage conditions should allow cowpea producers to take advantage of the seasonal price increase. Moreover, improved varieties like Gorom-Gorom with higher yield potential, are more susceptible to bruchid attack during storage, and consequently, call for post-harvest protection (Kodio, 1987).

d. Proposals.

Zones: North, central and south Seno, areas suitable for cultivation in the plateau and the non-flood areas of the delta.

Production systems: Agropastoral.

Collaborating agencies: Projet Legumineuses Alimentaires and Direction Regionale de l'Agriculture (SRCVO, Mopti).

Material and Methods:

A cropping pattern test of millet and cowpea crops (3/4 ha of millet for 1/4 ha of cowpeas, each grown in monoculture) is suggested in order to compare traditional millet-cowpea intercropping.

(1) Varietal selection.

The millet varieties to be tested are: NKK for south and central Seno, IBV 8001 for north Seno, and Toroniou de Ningari in the plateau area. Millet varieties for the flood recession areas of the delta remain to be determined.

The varieties NKK and Toroniou de Ningari offer higher yield potential and good adaptive characteristics for the different ecological areas chosen. However, the choice of the IBV 8001 variety for north Seno must be confirmed in comparative tests with local varieties. In fact, according to SAFGRAD tests, regardless of the amount of rainfall, IBV 8001 has always produced yields inferior or equal to those of local varieties.

The cowpea variety Gorom-Gorom will be tested in all zones in comparison with the local varieties.

The PNUD/MLI/86/005/B/01/12 project funds a multiplication and diffusion program for selected seeds of dry season crops such as millet and cowpeas. The millet varieties NKK and IBV 8001 and the cowpea variety Gorom-Gorom chosen for this technological package are a part of its program.

(2) Mineral fertilization selection.

TRP will be applied to millet plots at a rate of 300 kg/ha in south and central Seno, and in the plateau and the non-flood areas of the delta. During informal surveys in the west delta (Mema), the local technical personnel pointed out that the progressive soil fertility degradation in the area warrants testing TRP.

"Super-simple" phosphate will be applied to cowpea plots at a rate of 65 kg/ha in central and south Seno, and in the plateau and non-flood areas of the central and south delta. In north Seno and the west delta (Mema), the rate of application will be reduced by half to 32.5 kg/ha.

(3) Selection of cropping techniques.

In the south and central Seno, and the Bandiagara plateau areas, ridging before planting (including the incorporation of TRP) and weeding with animal traction methods are suggested for millet and cowpea crops. The TM plow drawn by two oxen is suggested for south Seno and the donkey plow is suggested for the other zones. In north Seno, the only mechanized operation will consist of using a donkey plow for weeding millet crops. Cowpeas, planted in rotation after millet, will be planted in the ridges resulting from weeding the millet the year before.

For the zones in the delta, soil preparation and crop maintenance will be chosen and tested depending on the soil types.

(4) Selection of planting arrangement and density.

The suggested planting density for millet is slightly greater than that which farmers normally choose. For the south and central Seno and the plateau areas, the suggested planting density for millet is 15,625 hills/ha, spaced 80 cm by 80 cm. In the north Seno zone, the suggested density of 10,000 hills/ha, spaced 1 meter by 1 meter, is lower because of lower rainfall and soil fertility. The suggested planting density for cowpeas is that tested by SAFGRAD; 31,250 hills/ha, spaced 80 cm by 40 cm.

(5) Selection of treatment and storage method for cowpeas.

Millet seed will be treated with the fungicide APRON+, and cowpea seed with the fungicide Thioral.

During the vegetative development of cowpeas, two treatments with the insecticides Decis or Cymbush super ED are suggested. Cowpea seed will be stored using the insecticide fumigator Phostoxin (one tablet for 100 kg of seed). This would allow the farmer to sell his product when cowpea prices are higher, from June to September.

(6) Expected yields.

Expected yields are determined from those obtained by SAFGRAD in the Fifth Region. First, an average yield for millet was calculated from the results obtained through the initial application of 300 kg/ha of TRP on the three-year rotation (millet-millet-millet). This calculation, carried out for the south and central Seno areas (the plateau included), provides an average annual yield from the rotation. These average annual yields were rounded[8] to 800 kg/ha and to 650 kg/ha for the south and central Seno zones and the plateau, respectively. For the north Seno zone where mineral fertilization is not recommended because of insufficient rainfall, the average annual yield was calculated from a control crop (TRP was not applied) tested by SAFGRAD and rounded to 350 kg/ha. Second, cowpea yields from SAFGRAD monoculture plots (Tables 5 and 6, Chapter II) were adjusted to 600 kg/ha for the south Seno zone, to 500 kg/ha for the central Seno and Plateau zones, and to 400 kg/ha for the north Seno zone. Yields of cowpea fodder material were adjusted to 500 kg, 400 kg and 300 kg for the south, central and plateau, and north Seno zones, respectively.

5. Development of Secondary and Minor Crops.

a. Introduction.

In order to sustain increased agricultural production, cash crops must be developed to provide the required financial resources to buy additional inputs. Cash crop sales could also alter transaction periods for coarse grain producers by allowing them to shift grain sales to more profitable periods. Cowpea, groundnut, wandzou, sesame and fonio crops are already grown in small plots or intercropped with millet, and could serve as cash crops given the existence of marketing outlets (see the research subject concerning the identification of market constraints).

b. Objectives.

The objective of this subject of research is to increase production and productivity of secondary and minor crops. This would make the following possible:

- increasing agricultural incomes, particularly those of women,
- improving diets (emphasis on lipids and proteins, diversification of foods during the hungry season),
- contributing to soil fertility maintenance and animal feed.

8/ Yields were rounded down slightly.

c. Purpose.

(1) Relative importance of secondary crops.

According to OMM statistics (monthly report, January and February 1987), areas planted in groundnuts make up 14,250 ha, or 5% of the total cultivated area in the OMM zone, 11,730 ha of fonio (4%) and 5,990 ha of wandzou (2%). Sesame is an important crop in the Seno plain. In terms of area cultivated, sesame is the most important secondary crop (Soumano, SRCVO, personal communication, October 1988). According to DNSI and DNA statistics (OSCE, 1988), both the area cultivated and the production of groundnuts have decreased since 1980.

Secondary crops are primarily grown by women, according to a survey from the plateau and the Seno plain. For 44% of the women interviewed, groundnuts were the principal crop grown, followed by millet-cowpea and millet-cowpea-dah intercropping for 31%, millet for 16% and wandzou. For male farmers, groundnuts are less important than millet-cowpea-dah ard mil-dah intercropping and millet crops. The heads of households grow very few secondary crops in their individual fields besides intercropping millet and cowpeas. In family fields fonio, followed by sorghum, groundnuts and wandzou are the secondary crops planted after millet-cowpea intercropping, millet-cowpea-dah and millet grown in monoculture. Secondary crops are generally grown at the end of the rotation period, except groundnuts which are planted at the end as well as at the beginning of the rotation in women's individual fields.

(2) Analysis of production constraints.

(a) Cultivation of cowpeas.

The heads of farms cited the following constraints limiting the expansion of cowpea cultivation, in decreasing order: 1) late germination of local varieties, 2) damage done to plants (30%), 3) lack of labor (15%) and 4) lack of land (8%).

According to the results of interviews with heads of farms, the primary criticisms of local cowpea varieties are 1) the lengthy cycle (29%), 2) poor storage (24%) and susceptibility to insect attack in the field (11%). On the other hand, 43% appreciate the taste of the local varieties and 37% find the growth cycle satisfactory. Forty nine percent prefer the creeping varieties, 39% the semi-upright and 13% the upright varieties.

The primary pests on local cowpea varieties as cited in the interviews were, first, insects in the field (47%), then insect attack during storage (23%), Striga and other pests (birds, mice, rats) named at 5% each.

(b) Cultivation of groundnuts and wandzou.

According to the survey, the lack of labor is cited as the main constraint to the expansion of groundnuts and wandzou as secondary crops for women and dependent men with individual fields. Next, lack of seeds, lack of land and the damage done to plants were cited as constraints.

In the Fifth Region, groundnut varieties like 47-10 are grown (Soumano, SRCVO, personal communication, October 1988). These local varieties have a 90-day cycle and are relatively well-adapted to the Fifth Region. The primary pests attacking groundnuts are insects in the field as cited by 46% of the farmers interviewed, and insects in the stored product as cited by 14%.

Wandzou is mainly grown by women in the Fifth Region as a hungry season crop. Even if the market for wandzou proves less profitable, the fact that it matures early and is rich in protein makes it desirable for home consumption. Multi-location tests have demonstrated the performance of varieties such as CMV4-1 (1.875 kg/ha) and CMV9-1 (1.309 kg/ha) (Kodio, 1988).

(c) Cultivation of sesame.

Productivity of sesame is relatively low, the average yield being approximately 300 kg/ha. In the CMDT zone, yields of sesame grown as catch crops[9] were between 200 and 300 kg/ha, while yields from monoculture crops were about 600 kg/ha. The producer price was fixed by the CMDT at 90 F CFA/kg. The CMDT extracts oil from the seeds or sells the crop to exporters (800 tons were sold from the 1987-88 harvest).

For the export market it is important that the varieties introduced to farmers are all white in color. There are two white sesame varieties that could be adapted to the ecology of the Fifth Region: 38-1-7 and Yendev 55. Both have a 94 to 98 day cycle. In Cinzana, yields of 711 kg/ha and 542 kg/ha, respectively, were obtained in 1987 with 558 mm of rainfall received in 52 days and a 65 kg application of "super simple" phosphate (Soumano and Traore, 1988).

In conclusion, proposals for improving secondary crops should be aimed at increasing labor productivity, facilitating the supply, storage and treatment of groundnut and wandzou seed. These proposals should also facilitate the introduction of improved early cowpea varieties as well as sufficient plant protection and crop storage.

The development of secondary crop production is also contingent upon possible marketing outlets (O. Coulibaly, 1987). This very important constraint is analyzed in the presentation of the research subject on the identification of marketing constraints.

9/ A type of secondary crop planted after the principal crop in the same year.

d. Proposals.

Zone: North, central and south Seno, the plateau, west delta (Mema) and the non-flood areas of the north, central and south delta.

Production system: Agropastoral and pastoral.

Collaborating agencies: SRCVO/DRA, Direction Regionale de l'Agriculture (Mopti).

Materials and methods:

Tests on secondary and minor crops such as cowpeas, groundnuts, wandzou, sesame and fonio are recommended. The subject of cowpea production has already been covered in the previous sections, and since marketing outlets and more available research results exist for both groundnuts and sesame (crops that have been overlooked by agencies in the Fifth Region), the topic covered in the next section is limited to intensifying production of groundnut and sesame crops.

(1) Intensifying the groundnut-millet-groundnut crop rotation.

Except in individual plots cultivated by women, millet is often the first crop grown in rotation immediately following the fallow period (Cunard, 1983; results from a formal survey, December 1987 to March 1988). The groundnut-millet-groundnut rotation is developed here because of the available research results. The DRSPR will be able to test the millet-groundnut-millet rotation that seems the most appropriate to local production system conditions in the Fifth Region. Another interesting rotation is that of millet-cowpea-millet. The most important agricultural consideration is to avoid one cereal crop following another. In fact, according to the IRAT (April 1978), neither groundnuts nor millet nor sorghum should be planted successively. They indicate that whether millet or groundnuts begins the rotation depends on the priority given to each crop, but that planting directly after the fallow provides a poor starting point for many crops.

A groundnut-millet-groundnut rotation is suggested here with a 300 kg TRP fertilizer application distributed at the beginning.

(a) Varietal selection and seed availability.

Improved varieties of cowpeas (see the research subject on increasing production of millet and cowpea monocultures), groundnuts, wandzou, sesame and fonio are available through agricultural research although their performance needs to be tested. In accordance with the ecological areas of the Fifth Region, several varieties of groundnuts already being extended in Mali can be selected ("Les Cultures Associees au Mali", IER-ICRISAT, 1987, p. 141). These are the early varieties 47-10 and 55-437 with the following characteristics:

Variety:	47-10	55-437
Growth type:	Upright	Upright
Cycle (days):	90 days	90 days
Shelling rate(%):	72	75
Yield in the shell(kg/ha):	1500	1000
Oil content (%):	50	49
Rainfall requirement (mm):	550-750	350-500
Recommended areas:	central delta south delta south Seno	north Seno central Seno the plateau west delta

The availability of groundnut seed (100 kg in the shell/ha) could be improved if storage conditions are improved (use of insecticides like Damfin and Actellic - application of 50g PC/100kg - or Phostoxin - application of one tablet/100kg). On the other hand, the availability of seed could be better guaranteed if the development of small animal breeding, for example (see the research subject on agricultural integration - breeding), enables people to manage unexpected expenditures[10]. NGOs or l'Action Cooperative could become involved in village seed storage as was done in Senegal and in the Gambia (Henry de Frahan, 1984).

Treating seed with Thioral before planting, for example, would increase germination rates. This technique is already used on millet seed and is well-known by farmers. It would be easily extended if the product were available in weekly markets or in village shops.

(b) Animal traction.

Extending animal traction use (see the research subject of improving cropping techniques and identifying input and credit supply constraints) should reduce labor time, and consequently, increase labor productivity as well as release women from weeding in the family fields. A timely survey would determine if animal traction also benefits women and the conditions in which its use would be the most advantageous.

10/ It is realized that groundnut, wandzou or cowpea stocks are used in times of financial need such as a family visit, baptism, marriage or medical care.

(c) Selection of mineral fertilizer.

In central Seno, SAFGRAD (1979. 1980, 1981, 1982), with a single application of 300 kg of TRP at the beginning of a groundnut-millet groundnut rotation, obtained yield increases for groundnuts of 25% in 1979 (2 locations) and 6% in 1980 (4 locations) in the first year of the rotation, and 45% in 1981 and 8% in 1982 in the third year. Results obtained in the south Seno area also indicate yield increases (47% and 3% for the first year, 26% and 21% for the third year). These results should be interpreted loosely in view of the limited number of test locations (one location for the first series of tests and two locations for the second series of tests). Results obtained in the plateau area indicate a 50% yield increase in the first year of rotation (3 locations, 1980) and 114% for the third year (one location, 1982).

The SAFGRAD results also show that yield increases for millet in the second year of the groundnut-millet-groundnut rotation, using an initial application of TRP, are greater than those obtained in the second year of millet-millet-millet rotation. Millet grown in the second year benefits not only from the TRP but also from the aftereffects of the groundnut crop that preceded it in the rotation (see the tables in Annex C).

(d) Expected yields.

Yields anticipated from the intensification of the groundnut-millet-groundnut rotation are those observed in the SAFGRAD tests[11] (see the tables in Annex C). For the south Seno zone, yields expected from this rotation using an initial application of 300 kg of TRP are 570 kg, 860 kg and 230 kg, respectively. In the central Seno and plateau areas, anticipated yields are 620 kg, 960 kg and 340 kg, respectively. Paradoxically, expected yields in the latter zone are higher than those in the south Seno zone while rainfall recorded during the three test months is frequently lower. A less equal distribution of rainfall could have had an unfavorable effect in the southern zone. Yields of groundnut plant matter are typically 80% of the shelled product yields (Soumano, SRCVO, personal communication, October 1988).

(2) Intensification of sesame cultivation.

In Cinzana (Soumano and Traore, 1988), the sesame variety 38-1-7 produced a yield of 711 kg/ha using 65 kg/ha of "Super simple" phosphate mineral fertilizer in spite of a lack of rainfall recorded for that period (1987-88, 558 mm, 52 days of rain). Yields were higher than those of the Yendev variety (542 kg/ha).

An experiment in sesame crop intensification could be carried in the south Seno zone and the central Seno and plateau zone, areas where the rainfall is adequate for mineral fertilizer use. The 38-1-7 variety

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11/ Rounded to the lesser tenth.

should be planted with a spacing of 60 cm by 10 cm, and a density of 16,650 hills seeded/ha. A donkey plow would be used for the weeding. One could expect yields of 600 kg/ha for the south Seno zone (16% less than that recorded in Cinzana), 450 kg/ha for the central Seno and the plateau zones (35% less than that recorded in Cinzana), and 300 kg/ha for the north Seno Zone (with half of the fertilizer use because of the risk of drought).

6. Improvement of Cropping Methods.

a. Introduction.

Cropping methods are linked, in part, to the distinctive characteristics of each zone in the Fifth Region (clay to silty-clay soils in the delta, sandy soils in Seno, sand and stony-sand in the plateau) and also to the variation in rainfall between the northern and southern parts of the region (amount of rainfall and the number of rainy days decreases as one moves from south to north). It should also be noted that variations in rainfall from year to year can also impede the standardized use of certain cropping methods.

Traditional cropping methods are most notably organic mounding, planting in mounds and weeding by hand. These traditional methods do not require the use of animal traction and are the most widely practiced in the Seno area, the sandy areas of the plateau and the flood recession areas of the delta.

Intercropping is practiced throughout the region except in the areas of the delta where rice is grown.

The traditional practice of mounding is limited by several constraints. The work is slow and tiring, the use of organic and mineral fertilizer in the mounds is difficult, and the weeding process is hard to mechanize. However, the use of these organic mounds has certain advantages. The farmer can directly seed the previous year mounds and benefit from the first rains. Also, the mounds contain plant matter which serves as organic material. In the Seno zones, this practice also helps to prevent sand accumulation.

The methods that have been extended deal primarily with using animal traction for tilling, planting and weeding. Mechanical harvesting is practically nonexistent in the Fifth Region.

The advantages of the extended methods lie in the time they save and in the reduction of physical energy needed for farming. They also free up certain individuals to engage in other work or economic activities. To be properly carried out, these methods call for sufficient soil moisture. This requirement inhibits their use for tilling at the beginning of the rainy season in certain parts of the Seno area where, if the planting does not directly follow the first rains, the harvest can be severely compromised.

Draught animals used in the region are oxen, donkeys, horses and camels. Most Seno farmers use donkeys because they are hardier and easier to maintain than oxen, and also because they are more suitable for the sandy soil in the Seno area.

Ridging is also an improved method similar to the traditional practice when it is done during the first weeding. It carries two advantages. First, considerable time is saved over the traditional method and second, sand accumulation is reduced more than through even tilling. For these reasons, ridging is suggested for areas where soil conditions and rainfall are acceptable.

b. Objectives.

The principal objective of this research subject is to adapt agricultural equipment to the agricultural, climatic and soil conditions of rainfed cropping systems in order to:

- increase labor productivity at peak labor periods (soil preparation and first weeding).
- release labor for other activities.

c. Purpose.

According to a formal survey, the most labor-intensive periods for producers in the Seno plain and plateau areas are the first weeding as cited by 68%, planting for 14% and the harvest for 10%. From those surveyed, 27% use workers outside of their own farm to carry out the first weeding, 14% for the second weeding and 7% for the harvest. Among those interviewed who have decreased the amount of land they cultivate, 70% cite a lack of labor as the cause. Among those who have made no changes in their cropland, 47% say this is because of a lack of labor.

According to Cunard (1983), often farmers plant a larger surface area than that which they can realistically expect to weed given their labor resources. Such a practice occurs in order to reduce the risks of crop loss due to climatic and biological uncertainties.

On farms using some equipment, a formal survey found that women do less weeding in family fields and cultivate a greater number of individual fields. This means that introducing animal traction into farming operations releases women to work on agricultural activities of which they are the primary managers.

Most of the farmers in Seno and the Bandiagara plateau with either an ox or donkey plow weed in ridges (Cunard, 1983; Henry de Frahan and Diarra, 1987). This practice, particular to this zone, requires two trips (up and back) to form the middle ridge between two rows of millet. It is usually on this middle ridge resulting from the first weeding that cowpeas are planted. Although this method requires less weeding time

than the traditional method, the fact that one must go between the rows twice makes it more time-intensive than if a cultivator were used. A cultivator ("Ciwara" or donkey plow) with weeding rakes could decrease the time needed for the first weeding. Since this equipment is not widely used for weeding in areas growing rainfed crops, and since it changes local cropping methods, it must be tested. However, using a cultivator demands even spacing between planting rows. For this reason, a "corps butteur" used to form the ridges before planting would be advantageous.

An initial tillage is also practiced in the Seno and plateau areas. Among those who till their fields, 51% till the soil surface evenly, 33% ridge the soil and 15% perform both methods. Ridging would be more effective than even tilling in combatting wind and water erosion. This would have a positive influence on the vegetative development of crops (especially protecting seedlings against frequent sand build-up which occurs in Seno). Consequently, any proposal to improve cropping techniques must include hilly seed beds produced either through mounding (traditional system), or through ridging (local mechanized system).

According to Shulman (1979), there are multiple advantages in ridging:

- Soil preparation is rapid. One hectare can be done in ridges in 150 passes with a ridger as opposed to 300 with a plow.

- Ridges formed with the "corps butteur" are parallel which is also conducive to mechanical weeding.

- Ridging is a good technique for incorporating broadcast fertilizer in the soil.

Vallee and Simpara (1980) do not recognize these advantages of ridging. The authors find that weeding in ridges is not recommended for Seno because it produces layering which negatively affects the soil structure. According to A. Toure at the DMA, (personal communication, August 1988), this observation would be true for heavy soils which are not, however, widespread in Seno. In these heavy soils, the middle ridge also promotes water erosion. There are two additional disadvantages to ridging which should be pointed out:

- The soil beneath the ridge is not completely worked, inhibiting root penetration in finely textured soils.

- Ridges which are not contoured or joined can accelerate erosion.

The possibility of using tied ridges in the Seno and the Bandiagara plateau areas is very limited due to the sandy nature of the soil. However, this technique could be used in several districts in south Seno (Bayes, for example) where the soil has more clay content. Studies carried out at the research center and in the field have demonstrated a significant yield increase and economic profit from the use of tied

ridges for millet crops (FSU Annual Report, 1983). This technique demands a lot of labor. In fact, manually constructing these tied ridges using animal traction calls for an average of 40 to 75 man hours/ha compared to 100 man hours/ha using only manual labor (Ohm. et al., 1985).

It must also be noted that low planting density (about 1x1 m) is a local practice designed to account for low soil fertility and grain lodging. Any proposal to improve cropping methods should not advocate significantly higher planting densities without recommending mineral application.

d. Proposals.

Zone: Central Seno, the Plateau, south Seno.

Production system: Agropastoral.

Collaborating agencies: SCRCVO/DRA, Direction Regionale de l'Agriculture (Mopti), Division du Machinisme Agricole/Direction du Genie Rural.

Materials and methods:

The introduction of a "corps butteur" attached to the cultivator for use in ridging before planting should:

- decrease time required for soil preparation,
- allow more even spacing between planted rows of millet, in order to facilitate mechanized crop maintenance.

Furthermore, using a cultivator for weeding should decrease the time needed to carry out the first weeding.

The choice of equipment and of cropping method must take soil type and rainfall into account (Cunard, 1982). For this reason, the tests are recommended according to agronomic, soil and climate conditions.

(1) For the south Seno zone (450 to 600 mm of rainfall, sandy-clay soils).

For millet crops, the Ciwara cultivator (using draft oxen) will be tested with the "corps butteur" to ridge the soil before planting, as soon as the rains begin. The same equipment, with weeding rakes, will be used to do the first weeding. Since the equipment mount is 60 cm wide, the spacing between millet rows should be at least 70 cm to facilitate weeding. Using a spacing of 70 cm x 100 cm instead of the local practice of 100 cm x 100 cm, the density will be increased by 40%. This equipment will be compared to the oxen-drawn TM SMECMA plow already in use for the same practices in the area. For this test, TRP will be used at a rate of

300 kg/ha to compensate for the exportation of minerals resulting from working the soil to produce higher yields. In fact, there is a risk of extending tilling or ridging methods without minimally restoring mineral elements and organic matter to the soil (Vallee and Simpara, 1980). TRP will be recommended only for improved seed packs, whereas both improved and control seed will be treated with fungicide.

(2) For the central Seno and Plateau zone (400 to 450 mm of rainfall and silty-sand soil).

The SMECMA donkey plow will be equipped with a "corps butteur" to ridge millet fields prior to planting at the beginning of the rains, if it is possible to for a donkey to draw the "corps butteur". This same equipment, modified with a weeding rake, will be used for the first weeding. Like the Ciwara plow, the equipment mount is 60 cm wide. Consequently, the current spacing practices in this part of the plain (approximately 1 m x 1 m) must be decreased moderately. In a cross-comparison of the same tasks, the donkey plow, equipped with the "corps butteur" and the weeding rake, will be compared to the TM plow or to another plow which is lighter than the TOM plow (currently used in the area).

(3) Current testing of equipment.

(a) "La houe hollandaise" (introduced into the Office du Niger with the ARPON project).

This lighter piece of equipment is designed for donkey traction. It could be used in Seno with the following modifications (S. Traore, 1988):

- move the scraping and weeding teeth forward,
- adapt the handle for adults,
- modify it to ease transportation,
- anticipate the addition of the "corps butteur".

The advantage of this equipment is its sliding equipment mount that extends to 80 cm, and is closer to the spacing found in Seno (1m x 1 m).

(b) The lighter DMA cultivator.

Ciwara equipment is 10 kg lighter, thus allowing for the weakened state of draft oxen at the beginning of the rainy season. The equipment mount can be lengthened from 60 cm to 1 m.

(c) Donkey traction cultivator with a wooden frame.

This well-priced cultivator (17,000 F CFA) is in prototype stage at the agronomic research center in Cinzana and at the DMA experimental station. It has the advantage of possibly being produced locally by village blacksmiths without the use of sophisticated imported materials. The current prototype lacks stability and resistance to local use conditions. The maximum work area covered by this cultivator is 60 cm. The hourly work capacity with the equipment is estimated at 10 ares. The amount of traction force exerted on sandy soil to achieve a soil depth of 5 cm is less than 40 kgf (Awadhwal, 1988).

(d) Other possible tests to study such as dry cross-scraping or soil preparation with pick-mattocks (Vallee and Simpara, 1980).

This technique has the advantage of allowing planting with the first rains, as opposed to tilling or ridging which cannot be carried out until the arrival of the first rains.

7. Integration of Agriculture and Animal Husbandry.

a. Introduction.

In the Delta zone and in the Seno plain, most agropastoralists have lost their draft oxen to droughts over the last ten years. This loss inhibits the use of equipment for such timely cropping operations such as tillage and weeding.

Increasing labor productivity demands mechanized cropping operations. One man can work approximately 0.8 to 1.2 ha of land with a hand hoe. Using a pair of oxen, he can work 2 to 3 ha, and with a tractor, 15 to 25 ha (Kessler and Ohler, 1983, p 46). However, the use of animal traction calls for increased availability of agricultural inputs. Draft cattle need sufficient grazing land (6-15 ha per UBT) or else they must receive supplements from agricultural products and by-products to maintain their health (Kessler and Ohler, 1983, p 46).

Another important benefit derived from the integration of agriculture-animal breeding is improved yields through working the soil (improved water infiltration and seedbeds) and using organic fertilizer.

A more advanced step in the integration process is increasing animal productions (milk-meat). One observes that draft oxen become sources of labor, fertilizer, and enhanced value for agricultural by-products and animal productions.

Small ruminant breeding is a means of survival for farms and plays a diverse role in their operation (remuneration for other work, taxes, different financial needs, etc.). Paradoxically, small ruminant breeding receives no particular attention from farmers except in the case of castrated sheep used for fattening.

b. Objectives.

The objectives are the following:

- to maintain draft animals for use with farmers' equipment in order to improve labor productivity, and to produce manure in order to maintain and improve soil fertility with the goal of increasing agricultural production.

- to develop small animal breeding in order to increase farmers' income, allowing them to better meet financial obligations (such as taxes and similar fees, etc.) and social demands.

c. Purpose.

(1) Improvement in Equipment Use and Pricing.

Due to the progressive degradation of grazing lands around villages and the insufficient supply of agricultural by-products, some farmers in the central Seno area and the Bandiagara plateau send their draft oxen out for seasonal grazing. In fact, according to the formal survey, from a sample of 20 farms in the central Seno and Bandiagara plateau areas with draft oxen, 11 farms, or 55% of the farms in this category, sent their draft oxen out to graze. The proportion of farms sending their draft oxen out to graze is 44% in the Seno plain and the Bandiagara plateau.

In the course of the seasonal grazing period, draft oxen as well as other types of animals, are susceptible to the risks of disease, theft and attacks by wild animals. Frequently, the animals do not return from grazing by the optimal date for soil preparation. In the Delta zone, tillage at the beginning of the cycle loosens the soil so it can receive the beneficial effects of the first rains. Tillage at the end of the cycle is important for weeding rice fields. However, oxen weakened from receiving insufficient feed during the dry season represent a major constraint to beginning- and end-of-cycle tillage of rice fields in the Delta. In the Seno, weakened draft oxen lower labor productivity, especially in the north and central Seno zones.

Underequipped farmers also hinder improvement of labor productivity. Table 4.8 shows the percentage of farmers with equipment by type of equipment in the zones serviced by the Operation Riz Mopti. In this table, one notices that the average percentage of farmers having equipment and draft oxen over a period of 11 agricultural seasons (1975-1976 to 1985-1986) has remained almost unchanged (41%). An analysis by season permits the observation of a reduction in the percentage of

TABLE 4.8 : PERCENTAGE OF FARMERS WITH EQUIPMENT BY TYPE OF EQUIPMENT IN THE ZONE SERVICED BY THE ORM.

Equipment	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Draft oxen	42	45	43	40.5	41	38	42.5	47	42.5	44	30.4
Plow	41	41	40	40	43	37	40.5	42	41	42	40
Harrow	6	6	5	4.1	7	6	5.4	6.2	7.4	6.6	6.7
Frame	4	7	6	5	10	11	12.6	14	14.1	13	15

Source : ORM Annual Reports, Monti.

farmers owning draft oxen during the 1980-1981 (38%) and 1985-1986 (30%) seasons. As for plow owners, one can see a reduction in owners during the 1980-1981 season (37%) compared to the average percentage during other seasons which was nevertheless only 41%. From the table one can also observe that there is a low percentage of farmers owning harrows and carts (frame). The average percentage of owners for the period from 1975-1976 to 1985-1986 was 6% for harrow owners; and for cart owners; 10%.

(2) Soil fertility improvement.

Seno soils are poor in organic material. The amount of organic material in Seno is about 0.9% (Vallee and Simpara, 1980). In addition, farmers in Seno seldom return residue from the harvest to the soil as a source of organic fertilizer. These residues are primarily used by farmers as fuel for cooking, construction material, and feed for animals. Manure from draft oxen is a source of organic fertilizer. Shulman (1979, p. 12) reports that by leaving two draft oxen in a pen overnight, one can collect 5 to 6 tons of manure in a year. A layer of bedding placed with the animals absorbs urine and increases the amount of compost. Shulman (1979) reports that, empirically, one ton of manure (water content of 50-70%) is equal to 50 kg of 10-5-10 fertilizer corresponding to 12.5 kg of fertilizer elements (N-P-K) and at least 3 kg of Ca-Mg nutritive substance. The Memento de l'Agronome (1980, p. 123) states that one ton of manure furnishes 100kg of humus, 5 kg of N, 3 kg of P_2O_5 and of K_2O. Restoring fertilizer elements to the soil increases crop yields. Shulman (1979, p. 13) reports that a seven-year experiment (1963-1969) in M'Pessoba, Mali that incorporated fertilizer at the beginning of a cotton. sorghum, groundnut and fallow rotation produced the yield increases reported in Table 4.9.

TABLE 4.9 : AVERAGE YIELDS OBTAINED IN M'PESSOBA (1963-1969).

Crop	Fallow after slash and burn			
	without manure without fertilizer	15 tons/ha manure only	15t/ha of manure + complete annual fertilization with chemical fertilizers	15t/ha of manure + 50kg of rock phosphate + 1 localized annual application of N and K chemical fertilizer
Cotton	568	1270	1648	1725
Sorghum	487	973	1525	1979
Groundnut	919	1128	1613	1770

Source : Shulman, 1979, p 13.

(3) Estimate of food requirements and grazing area for one pair of oxen in non-flood and flood zones.

Integrating agriculture and livestock to improve equipment rates and soil fertility is only possible if the food needs for draft animals, here in the case of one pair of oxen, can be supplied. The provision of these needs is analyzed below. It is shown that supplying these needs is easier in flood zones than in non-flood zones due to the development of bourgou areas.

(a) Estimate of nutrients in agricultural production.

Harvest by-products are food sources for fat and carbohydrates. Kessler and Ohler (1983, p. 32) give the quantities of nutrients in kg found in 100 kg of these products derived from several crops grown in West Africa, namely millet, sorghum and groundnuts. These quantities are given in Table 4.10.

TABLE 4.10 : Quantities of nutrients in kg for 100 kg of products derived from several crops from West Africa.

Crop	Products	N	P	K	S
Millet	stalk and foliage	5 - 9	0.2 - 0.4	8 - 27	0.6 - 3
		7 - 10	0.4 - 0.9	8 - 25	0.8 - 4
Sorghum	stalk and foliage	3 - 6	0.4 - 1.3	6 - 24	1
Groundnuts	shell and hay	5 - 11	0.3 - 1.1	5 - 15	0.7 - 1.7
		8 - 20	1.1 - 3.1	10 - 25	1.7 - 2

Source : Excerpted and adapted from Table 11, p. 32,Kessler and Ohler (1983).

Shulman (1979, p. 56) reports that one unit of fodder plants (UF) can be supplied by:

1.8 kg of hay from legumes,
3.5 kg of straw or fodder,
2.5 kg of hay from grasses,
1.5 kg of millet or sorghum bran,
2.3 kg of rice bran.

In the Delta, bourgou areas contribute considerably to animal feed during the dry season. In fact, 1.5 kg of bourgou can provide one UF (Keita, assistant director at ODEM, personal communication, October 1988).

(b) Estimate of food requirements for one pair of oxen.

Shulman (1979, p. 56) reports that an ox weighing 250 to 350 kg needs 2.5 to 3 UF/day for maintenance and 0.5 UF for growth. On the average, 3 UF/day are necessary for maintenance and 0.5 for growth, for a total of 3.5 UF. According to Shulman (1979), as soon as the oxen are working, the intake for maintenance should be increased from 50% to 100%. The full intake increases to 5 or 6.5 UF, or an average of 6 UF/day for maintenance, growth and labor productivity.

(c) Estimate of land area needed to feed one pair of oxen.

The land area needed to feed one pair of oxen can be estimated according to farm location, whether non-flood or flood zone. In non-flood zones the fodder source is primarily harvest residues. We will look at the case of cowpea hay, a complementary product derived from cowpea grain monoculture. According to SAFGRAD (1987), one hectare of cowpea grain produces 400 kg of dry hay, in addition to grain. During the dry season a pair of oxen requires 7 UF for maintenance and growth (Shulman, 1979). We restrict this requirement to four months of the dry season (March to June) because during the first months of the dry season (October to January), oxen can graze on fallow lands and fields. During the rainy season (from July to September), we reduce the requirements for a pair of oxen to that which is necessary for work (5 UF/day), and the requirements for maintenance and growth are satisfied through grazing near the farm.

The fodder source in flood zones is alleged to be primarily bourgou. In these zones, one hectare of bourgou area can produce 17 tons (moderate bourgou) to 25 tons (heavy bourgou) of dry matter (Keita, assistant director at ODEM, personal communication, October 1988). During the dry season, also limited to the months March to June, a daily intake of 7 UF is necessary for the maintenance and growth of a pair of oxen. During the rainy season (from July to September), it is difficult for farms in flood zones to find abundant fodder. Therefore, it is necessary during this period to count on a full daily intake of 12 UF for maintenance, growth and work for one pair of draft oxen. Fodder and land area requirements for a pair of draft oxen in both flood and non-flood zones are estimated in Table 4.11 below.

Land area requirements for grain legumes is 5.8 ha. This important requirement could be decreased considering that food needs can also be supplied through other sources of vegetation (straw, forage, hay and bran). However, fulfilling the food requirements of draft oxen will

always be problematic since agricultural by-products are employed for uses other than livestock feed.

On the other hand, in flood zones, meeting the feed requirements of one pair of oxen seems easier with only 0.15 ha of bourgou area. Bourgou culture is, therefore, an activity to be encouraged. Diakite and Keita (1988) estimated the costs of regenerating a bourgou area at 11,500 to 13,000 F CFA. The regeneration period of such an investment depends on successive flood levels. If several successive years experience insufficient flood levels (drying out occurs) or overflooding (drowning occurs), the investment is lost.

TABLE 4.11 : Estimate of food requirements and land areas for one pair of oxen in non-flood and in flood zones in the Fifth Region of Mali.

Zone	Non-flood	Flood
Daily intake (UF):		
Dry season	7	7
Rainy season	5	12
Food requirements (UF):		
Dry season (4 months)	840	840
Rainy season (3 months)	450	1080
TOTAL	1290	1920
Composition (UF/Kg dry matter):		
Hay	.56	-
Bourgou	-	.67
Food requirements (Kg dry matter):		
Hay	2304	-
Bourgou	-	2866
Yield (Kg dry matter/ha):		
Cowpea hay	400	-
Bourgou	-	20000
Land area (ha):		
Cowpea	5.8	-
Bourgou area	-	.15

Source: According to estimates by the authors.

According to Diakite and Keita (1988), bourgou regeneration is well-accepted among the population and administrative officials. In addition, this plant's biology facilitates and favors large-scale planting or progressive planting in fields. Since 1981, 3,411 ha have been regenerated in bourgou, 2133 of which (63%) are in the Mopti circle. Expanding this regeneration is limited, however, by the legal and land tenure situation and the overall institutional level (political, administrative and technical).

For grazing lands undergoing land title litigation, bourgou culture is sometimes an easy solution to a problem. This protected and regenerated area is guaranteed not to be subject to litigation for the pastoralist (Diakite and Keita, 1988).

(4) Improving agropastoral incomes.

It would be interesting to proceed with a study of transactions concerning small ruminants and grains in order to decide on the manner in which these two transactions could be integrated so that farmers could maximize their incomes. In fact, small ruminants represent a financial source for buying grain during the hungry season. According to the results of a formal survey in Seno and the Bandiagara plateau, 75% of the farmers interviewed who raise small ruminants sell them later. The price of small ruminants is beneficial to producers during the hungry season. In fact, according to the list of monthly prices for different types of sheep in the Fatoma market in "Refuge in the Sahel" (Ministere des Ressources Naturelles et de l'Elevage, 1987, p. 28-29), the prices for small ruminants seems to be higher during the months July to August. For the years in which this was observed (1982-1987), price increases corresponded to the holiday periods of Ramadam and Tabaski. The lowest price level, on the other hand, corresponded to the period when cattle herds return from season grazing, from October to December (Diakite and Keita, 1988). Moreover, to meet pressing financial demands such as taxes and other fees, most farmers sell their grain immediately after harvest. At this time, the supply of grain on the market is greater than the demand, causing a decrease in grain prices. This is the over-marketing period. Several months after the harvest, farmers buy the grain back at a higher price. Henry de Frahan and Diarra (1987) report price increases of 50 to 100% between the post-harvest and the hungry periods. According to results from a formal survey in Seno, 67% of the farmers interviewed sell their millet and 92% buy millet. The sale and purchase of millet are the most important financial transactions compared to other agricultural product transactions.

d. Proposals.

Zone: the active and inactive Delta (north, central, south and west), Seno (north, central and south) and the Bandiagara plateau

Production system: Agropastoral

Collaborating agencies: SRCVO/DRA, INRZFH, ODEM, ORM, Direction Regionale de l'Agriculture (Mopti).

Proposals:

The integration of agriculture and livestock provides mutual advantages: agricultural by-products on the one hand, and manure and traction power on the other. Increased availability of feed from forage crops and/or good quality by-products, can favor the development of milk and meat production, a more advanced stage of agriculture and livestock integration.

The subject of agriculture-livestock integration should be pursued, taking into account the proposals made regarding draft oxen and agricultural equipment in the following subjects: Study of cropping systems in the Delta; Identification of market, input and credit constraints.

The following subjects are proposed to 1) improve the feed and health of draft oxen and small ruminants, 2) increase manure production and 3) increase the level of equipment.

(1) Study the management of draft oxen and small ruminants with the goal of identifying feed, watering, and health problems.

(2) Test and evaluation of forage production.

(a) Millet and cowpeas will be planted in fallow areas or in tilled fields. Millet and cowpeas will be sown by broadcasting or in moderately close hills. Cowpeas will ideally be planted after the millet is weeded for the second time. Millet and cowpeas will be cut together when the millet reaches a height of approximately 60 to 70 cm.

(b) Forage cowpeas (for example, a creeping variety like Niban) will planted in a tilled field. Weeding and plant protection measures are not necessary with forage cowpeas.

(c) Labor productivity and weight gain among draft oxen subject to supplementary feed and appropriate health measures will be evaluated. An evaluation of small ruminants subject to appropriate health conditions will also be carried out.

(d) Estimation of the quantity of manure produced by oxen in improved pens. Installation of compost using TRP in places where there is sufficient water. Estimation of the effect of organic fertilizer on crop yields.

(e) Study of the acquisition and sale (disinvestment) of draft animals in order to identify constraints and propose solutions to lift these constraints.

8. Study Of Cropping Systems In The Delta: Constraints Of The Agricultural Calendar.

a. Introduction.

According to the results of a formal survey, most farmers in the Delta zones grow several crops or practice different cropping systems. One can differentiate between two situations according to agroclimatic zones:

(1) In the central and south Delta, farmers serviced by the Operation Riz Mopti (ORM) grow Oryza sativa rice varieties by controlled flooding in rice polders, and also outside the polders. Local rice varieties or Oryza glaberrima varieties are grown by natural flooding. In addition to rice grown by controlled and natural flooding, rainfed crops such as millet, sorghum, cowpeas, groundnuts, etc., are also grown in non-flood areas of the Delta. One must also include rice grown on small irrigated village perimeters (PPIV). In fact, the installation of these irrigated perimeters in some villages (20 to 30 ha each) through a river-based pumping system, constitutes a policy adopted and proposed by the ORM to help farmers to bridge disruptions in rainfall and water levels.

The diversification of cropping systems is used as a means of survival since it allows the initiators to minimize the risk of total agricultural production loss. The current centrist policy assumed by the ORM is a reaction to the current climatic crisis. In fact, according to Togola (ORM Director, personnel communication, August 1988), the said ORM policy focuses primarily on ORM control of the entire Delta flood zone (managed and unmanaged zones). Through this centrist movement, the ORM consequently adds the development of cultivation for Oryza glaberrima rice varieties to its previous actions in unmanaged zones. As for the managed zones in the Delta judged to be unsuitable for rice culture, they will be used for the development of better-suited and more beneficial activities for farmers. In this area, the ORM has already begun to progressively reduce managed lands from 40,000 ha to 20,000 ha for the Mopti, Djenne and Tenenkou zones.

As for the small irrigated village perimeters, negotiations between the ORM, the African Development (ADB) and the World Bank (WB) resulted in funding for a 700 ha extension. One must also mention the PPIV funding by the European Development Fund (EDF) aimed at local development groups.

(2) In the north Niger delta, farmers grow sorghum, cassava, potatoes, cowpeas, sorrel, tomatoes, eggplant and onions as flood recession crops around ponds and lakes. Some farmers also grow rice on the bottom of these bodies of water. Before climatic and rainfall

disturbances, rice was generally grown alongside the water. In addition to flood recession crops, these farmers increasingly grow millet on the sandy non-flood plains. Poor rainfall conditions are the reason for extending millet culture to some ponds also. This is why farmers in the north Delta region practice two cropping systems that lead, nevertheless, to available labor organization and allocation problems in carrying out cropping operations.

b. Objective.

The primary objective of this research subject is to coordinate cropping operations for the different cropping systems; rice culture by controlled and natural flooding, rainfed agriculture in non-flood areas, irrigated rice culture in the PPIV and flood recession agriculture.

c. Purpose.

According to an informal survey, farmers in the Delta, due to diversity in cropping systems, are not able to optimally carry out some cropping operations, especially tillage, planting, weeding and harvesting. The optimal execution of cropping operations is limited by several problems at the farm level. One can cite the following constraints:

- lack of equipment on some farms,
- insufficient farm equipment and draft oxen,
- weak draft oxen,
- water deficit which makes the soil hard,
- overflooding in some polders preventing use of a seeder,
- insufficient labor within the family and problems organizing this labor in the space and time of the different cropping operations,
- distance of some rice growers from their fields (10 to 60 km).

According to farmers, when rainfall conditions are satisfactory, tillage of rice fields at the end of the cycle is the first cropping operation carried out. This tillage is followed by the re-opening tillage before the first rains. After re-opening tillage and rice planting, farmers turn to their millet fields. With climatic and rainfall disturbances, work in the rice fields now coincides with work in millet fields. Table 4.12 provides the cropping calendars for several crops in the Delta.

TABLE 4.12: Agricultural calendar for the different crops grown in the zones of the Delta.

Cropping operations	J	F	M	A	M	J	J	A	S	O	N	D
1. Controlled-flood agriculture												
Tillage at end of cycle	XXXXXXXXXXXXXXXXXXXXXXXXXXXX											
Tillage, weeding and planting												
Weeding and fertilizing												
Scything												
Harvest and threshing												
2. Rainfed agriculture												
Tillage and planting												
First weeding												
Second weeding												
Harvest and threshing												
3. Irrigated agriculture (PPIV)												
Seedbed establishment		XXXXXXXX				XXXXXXXXX						
Transplanting												
Fertilizing and weeding												
Maintenance												
Harvest and threshing												

Source: Informal survey, 1988. IER-USAID-MSU project.

One can see from the table that planting and maintenance periods coincide for rainfed agriculture and controlled-flood rice culture. In order to resolve this timing problem, farmers broadcast rice to gain time for weeding millet crops which demands a lot of time and labor. When the labor margin becomes too narrow, some farmers leave rice culture for rainfed agriculture, which according to them, is less risky. The most common solution is to resort to wage labor (nonetheless, an expensive solution). Farmers working the Koubi rice polder[12] (Tenenkou zone) cite the following remuneration rates for wage labor:

- tillage: 7,500, 10,000 to 15,000 F CFA/ha, including lunch,
- weeding: 500 to 750 F CFA/day, including lunch,
- harvest: 500 to 750 F CFA/day, including lunch or one tenth of the employer's harvest.

Wage labor is generally found in rainfed cropping areas like the Bandiagara plateau. However, in some villages in the Delta, youth groups work either for money or payment in kind (bales of rice for example). It should be pointed out, nonetheless, that youth labor is becoming rarer due to migration.

1/ The amounts offered daily in the Mopti zone correspond to maximum amounts offered at Koubi.

The existence of small irrigated village perimeters (PPIV) has aggravated the labor allocation problem, especially for farmers who want to grow both rainfed crops and controlled-flood and irrigated rice crops. For example, in Table 4.12, pressing cropping operations like weeding and fertilizing rice fields (controlled-flood and irrigated areas) are jobs competing with the second weeding in rainfed crops. In controlled-flood rice culture, harvesting, threshing and end-of-cycle tillage coincide with seedbed establishment, transplanting, weeding and fertilizing work in small irrigated perimeters. In addition, if farmers do not take time to look for rice seed, they lose time weeding because they must separate the wild rice from the desired variety. Also, rice harvesting and threshing conflicts with millet harvesting and threshing. Even though the agricultural calendar for flood-plain rice culture is not represented in Table 4.12, one presumes that the cropping operations involved also conflict with those of other cropping systems in the Delta.

Labor problems involving conflicting crop operations compound farmers' problems of no or insufficient equipment. In fact, in the Delta zone, most agropastoralists lost their draft oxen to droughts over the last ten years. This loss of draft oxen impedes the use of equipment in carrying out timely cropping operations like weeding, tillage, etc.

As for seeders, village interviews revealed that their use is hindered not only by flooding in some polders but also by the fear that some oxen demonstrated upon seeing the red colored seeder. Therefore, seed is broadcast to save time. Broadcasting, however, wastes seed. When sowing with a seeder, the ORM recommends using 60 to 80 kg/ha instead of broadcasting 100 kg/ha. In addition, broadcasting seed makes it difficult to weed by plow or mechanical weeder.

Problems of insufficient equipment are accompanied by the fact that some equipment is not multiple-purpose and adaptable for use in different cropping operations. For example, the Bajac B2 plow (73 kg) or the B4 (58 kg) is well-adapted to the silty-clay soils needed for rice culture while the Bajac TM plow is better adapted to millet culture in sandy soils. Farmers who grow rice in ORM polders and cereals in non-flood areas need to have both the Bajac B2 plow or the B4 (heavy) and the Bajac TM plow (light) for easier and proper tillage. Owning both of these plows is not financially feasible for most farmers.

d. Proposals.

Zones: North, central and south Delta

Production system: Agropastoral

Collaborating agencies: ORM and DMA.

Proposals:

In an uncertain climatic and hydrological context, farmers, because of insecurity, prefer to increase the number crops planted instead of improving their other endeavors. Diversification of cropping systems poses organizational problems for farmers in carrying out these operations in the proper order. In order to release bottlenecks in the cropping calendars, principally during planting, weeding and harvesting, farmers often employ last-resort strategies. These farmer strategies are the following:

- broadcast seeding rice fields,
- resorting to labor outside the farm or to youth groups,
- abandoning some crops to undertake other crops having greater chances of success,
- spreading out cropping operations, especially maintenance and harvesting, by choosing varieties according to their cycles (early and late rice and millet varieties).

Thus, seeking equilibrium among cropping systems and the amount of labor these systems require is a necessity for farms. The primary constraint to finding this equilibrium is the risk-adverse strategy adopted by farmers. In this context, research on the most effective technical procedures should be based on the diversity of cropping systems. For example, sufficient conditioning of draft oxen should assure that cropping operations such as end-of-cycle tillage and re-opening tillage are carried out in a timely manner. The DRSPR's contribution in resolving these agricultural scheduling conflicts in the Delta can be suggested as the following:

1) Diagnostic study of cropping systems practiced together on farms in the Delta, and even more so, a study of constraints in the agricultural calendar.

2) Study of the supply and use of farm equipment, draft oxen and credit on farms in the Delta.

3) Study of draft oxen conditioning on farms in the Delta.

Aside from the DRSPR's contribution, the ORM should try to remove farm level constraints regarding the use of some equipment such as seeders. The ORM and the DRSPR, working with the DMA, can plan to test farm equipment that could be used with different types of soils and different cropping operations (the Ciwara cultivator which weighs 30 to 40 kg, for example).

9. Study Of Cropping Systems In Village Irrigation Areas.

a. Introduction.

Controlled-flood rice culture is heavily dependent on rainfall and water levels. For the past ten years, rainfall and the water levels have become uncertain factors in the ORM zone. According to Table 2.11 in Chapter II, the flood levels were poor in 1983, 1984, 1986 and 1987. The amount of land harvested from 1978-79 to 1985-86 was among 0 to 66% of the area under cultivation. The lowest figures were recorded for the 1983-84 (12%) and 1984-85 (0%) seasons during which the Bani's highest water levels at Mopti were 502 cm and 440 cm, respectively. Since 1981, for example, the Sofara rice polder has been absolutely barren, except during the 1985-86 season when approximately 3 to 5% of the land area was harvested. Multiple consequences have arisen such as insufficient food for the population and a massive migration out of the area. To confront this crisis, ORM administrators and local development committee leaders have stimulated investment in construction and supervision of small village irrigation areas (PPIV) an average area of 20 to 30 ha.

Irrigated rice culture in these small perimeters is a new production system in the ORM zone. This system calls for a lot of stringency on the part of the ORM and the farmers who do not have extensive experience with the subject. Problems observed at the PPIV can be summarized as follows:

- lack of recorded data concerning the motor-pump operation (for example, no data on the volume of water supplied and fuel consumption, etc.),
- excessive use of water by the farmers,
- poor maintenance of irrigation canals,
- inadequate leveling of rice fields,
- poor planning of activities such as seedbed establishment, transplanting, weeding and fertilizer application,
- no topographic or soil studies to direct the irrigation method and crop composition of some PPIV.

In spite of these problems, paddy rice yields of approximately 5 to 6 tons/ha were recorded in several fields in the perimeters. Such yields demonstrate that production potential in the PPIV exists.

b. Objectives.

The ultimate objective of research proposals concerning the PPIV is to contribute to an increase in productivity of the resources used in

the production process, in order to improve rice yields or cropping systems that are better adapted to the present irrigation method.

c. Purpose.

The ORM hopes to extend the PPIV program, expanding from the current 140 ha to 840 ha, through World Bank and Fonds d'Aide et de Cooperation funding. Furthermore, under the VIth E.D.F., construction of 15 sites on 500 ha is planned for the Mopti and Youwarou circles in coordination with local development committees.

For some of the perimeters already constructed, it is necessary to find crops and irrigation methods that are well-adapted to the area's topographic and soil characteristics. At Tongorongo's PPIV, for example, the soil's permeability and slope are not conducive to irrigated rice culture.

The ORM recommends the upright rice variety IR 15-29 and IR 15-61 for transplanting in the PPIV. It is also possible that there are other more productive upright varieties that should be tested in the PPIV.

Another alternative to be studied is the introduction of other crops into the system during the colder dry season. The intensification or introduction of another crop can be justified by farmers who lament the insufficient field area allocated by the family.

In order to improve management of the PPIV it would be equally as interesting to study the impact of the population's social organization on PPIV management.

Irrigated rice culture on these small village areas is a new irrigation method that calls for a lot stringency on the part of the ORM and the participating farmers. One encounters scheduling problems for cropping operations and resource management problems. These problems should be studied in depth in order to identify actual constraints and to propose solutions.

d. Proposals.

Zones: North, central and south Delta.

Production system: Agropastoral.

Collaborating agencies: SRVCO/DRA and ORM.

Proposals:

Study of the availability and use of factors of production (labor, land, capital and management) and their productivity. Identification of

constraints linked to the accomplishment of different farm activities and proposal of solutions.

Study of crop and variety selections as a function of the system, soil type and season, with consideration of market outlets for harvest products. This can be accomplished in the following manner:

1) Tests of upright rice varieties which demonstrate their productivity, resistance to boring insects and disease and their adaptability to area climatic conditions.

2) Study of and program on crop diversification, including the addition of market-gardening between the hot dry season and the rainy season. This includes market-garden crops like sweet potatoes and potatoes and other crops such as maize and cowpeas.

3) Study of outlets for those crops which are introduced and suggested.

4) Study of fertilizer tests (for example, combining TRP and organic fertilizer).

10. Evaluation Of Rice-sorghum Intercropping In Areas At Risk For Rice Cultivation In The Delta.

a. Introduction.

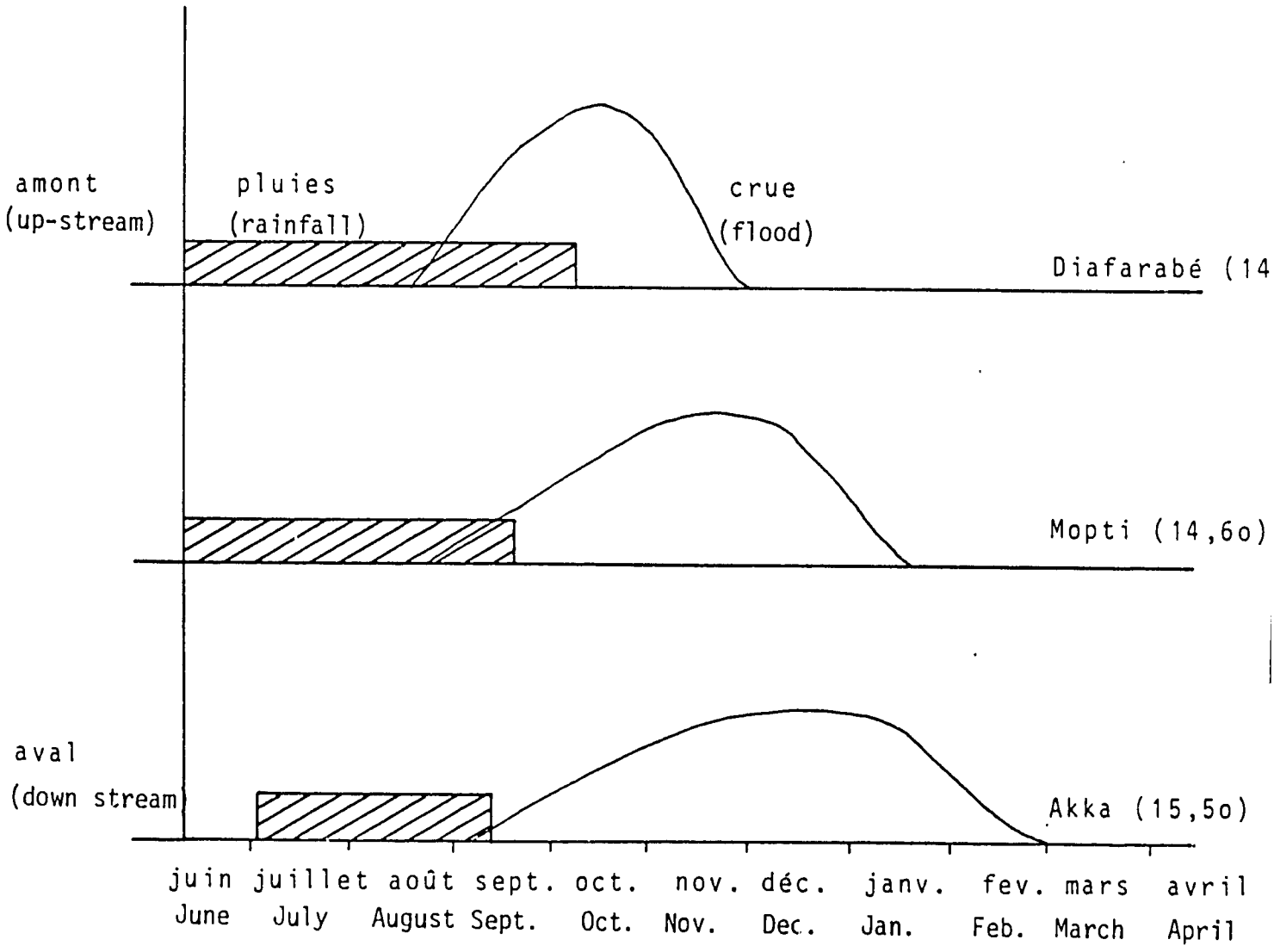
Since 1968, throughout the entire Sahelian region, one notices a significant climatic aridity, punctuated by particularly dry years (1972-1973 and 1983-1984) and also by poorly scattered rainfall during the rainy season.

The origin of these climatic disturbances is still not really known. In the interior Niger Delta and the Fifth Region, climatic alterations are seen in reduced rainfall and lower water levels in the Niger.

In Mopti, annual rainfall which previously averaged 546 mm from 1929 to 1969, has dropped to 390 mm in 1972, 326 mm in 1973, 318 mm in 1982 and 321 mm in 1984 during periods of drought. The Niger's reduced water levels have decreased the area and submersion period for flood area ecosystems in the Delta. Figure 4.1 shows the relationship between the flood level and rainfall up- and down-river in the Delta.

In the presentation of this research subject, the ORM (Operation Riz Mopti) polders or the areas outside the polders where the frequency flood levels has decreased are considered risk zones. Traditionally, rice was grown exclusively in these zones. Currently, however, sorghum

FIGURE 4.1: LINKS BETWEEN THE FLOOD AND THE RAINFALL ON THE DELTA, FOR UP- AND DOWN STREAM AREAS (From Hiernaux, 1982).



is becoming increasingly important and is supplanting rice culture. Even so, when flood levels return to normal, the sorghum harvest is lost because it cannot survive a long flooding period. When flooding comes early, local sorghum varieties cannot mature before the flood period. This is also the case when the rains arrive late or are insufficient. On the other hand, when the flood level is too low, rice production is insignificant.

To reduce the risk of total loss, rice-sorghum intercropping is becoming a viable alternative for ensuring at least one crop, regardless of the water level. In addition, by choosing the appropriate sorghum variety, it is even possible to save both crops and improve total production in years with an adequate rainfall and flood level. The sorghum must mature before the water levels rise (see Figure 4.1). However, the ORM's first attempt in this area was unsuccessful due to insufficient rainfall for sorghum on the one hand, and low water levels for rice on the other. Nevertheless, farmers who carried out the same test the following year obtained satisfactory results (Dembele, director of experimental research at ORM, personal communication).

On-station research on rice-sorghum intercropping provides few results, probably for the following reasons:

- rice and sorghum are different crops and have different moisture and soil requirements,

- potential yields and the selling price for rice are relatively higher than those for sorghum, which implies poor profitability for rice-sorghum intercropping where the ecology favors rice culture.

b. Objective.

The primary objective is to ensure cereal production in risk zones.

c. Purpose.

Risk zones represent a small proportion of the ORM's rice polders. These zones are primarily the Sofara, Syn and Bougoula polders which are flooded by the Bani. In 1985-1986, these three polders covered 4,370 ha of the 29,831 allotted; approximately 15%. They are, however, important areas for zones outside of the polders.

Rice-sorghum intercropping is coming to light in some areas in the rice growing zone and appears to interest certain farmers. In fact, interviews with the Sofara Comite des Producteurs de Riz (CPR) in February 1988 revealed that yields of 100 kg of sorghum and 500 kg of rice per hectare were obtained in the same year, without entailing much attention to the sorghum crop.

According to Diarra (assistant director at ORM, personal communication, August 1988), the total yield for the system could be improved by planting sorghum at the beginning of the first rains, and planting rice shortly after the sorghum germinates. The sorghum variety used should mature early enough to be harvested before the flooding begins.

d. Proposal.

Rice-sorghum intercropping experiment in risk zones over a period of several years to confirm or affirm this system's superiority compared to traditional practice (either rice or sorghum monoculture).

11. Development Of Anti-erosion And Agroforestry Techniques.

a. Introduction.

In Mali, soil and forest resource degradation constitutes a serious problem that affects over 75% of the land area in production (Christophersen and Karch, 1988). Over half of the rural population in the central and north area of the country is faced with this degradation of natural resources. Low crop yields and scarcity of firewood are pertinent problems to environmental degradation that are felt throughout the country, and especially in the Fifth Region. Drought and population pressures destroy forest resources at more rapid rates than natural regeneration, reforestation or protective actions.

Unfortunately, the Malian government is poorly equipped to confront the current evolution of events. In fact, the Service National des Eaux et Forets, which is responsible for this area, lacks the means and the technical structure, especially at the local level where the problem should be approached (AID, 1988).

Wind and water erosion, combined with extensive agricultural practices, constitute the principal causes of soil degradation, particularly in the Seno plain.

Several actions are necessary for the maintenance and improvement of soil fertility as well as forest resource regeneration, and among these is the improvement of crop and agroforestry systems.

Asif Shaikh (1985) notes that in the Fifth Region the highest potential benefit derived from a one dollar investment would come from agroforestry (planting trees and wind-breaks in fields) and from organizing demand (commercial ovens in urban areas). He finds it difficult to plant sufficient trees to reconstitute the entire environment and to satisfy the populations growing wood needs. According to Shaikh, the most promising approaches should emphasize two objectives:

- creating micro-environments around farms that have a two-fold role; protecting the soil and furnishing a defined quantity of forestry by-products,

- following only those development strategies having sound potential for success, and giving priority to those which could have the greatest global impact for the amount of resources invested.

Charreau and Vidal (1965) reported considerable millet yield increases by incorporating Acacia albida into the millet cropping system.

In Mali, anti-erosion activities initiated by the DRSPR in the Sikasso region showed positive results and were extended into the CMDT zone.

Similar anti-erosion activities have been well-accepted by farmers in Bandiagara as protection for market-gardening plots as well as for grain fields.

In the Fifth Region, several development projects are involved in different aspects of agroforestry, anti-erosion activities and environmental conservation; such as the village reforestation projects financed by USAID in Djenne, Bandiagara and Mopti, the village agroforestry project in Koro directed by CARE, anti-erosion activities carried out by the Cooperation Technique allemande (GTZ) and those executed by the International Union for the Conservation of Nature (IUCN).

Given the significant number of projects working on anti-erosion and agroforestry activities, the DRSPR should collaborate with different projects in the Fifth Region on the aspects pertaining to production systems.

b. Objectives.

The primary objectives of this research subject are the following:

- to maintain and even improve soil fertility,

- to improve firewood production,

- to improve forage production,

- to protect flood recession zones against sand encroachment.

c. Purpose.

(1) Overview.

Water erosion is a problem in several areas of the Fifth Region. This phenomenon is especially critical in those zones where the slope

and the soil structure are conducive to it, such as the Bandiagara plateau and the Djenne circle. In these areas, anti-erosion activities are necessary to stem water erosion. In Seno, however, in some parts of Mema and in areas bordering lake zones, wind erosion is the most important impetus to soil degradation, particularly in the dry season. Wind erosion, bringing sand encroachment, also handicaps cereal crops during their initial period of development (germination and emergence) at the beginning of the rainy season. Any action to reduce wind force would be justified in this area.

The decrease in the duration of fallow periods (see the research subject on the improvement of cropping methods) and the generally low use-level of fertilizer constitute the principal factors causing decreased soil fertility. Even though some methods, such as sufficient rotation and appropriate cropping techniques could contribute to fertility maintenance, mineral and organic fertilizer application is essential for improvement. When land is left in fallow it is supposedly at its maximum production capacity (Christophersen and Karch, 1988). However, if the land is cultivated in the traditional manner with no improvements, it will become exhausted. Yields will decrease progressively and it will be necessary to turn to new fallow land. The Operation Mils Mopti estimates that the annual decrease in soil fertility is 6%. This estimate is not based on any empirical research (Christophersen and Karch, 1988).

Wood shortage is a problem throughout the region. Reforestation activities are necessary but insufficient to meet the population's growing need for wood.

(2) Possible yield increase through soil conservation and agroforestry efforts.

Several agroforestry and anti-erosion actions are in progress in the Fifth Region. In fact, the Bandiagara and Mopti village agroforestry projects began in June 1981 by the planting of trees for soil conservation, fuelwood and shadetree production. Another similar project began in the Koro circle in June 1983. In addition to planting trees in fields and constructing wind-breaks, the use of contour ridges and dikes to prevent water erosion has become especially important.

The primary goals of these efforts in the areas of soil conservation and agroforestry are the following:

- To increase crop yields in order to improve farmers' welfare.
- To stabilize the area's agro-ecological system.
- To restore and maintain soil fertility at a level where yields will remain constant or increase with time, and to the point where returning fields to fallow land will be delayed or no longer necessary (Christophersen and Karch, 1988).

Wind erosion can be controlled locally with wind-breaks. A yield increase of 18% was obtained in the Majjia valley in Niger through wind-break alleys.

Soil fertility can be restored through efforts based upon the Acacia albida. The presence of Acacia albida in fields supposedly increases crop yields, as the tree is able to fix nitrogen. The leaves and pods provide excellent forage for cattle during the dry season when grasses are scarce. Farmers can also cut branches to feed cattle during the dry season. When grazing on the leaves, animals also contribute to soil fertility improvement by leaving organic wastes. As crops can also be grown beneath the trees, their presence does not significantly reduce cultivation areas.

Studies carried out by Charreau and Vidal in 1965 in Senegal regarding the effect of Acacia albida on millet yields showed yield increases of over 200% (Table 4.13). The soil analysis under this system also provided interesting results (Table 4.14).

TABLE 4.13 : Effects of Acacia albida on millet yields in Senegal.

Parameters measured on millet	Beside the tree trunk	At the foliage edge	Outside the foliage
Protein yield (Kg/ha)	180	84	52
Average number of heads/plant	5.4	4.2	2.9
Weight in grain per head (in gr)	29.8	23.3	22.6

Source: Charreau and Vidal, 1965 in Wood (1984).

TABLE 4.14 : Analysis of soils in *Acacia albida* environments in Senegal.

Params. measured Relative values (outside the foliage=100)	Beside the tree trunk	At the foliage edge	Outside the foliage
Ratio C:N	84	87	100
Total humus(%)	142	142	100
Assimilable P_2O_5	234	127	100
Transferable cations(Me/Kg):			
Ca	200	158	100
Mg	178	158	100
K	143	114	100
Na	133	144	100

Source: Charreau and Vidal, 1965 in Wood (1984).

In addition to studies on yield increases obtained with *Acacia albida* in the field, studies on its phenology were initiated in Sadore (Niger) in 1987 by an ICRISAT research team from the Sahelian Center. Their research objectives in agroforestry are the following:

- to collect, evaluate and improve tree species adapted to Sahelian agroforestry systems,
- to study the crop-tree interactions in these systems,
- to develop and evaluate new agroforestry techniques for the Sahelian zone.

(3) Reforestation.

Projects operating in the Fifth Region are also involved in reforestation. Their activities are initiated with village participation to plant village groves and shade trees for schools, private walks, public areas and along roads. Some villagers and villages have achieved relatively large plantations. Private owners are beginning to exploit these plantations for commercial and household goods (fuelwood, poles, etc.), and some have made significant profits (Christophersen and Karch, 1988).

(4) Economic analysis of possible interventions.

According to Christophersen and Karch (1988), protection of Acacia albida fields stemming from natural regeneration calls for very little investment and favors yield increases. On the other hand, the profit obtained from voluntarily planting Acacia albida is lower due to the time and monetary investments required. Living hedges are financially attractive, not only because they protect crops from animal destruction, but also because they do not require periodic rebuilding as do other fences. In addition, living hedges can also bring income from their by-products such as fuelwood, construction and forage wood. They can also contribute to nitrogen fixation.

The results of Christophersen and Karch's economic analyses show that most of the suggested interventions should be financially attractive for the villager, under normal rainfall conditions -- even by using a discount rate of 20%. Every intervention suggested for soil conservation that they analyzed (wind-break, living hedge, Acacia albida), with the exception of contour ridges, had a positive current net value.

(5) Institutional constraints.

Significant institutional constraints exist at the development level for reforestation, wind-break, agroforestry and anti-erosion actions. First, the Service des Eaux et Forets, responsible for enforcing the forest code and for collecting taxes and fees, is often viewed by villagers as a repressive agency rather than an extension and development agency. Second, there is an uncertainty at the level of the rural population regarding the appropriation of profits resulting from reforestation or agroforestry activities, which is linked to an unequal and ambiguous application of the forest code.

Added to these institutional constraints, is the lack of means provided to the Service des Eaux et Forets. This lack of means spurs a lack of motivation on the part of the agents in carrying out their extension activities and a tendency to be unaware of the need to protect hard-to-access zones.

d. Proposal.

Zones: The entire Fifth Region.

Production system: Agropastoral and pastoral.

Collaborating agencies:

The Service des Eaux et Forets et de l'Elevage as well as existing projects concerned with agroforestry and soil conservation (village reforestation projects in Bandiagara, Mopti, Koro, Djenne and the GTZ at Bandiagara).

Proposals:

(1) Socio-economic study concerning reforestation of the areas surrounding lakes.

(2) Other agroforestry and soil conservation tests in collaboration with the Eaux et Forets and projects in the research villages.

12. Improvement Of Processing And Storage Techniques For Agricultural Products.

a. Introduction.

Rural populations use traditional methods of food processing and storage of agricultural products. These traditional methods, although often effective, comprise certain constraints and shortcomings which should be resolved. By giving additional value to agricultural products, improved food processing enables entrance into new markets and generates employment for labor in search of work. Reducing the labor required for processing agricultural products, such as millet or groundnuts, also improves the productivity of women and frees them for other activities. Finally, better storage methods assures greater food availability, which allows more control over selling surplus produce at opportune times, and reduces price fluctuations during the year.

(1) Food processing methods.

Some processing techniques for grains and oilseed that have already been tested at the grain technology laboratory or at the village level appear interesting.

The grain technology laboratory is studying methods of storing different flours. This laboratory seeks to develop a simple technique (soaking the grain in an alkaline solution before grinding) permitting longer conservation of large quantities of flour without altering the appealing quality of the product (Fofana and Kante, 1988). In addition, tests of flour blended from grain and cowpeas, for feeding children, were conducted by this laboratory at Bamako, Kolokani, Cinzana and Pel.

In Seno, groundnuts are grown chiefly by women. A large part of the groundnut crop is consumed by the family in the form of butter or as oil extracted using traditional methods. Improvement of traditional processing methods will increase the market value and product hygiene. A test of groundnut processing techniques using a mill was conducted by the DRSPR at Tsevie, near Sikasso. It must be noted, however, that this mill is expensive, with an overall cost of 800,000 F CFA. According to initial test results, this technique is not very profitable (DRSPR, volet Fonsebougou, 1987).

(2) Crop storage.

Food crop yields are substantially diminished by a series of ravagers, of both animal and vegetable origin, which ruin crops both during growth and during the post-harvest period. Indeed, worldwide, pre-harvest losses due to infestation are estimated at 35% (Diallo, 1977). These losses include damage caused by insects, diseases, animals, birds and weeds. Even though losses due to birds and animals are higher in tropical and subtropical regions than in temperate zones, these losses remain nevertheless low when compared to damage caused by insects, diseases and weeds. Worldwide post-harvest losses are estimated between 10% and 20% (Guggenheim, undated).

In the Dogon area, total crop losses, both pre- and post-harvest, were estimated at 14% (Guggenheim, undated). Rat and mouse population explosions can be large enough to destroy the stocks of entire villages. The greatest damage is caused by insects in granaries, particularly that caused by Sototroga cerealla and Sitophilus granarius. Damage from these two insect pests represents 56% to 88% of all damage to grain on heads stored inside granaries. The total of this damage, however, involves only 6% to 9% of stored grain (Guggenheim, undated).

A study conducted at the Office du Niger in 1979-1980 on irrigated rice showed that losses due to insects and fungi amounted to 3.7% of the rice removed from granaries over a period of six to seven months. The losses would have been 5% if no grain had been withdrawn during that period (Kamuanga and Spencer, 1981, in M. Dembele, 1987).

Work to evaluate insect losses inflicted on paddy rice in storage was conducted by WARDA in the Fifth Region (M. Dembele, 1987). According to this work, insect losses are disturbing to some farmers holding stocks of Oryza sativa paddy for at least one year. These losses begin after the fifth or sixth month of storage of paddy rice in the granaries. The losses sometimes attain 12% in older stocks. Average losses for the Fifth Region are low, however, approximately 0.6%. This is why, in a general sense, insect losses to paddy rice in storage can presently be considered insignificant in this region. Storage periods are therefore reduced more than during unfavorable weather conditions which cause poor rice production, and they rarely exceed six months (M. Dembele, 1987).

Still, with the small, irrigated areas arranged so as to take maximum advantage of the water, the villagers will probably achieve a high yield. Each villager stores some paddy at least until the next harvest. The losses to paddy rice beginning after five to six months in storage can be high if no insecticide treatment or improved storage methods are proposed (M. Dembele, 1987).

On the Bandiagara plateau, onion production constitutes the main off-season activity. The difficulty of storing onion bulbs during the wet season limits production from the first off-season crop. In collaboration with the agricultural development sector and the

Bandiagara Centre d'Action Cooperative, GTZ undertook activities focused on improving onion storage, including testing solar driers and improved granaries for storing onion seeds. For the second phase of the GTZ project, this storage problem is among their priority activities.

b. Objectives.

The principal objectives for this research subject are, on the one hand, to improve processing techniques for agricultural produce and, on the other, to improve crop storage. Improvement of processing techniques will :

- diversify market outlets for agricultural produce (millet and leguminous crops) and sources of farm income,
- improve and diversify diets,
- reduce work hours spent on food processing.

Improved crop storage techniques allow longer storage periods and larger quantities to be stored, so as to benefit from the best sale periods.

c. Purpose.

(1) Food processing technologies for agricultural products.

Rural populations employ traditional food processing methods for agricultural products. The principal food processing activities include those for:

- groundnuts to extract oil, to make "soumbala" (a popular condiment in the villages used in all their sauces), and to make groundnut butter,
- shea nuts to extract oil,
- grain to make flour for the millet- and sorghum-based cakes, and for making couscous.

Traditional food processing methods present a number of constraints, the most important of which are high labor intensiveness, and lack of hygienic conditions during preparation which can possibly impair the quality of the final product.

Some of these methods have already been the focus of studies and improvement tests.

(a) Groundnut processing.

i) Traditional methods.

Groundnut oil is extracted either by boiling or pressing. These techniques are used by women in all groundnut-growing areas. The preparation of condiments like "soumbala" is also based on groundnuts (used in San, in the CMDT zone, DMA, 1984). Groundnut butter is prepared manually by women in areas where groundnuts are grown and consumed.

ii) Modern methods of processing groundnuts.

Groundnut processing was performed at Tsevie by women using a mechanical oil press (DRSPR, Fonsebougou section, 1987). The nominal daily capacity of the press is 120 kg of groundnuts, resulting in the production of 40 kg (42 liters) of oil and 80 kg of groundnut meal. The operation is carried out by 10 women. Costs and benefits of this processing are as follows:

Gross daily revenue:

Oil: 42 l @ 250 F CFA/0.66 l	= 15,909 F CFA
Groundnut Meal: 80 kg @ 150 FCFA/kg	= 12,000 F CFA
TOTAL	= 27,909 F CFA

Daily expenses:

Groundnuts: 120 kg @ 200 F CFA/kg	= 24,000 F CFA
Maintenance and depreciation	= 1,000 F CFA
Firewood and water	= negligible
TOTAL	= 25,000 F CFA

Daily profit	= 2,909 F CFA
Daily profit per woman	= 291 F CFA

The daily profit is quite low. It depends significantly on the purchase price of the raw material and the sale price of the final product. The advantages to this processing method would be the production capacity and time saved.

(b) Shea butter extraction.

i) Traditional method.

The traditional method of extracting shea butter has been used for thousands of years by African women. Contrary to a generally accepted idea, this method is relatively efficient if one considers the extraction rate obtained. On the other hand, the work is exhausting and requires a great deal of work for a minuscule final return on the labor (DMA, 1984).

The extraction rate is approximately 30%. With a yield of one kilo of butter produced for 12 hours of work, the return to labor comes to about 20 F CFA per hour, for a final product valued at 250 F CFA/kg (DMA, 1984).

ii) Modern methods.

Modern extraction tests for shea butter were conducted by CEPAZE and GTZ at Daban, in collaboration with the DMA. With the CEPAZE press, some results were recorded. Three women were able to process 150 kg of shea nuts per day (5.5 hours), with an extraction rate of 28%. Compared to the traditional process, this process demanded little labor for a comparable extraction rate.

The price of the press is one million F CFA, to which must be added construction costs for 25 ovens, for a 50 sq. meter building, and for a 2,000 to 3000 sq. meter enclosure. Operating costs and depreciation are approximately 75 F CFA/kg of butter, which leaves an appreciable margin if the sale price of shea butter remains at 250 F CFA/kg.

(c) Grain processing.

In Mali, millet is used to make diverse traditional meals, the most important of which are "To," couscous, and "Degue." Preparation of these dishes requires important, primary processing steps -- hulling and grinding. These are difficult steps if done manually. The difficulty of processing millet and sorghum results in urban consumers replacing these grains with rice and wheat (Fofana and Kante, 1988).

Flour obtained by the traditional method of grinding moist grain has very limited storage time. In view of the technical, economic, and nutritional importance of storing flour, a method was devised by the SRCVO/DRA grain technology laboratory to allow longer storage of large quantities of flour without deterioration of the organoleptic quality of the product. This method consists of soaking (before grinding) the hulled grain in an alkaline solution. After drying and grinding the grain, the flour is stored in plastic or cloth sacks. This flour can be stored without deterioration for more than three months, versus one month for untreated flour. The drawback to this treated flour is that, in the Malian context, its range of uses is somewhat reduced. It can be

used only to make "To." Other uses for treated flour are under study (Fofana and Kante, 1988).

To improve child nutrition, tests of flour composed of millet and cowpeas were conducted by the grain technology laboratory. Indeed, grains in general have a low protein content, in contrast to legumes. This is why, when eaten alone, grains cannot provide a balanced diet, especially for children.

The flour mix is made up of 15% cowpea flour and 85% millet flour. The test, whose results are reported in Table 4.15, was carried out at the "centre de placement familial" in Bamako.

TABLE 4.15: EVALUATION OF THE WEIGHT OF CHILDREN ON A MIXED FLOUR DIET. (85% millet and 15% cowpea).

SUBJECTS	AGES (months)	WEIGHT (in kg)	MONTHLY WEIGHT GAIN (g)	
			Before the test	After the test
1	33	13.500	125	425
2	25	10.600	125	275
3	9	6.200	50	375
4	26	9.300	170	175
5	26	8.00	150	475

Source: Inspired by the document "Etude des transformations technologiques du mil et du sorgho". Fofana and Kanté, 1988.

The flour proved to be very beneficial, especially for subject No. 5. The other subjects also showed a notable weight gain. The test was repeated in a rural setting in Cinzana and in Pel, near Koro. Baking tests for cookies and crackers made from millet and sorghum are also in progress (Fofana and Kante, 1988).

(2) Harvest preservation and storage techniques.

At the village level, protection of food stocks is carried out according to several methods:

- the protection method based on insecticidal or insect-repellant plants, such as Benefin (Hyptis specigera), Neem, Kere, Wangaro, Sukolan (Ocinum basilium), M'Bere (Basica augustifolia), etc. (DMA, 1984),

- the protection method consisting of plastering the granary walls with sand, cinders, or mud, or mixing the grain with the above substances (DMA, 1984),

- fumigation of the granaries by burning inside the granary the harvest residue mixed with powdered, hot spice. The smoke repels

rats and insects. As the granaries are somewhat hermetic, this method appears to be effective (Guggenheim, undated).

Some of these traditional methods are indeed effective, but their protective capacity is limited (DMA, 1984). If improved, these methods could resolve crop protection and storage problems. Some chemical insecticides are available for protecting harvested stocks (see Table 4.16).

TABLE 4.16: Available chemical insecticides.

PRODUCT	MANUFACTURER	RECOMMENDED APPLICATION	PRICE
Phostoxin	ICA	1 tab/100 kg	150 F/tab
Actellic	SOPRA/ RENAULT	50g/100 kg	
Nuvanol (N5P)	CIBA	50g/100 kg	
Damfin	CIBA	50g/100 kg	

Source : Informal survey. IER-USAID-MSU project.

d. Proposal.

Zone: The entire Fifth Region.

Production system: Agropastoral and pastoral.

Collaborating agencies: Units of grain technology and entomology (SRCVC/DRA), chemical producers (SMPC, CIBA-Geigy, etc.).

Proposals:

(1) For grain technologies.

Conduct a market study for millet flour soaked in alkaline solution, for millet couscous, for mixed millet-cowpea flour, and for cookies and crackers made from millet and sorghum (from an opinion survey).

(2) For oilseed technologies.

- A market study (demand) for processed oilseeds (groundnut oil, sesame seed oil, shea butter, groundnut butter, etc.).

- Identification of constraints and potentialities with respect to the introduction and use of an oil press.

- A market study (demand) for tnese foods processed using an oil press or other improved, appropriate technique.

(3) For crop storage and preservation.

- Comparative tests among several chemical products.

- Comparative tests between traditional and modern storage methods.

13. Collection Of Local Millet Germ Plasm.

a. Introduction.

At the present level of varietal selection, improved millet varieties, as they come from research stations, do not attain the production level of local varieties. Even in years with rainfall shortages, millet varieties selected for their short growing season do not produce better than local varieties. Indeed, SAFGRAD tests in the Fifth Region did not show that the short growing season varieties, such as IBV 8001 and HKP, had better yields than local varieties in years with poor rainfall. The improved, short-season varieties are particularly subject to damage from birds and boring caterpillars on the heads (Raghuva). In comparison, local varieties are endowed with certain characteristics which permit them to better resist the difficult conditions in the region. They are hardy and have a relatively long growing cycle which discourages insect attack (Raghuva and blister beetles) and grain-eating birds. Just like the selected varieties, local varieties have higher potential yields when they are grown in yield-enhancing conditions. For example, it was shown that the local variety NKK has a potential yield of two tons.

According to Matlon (1985), a brief analysis of village level tests conducted by ICRISAT in Burkina Faso since 1981 show that, when the select varieties are transferred from the station to villagers' fields, the stress greatly reduced their yield performance. Of 3,000 types of millet screened, only five cultivars were tested in villages, but no variety superior to the local variety could be identified. Matlon explains that the poor performance of the improved millets vis-a-vis local millets is due to the screening and selection methods used on-station.

Certain varieties which have been extended, like NBB and NKK, have been widely adopted by villagers (see Table 4.17), and in fact, are improved local varieties. These local varieties were improved through a comprehensive selection done about 10 years ago. According to Niangado, director of the agricultural research station at Cinzana, such a varietal improvement is again necessary in order to compensate for environmental changes which have occurred since the selection period. With the help of a new collection of local millet germ plasm, the best

performing varieties could be identified for each ecological zone. Once refined, these varieties could ensure adequate grain production without the intensive use of agricultural inputs currently required by the varieties selected on-station.

Moreover, the varieties coming from local areas could serve as the plant-material base for variety-improvement programs. These programs are currently undergoing a new orientation which should emphasize drought resistance at the early and the post-flowering phases, and a relatively long growing cycle to avoid the peak swarming period of the Raghuva caterpillars, in order to achieve a higher yield than the existing, improved, short-season varieties (Niangado and Traore, 1988).

b. Objectives.

The principal objectives of this research subject are the following:

- To identify high performing varieties of local millet which are adapted to specific ecological conditions. These varieties, after a comprehensive selection, could be diffused to villages in the same zone or in other zones where the varieties, although appropriate, are not known.

- To provide researchers with a plant-material base for the selection of new, better performing varieties.

c. Purpose.

The principal millet varieties grown by farmers interviewed during the formal survey are presented, by ecological zone, in Table 4.17. From these varieties, those interviewed recognized certain deficiencies (Table 4.18) and certain positive attributes (Table 4.19).

Analysis of Tables 4.17, 4.18, and 4.19.

1) Deficient characteristics cited:

NBB: 58% of farmers interviewed who grow this variety find that its growing cycle is often too long (110 - 120 days), and 30% state that it has poor resistance to stem caterpillars (Acigona).

NKK: 46% of farmers interviewed who grow this variety state that it has poor drought resistance.
Toroniou from Ningari: 46% of farmers interviewed who grow this variety find that it has poor resistance to stem-boring caterpillars (Raghuva).

Torombedie: 75% of farmers interviewed who grow this variety find that its growing cycle is often too long (90 to 100 days).

TABLE 4.17. VARIETIES OF MILLET GROWN AND THEIR GROWTH CYCLE ACCORDING TO AGROCLIMATIC ZONE (1).(Given in % of farmers interviewed).

VARIETY	CYCLE (days)	NORTH	CENTRAL	SOUTH	PLATEAU
NBB	110-130	10	52	99	-
NKK	100-110	1	42	1	-
Ningari Toroniou	80-100	5	1	-	8
Torombédié	90-100	2	1	-	8
Niou Pirou	100-110 & 120-130	-	4	-	-
Koko millet	90-100	-	-	-	14
Néléy/mil.	90-100	-	-	-	14
Souna	80-90	-	-	-	6
Kowa millet	90-100	-	-	-	10
Pigna millet	80-90	-	-	-	14
Ororo millet	80-90	-	-	-	14
Gondori	90-100	14	-	-	-
Sénori	100-110	6	-	-	-
Haireri or Toroniou	80-90	48	-	-	-
Oyari	80-90	1	-	-	-
Kelsaro/mil.	80-90	12	-	-	-
Bamba millet	90-100	1	-	-	-
Fuko millet	80-90	-	-	-	12
TOTAL	-	100	100	100	100

(1) Percentages indicate the proportion of farmers using the variety cited in each agro-climatic zone.

Source: Survey carried out from December 1987 to March 1988. IER-USAID-MSU project.

TABLE 4.18: DEFICIENCIES CITED IN MILLET VARIETIES COLLECTED IN THE SEHO PLAIN AND THE BANDIAGARA PLATEAU (1). (Given by % of farmers interviewed).

VARIETY	Cycle duration too long	Low drought resistance	Poor resistance to caterpillars--head	Poor resistance to caterpillars-stalk	Low resistance to mildew	Low resistance to striga	Susceptible to cantharides	TOTAL
NBB	58	-	-	30	-	-	-	88
NKK	-	46	19	12	-	12	-	89
Ningari Toroniou	-	27	46	-	-	-	-	73
Torombédié	75	-	-	25	-	-	-	100
Niou Pirou	33	67	-	-	-	-	-	100
Koko millet	80	-	-	-	-	-	-	80
Néréley/mil.	20	-	40	-	20	-	-	80
Souna	-	-	-	50	25	-	25	100
Kowa millet	86	-	-	14	-	-	-	100
Pigna millet	-	-	70	-	-	-	-	70
C.oro millet	-	-	90	-	-	-	-	90
Gondori	33	-	17	25	-	-	-	75
Sénori	80	-	-	-	-	20	-	100
Haireri or Toroniou	-	15	-	51	-	24	-	90
Oyari	-	100	-	-	-	-	-	100
Kelsare/mil.	-	-	-	50	-	30	-	80
Bamba millet	-	-	-	100	-	-	-	100
Fuko millet	-	44	33	22	-	-	-	99

(1) Percentages indicate the proportion of farmers who cited the aforementioned deficiencies per variety.
Source: Survey carried out from December 1987 to March 1988. IER-USAID-MSU project.

TABLE 4.19: DESIRABLE QUALITIES FOUND IN MILLET VARIETIES IN THE SENO PLAIN AND THE BANDIAGARA PLATEAU (1). (Given by % of farmers interviewed).

VARIETY	Cycle rarely too long	Good drought resistance	Good resistance to caterpillars--head	Good resistance to caterpillars-stalk	Good resistance to mildew	Very good resistance to striga	Good resistance to cantharides	TOTAL
NBB	-	24	-	-	-	19	23	66
NKK	88	-	-	-	-	-	-	88
Ningari Toroniou	91	-	-	-	-	-	-	91
Torombédié	11	89	-	-	-	-	-	100
Niou Pirou	67	-	-	-	-	33	-	100
Koko millet	20	50	20	-	-	-	-	90
Néréley/mil.	50	-	-	-	20	-	-	70
Souna	100	-	-	-	-	-	-	100
Kowa millet	14	-	29	-	43	14	-	100
Pigna millet	90	-	-	-	-	-	-	90
Ororo millet	90	-	-	-	-	-	-	90
Gondori	25	67	-	-	-	-	-	92
Sénori	20	40	-	40	-	-	-	100
Haireri or Toroniou	93	-	-	-	-	-	-	93
Oyari	100	-	-	-	-	-	-	100
Kelsare/mil.	100	-	-	-	-	-	-	100
Bamba millet	-	100	-	-	-	-	-	100
Fuko millet	22	11	33	-	11	22	-	99

(1) Percentages indicate the proportion of farmers citing the aforementioned qualities per variety.
Source: Survey carried out from December 1987 to March 1988. IER-USAID-MSU project.

For the other varieties found on the Bandiagara plateau, 33% of the farmers interviewed stated that their growing cycles were often too long (90 to 100 days), and 33% stated that they have poor resistance to ear-boring caterpillars (Raghuva).

For the other varieties in Seno, principally in the northern Seno zone, 23% of the farmers interviewed state that the growing cycle is often too long (80 - 90 days), and 25% say that they resist very poorly to stem-boring caterpillars (Acigona).

2) The positive attributes mentioned are as follows:

NBB: 24% of the farmers interviewed growing this variety find that it has good drought resistance.

NKK: 88% of the farmers interviewed growing this variety state that its growing cycle is rarely too long, according to the rain patterns (100 - 110 days).

Toroniou from Ningari: 89% of the farmers interviewed growing this variety said that it has good drought resistance.

For the other Plateau varieties, 61% of the farmers interviewed state that their growing cycles are rarely too long (80 - 90 days). According to the informal survey, the Toroniou varieties from Ningari and Flanio are particularly desired by growers for their short growing season, high yield potential, and taste (Henry de Frahan and Diarra, 1987).

The aforementioned deficiencies indicate that it would be timely to deliver ecologically appropriate plant material to villagers. The attributes mentioned indicate, however, that currently existing local varieties have desirable characteristics. Such varieties can either be extended to those zones where they are unknown, or serve as base material for selections or eventual hybridizations.

d. Proposals.

Zones: Seno South, Center, North, Plateau, and non-flood areas of the Delta.

Production systems: agropastoral and pastoral.

Collaborating agencies: Cellule Amelioration Varietale/SRCVO/DRA and the Direction Regionale de l'Agriculture (Mopti).

Method:

(1) A collection of millet varieties in the Seno plain, the Bandiagara plateau, and other production zones, recording all characteristics of the local varieties, their local names, and where grown (village and site). This collection will be supported by an opinion survey.

(2) Evaluation of ecotypes on-station and at the village level (3 years).

(3) Selection of the best varieties according to the ecosystem and improved cropping conditions/practices (planting density, tillage, fertilization, plant treatment, etc.).

Such proposals were the object of a special recommendation at a seminar on millet and sorghum organized by IER, ICRISAT, USAID, and the CIBA-GEIGY foundation, from October 4-9, 1988. The recommendation regarding millet-sorghum varietal creation was specified in the following manner (translation from French):

- Considering the poor adoption rate for improved varieties, for their productivity and cooking quality,

- considering the importance of local varieties for their organoleptic characteristics,

- considering the need to improve yields and production stability for food security, the seminar recommends: 1st) that particular importance be given to local varieties in the selection process; 2nd) the sampling, evaluation, and diffusion of the best local ecotypes; 3rd) the evaluation of material under different levels of intensification; and 4th) the diversification of the genetic base of local varieties by introduction."

14. Research On Cropping Systems Practiced During Flood Recession.

a. Introduction.

The lakeside zone of the Niger delta in the Fifth Region covers the majority of the Delta zone between Lake Debo in the Youwarou circle and Lake Niangaye at the border of Gourma. It is characterized by the presence of lakes and ponds around which the population undertakes different economic activities, particularly floodplain cropping, animal husbandry and fishing. Currently, low water levels that flood increasingly smaller land areas are reducing the importance of these lakeside agricultural activities. The principal lakes are: Lakes Debo, Tanda, Kabara, Korientze, Kolardu, Korarou, Kondire, Sao, Belambambi, Aougoundou, and a part of Lake Niangaye.

Moreover, wind-blown, encroaching sand constitutes a menace for most of the lakes situated in the Korientze and N'Gouma districts. Sand encroachment is especially a problem for those lakes no longer receiving water. Counteracting this phenomenon requires large-scale measures (wind-breaks, dune fixation, etc.). The border-zone lakes near Gourma are most affected by the water deficit due to their strict dependence on some lakes and ponds situated further south.

Over the years, grain-eating birds have also become an important enemy to flood-plain culture.

Despite the lakeside zone's potential, especially in the cropping and livestock sectors, no thorough study has been done with respect to integrated development of the different economic activities found there. The lake zone in the Fifth Region has not been served by technical support agencies.

Although most production comes from lakeside flood plains in some districts, the lakeside zone has support of extension agents from the Operation Mils Mopti only for dryland, rain-fed agriculture in non-flooded areas.

With the ODEM, bourgou reclamation work began in 1985 in some lakeside zone villages. At present, 300 ha have been reclaimed since 1981 in the Douentza circle lake zone (Diakite and Keita, 1988). The village of Gouloumbo in the Korientze district also undertook a similar project which is well cultivated and well managed by the population (communication from the Gouloumbo village chief, April 1988).

Conditions in the Delta region, and particularly in the lake zone, favor animal husbandry and crop production. Well planned integration of these two agricultural systems could increase production in both.

b. Objectives.

The two principal objectives of this research subject are:

- to maintain and improve flood-plain agricultural systems,
- to diversify and intensify these systems.

c. Purpose.

The potential of the lake zone remains important. The zone is indeed vast. It covers a part of the Youwarou circle, part of the Sindegue and Korientze districts in the Mopti circle, and part of the Bore and N'Gouma districts in the Douentza circle. In addition to the several lakes previously mentioned there are also numerous ponds,

especially in the Korientze and N'Gouma districts. Land around many of these ponds is cultivated by villagers in the same fashion as around the lakes.

There has been no on-station research on flood-plain agriculture in Mali. According to the Circle Director of OMM at Douentza, millet and sorghum varieties grown in the lake zone are late-maturing varieties requiring eight or nine months of growth before harvest. Residual soil moisture after the water recedes provides the fundamental support for flood-plain crops during their early growth phase. Depending on the year, millet and sorghum planting can begin during January or February. The rains which ensure the remaining development of the crop are expected to arrive beginning in July. The varieties presently cultivated manage, consequently, to survive and even develop for five to six months with only residual soil moisture from the lake water. The proposed research could proceed with tests of early varieties (90 days, for example) that could perhaps come to maturity using this residual soil moisture.

Some advantages and disadvantages to using early varieties in the lakeside zones are already foreseeable. Growing early varieties first will eliminate the need for a third weeding of the long-season variety. In addition, by increasing the planting density with respect to the long-growing varieties, production can be increased. With this strategy the villagers could overcome a grain deficit during years when the harvest of rainfed crops is poor. On the other hand, with use of short-season varieties, birds can cause considerable losses due to the fact that there will not be a large enough surface area planted to spread out their damage. Also, since lake waters recede progressively it will be difficult to plant a large area at one time to ensure that the crop matures homogeneously. Elsewhere, when possible, one can even envision a two-crop system for the lake zone: a first crop using only residual moisture from the high waters, and a second crop using only rain during the rainy season.

In the Korientze district, where rice production is still practiced around some lakes, Kakari black and white are the only upright varieties of rice in the zone. Some tests of new upright varieties of rice might improve rice production in these areas.

Several other secondary crops such as cassava, sweet potato, groundnuts, and cowpeas are raised in the zone. These secondary crops are often intercropped with the grains. Market-gardening production also appeared during the drought years (statements by villagers at Kodie pond, Korientze district).

In analyzing constraints to current production, a multi-disciplinary team could assist villagers in the zone to improve their production systems and to identify other issues where on-station research could be helpful.

d. Proposals.

Zone: North, Central, and South Delta.

Production System: Agropastoral.

Collaborating Agencies: SRCVO/DRA and the Direction Regionale de l'Agriculture (Mopti).

Proposals:

(1) A thorough study to better understand the flood-plain agricultural practices and to identify production constraints.

(2) Variety trials with millet and sorghum, in collaboration with the DRA.

(3) Tests with other secondary crops, such as maize and potatoes (the advantage of tubers and maize is to avoid damage by birds).

(4) Tests of cropping techniques for working the soil (this appears necessary in view of the clay soils in the flood-plain zones).

15. Data Collection On Glaberrima Rice.

a. Introduction.

Goita (1986, p. 1) described deep-water rice production in the following manner (translation from French): "Floating and deep-water rice production is practiced to some extent in the same fashion all over the world. Before the wet season begins the soil is tilled and seed is broadcast." Germination is triggered by the first rains and vegetative development of the plant follows with the successive rains. Before rising lake waters arrive the plant must be sufficiently developed so as not to drown. "As the water level rises, the rice plants grow rapidly to maintain their leaves above water level. In these conditions, it is necessary to have varieties with rapid stem growth thereby allowing them to follow the water surface, and varieties which are capable of emitting adventitious roots so they can directly use nutrients in the water."

In the Fifth Region, there is a larger area of unmanaged flood-plains with natural submersion than managed plains with controlled submersion (M. Demoele, 1981). Due to successive droughts and a decreasing high-water level in the past few years, land areas experiencing natural submersion have increased rapidly, from 30,000 ha in 1985 to 45,000 ha in 1987 -- an increase of 50%. Areas under controlled submersion tended to decrease over the same period, from 24,515 ha to 18,888 ha -- a decrease of 23% (Diakite and Keita, 1988).

Most rice grown on the unmanaged plains are Oryza glaberrima varieties, while all rice grown under controlled submersion conditions on the ORM polders are Oryza sativa varieties. In view of the importance of the Oryza glaberrima varieties, agricultural research in Mali has been interested in their study. According to Goita (1986, p. 4), "Between 1962 and 1968, efforts were made to improve local varieties of Oryza glaberrima. Trials indicated that Oryza glaberrima varieties yielded less than Oryza sativa varieties (IRAT, 1969; IRAT, 1974). Among the reasons for this low yield one finds: fallen grain losses, early ripening necessitating harvest while still in water, and a poor response to nitrogen-charged manure. Nevertheless, Oryza glaberrima varieties offer certain advantages over Oryza sativa varieties, especially better drought resistance and a longer dormant stage thus reducing the risk of germination in water (IRAT, 1966; IRAT, 1969)."

When a study in agricultural economics was conducted by the Evaluation and Technology Transfer Division of Mopti's rice research station from 1980 to 1982 (M. Dembele, 1981), the following characteristics of the two rice species Oryza glaberrima and Oryza sativa were given by growers (see Table 4.20 below).

The below table shows that certain Oryza glaberrima varieties possess desirable, exploitable characteristics requiring study, purification, and repropagation. Over the long rum, these varieties will serve as base material for seed selection or hybridization. Diarra, Director of the rice research station at Mopti, indicated some trial cross fertilization is underway between Oryza sativa and Oryza glaberrima, with back-crosses to Oryza glaberrima, as well as improved resistance to grain loss through mutation for Oryza glaberrima varieties (personal communication, August 1988).

b. Objectives.

The principal objectives of this research subject are:

- To catalogue the Oryza glaberrima varieties from different ecosystems. After a broad selection and purification, the best performing varieties can be extended at the village level in the same or in other zones.

- To provide base plant material for research to select the best performing varieties and for hybridization.

c. Purpose.

According to M. Dembele (1987), villagers who grow Oryza glaberrima are not ready to abandon it to grow Oryza sativa varieties in its place, due to performance characteristics of the former (see comparative table).

TABLE 4.20. Comparison between *Oryza glaberrima* and *Oryza sativa*.

Characteristic	*Oryza glaberrima*	*Oryza sativa*
Origin	Adapted to ecological conditions in the Delta, this species offers a high level of hardiness (resistance to drought, storm, insects, diseases, and weeds).	Variety introduced into the Delta, therefore poorly adapted to its ecological conditions (hence sensitivity of most varieties to climatic uncertainties).
Cycle	Some varieties mature very early, which ensures some production even if the water recede quickly or if there is insufficient flooding.	This variety matures later than *O. glaberrima*.
Floatability	Adapts well to all water levels (1.5 to 4 m), very resilient.	Each variety generally corresponds to water level (shallow, medium or high).
Dormancy	Significant dormancy (2 to 4 months in the ground).	Little dormancy exhibited, loses its germinative ability under low soil-moisture conditions (may need to be resown).
Grain drop	Significant grain drop. Given this characteristic in conjunction with dormancy, farmers do not need to plant each year.	Not significant. Planting is required each year.

TABLE 4.20. Comparison between *Oryza glaberrima* and *Oryza sativa* (following).

Characteristic	*Oryza glaberrima*	*Oryza sativa*
Mutation	Not replacing the seed stock results in regression of the variety to a wild, invasive species.	
Production potential	Weak due to grain loss and poor response to manure.	Usually high under normal conditions (good response to manure).
Market value	Little market value (difficult to polish).	Highly valued for marketing (easy to polish). In addition, not as hard as *O. glaberrima*.
Emergence	Stronger at emergence, better competition with self-propagating varieties.	Weaker at emergence
Storage	Stores for several years without insect attack.	Does not store as well as *O. glaberrima*.
Photoperiod sensitivity	Tolerant; flexible planting date.	Not tolerant; demands stricter planting date.

Source: Inspired by M. Dembélé, 1981.

d. Proposal.

Zones: rice production zones of the Delta (unmanaged).

Production system: agropastoral and agro/fishing.

Collaborating agencies: Rice research station at Mopti (SRCVO/DRA), and the ORM.

Method:

(1) Catalogue *Oryza glaberrima* varieties in rice producing areas on the Delta's unmanaged flood plains, recording all characteristics, local names, and where grown (village site). This census is supported by an opinion survey.

(2) Evaluate local ecotypes on-station and in the village (probable duration: 3 years).

(3) Select the best varieties with respect to the ecosystem and improved growing conditions (tillage, fertilization, etc.).

B. PROGRAMMING THE RESEARCH ACTIVITIES.

On the basis of the information gathered and analyses presented in the preceding section, the following 15 research subjects were established by the team:

I. Study of input factor markets and agricultural credit.

II. Study of agricultural product and livestock markets and transactions.

III. Intensification of millet-cowpea intercropping.

IV. Intensification of the millet-cowpea cropping pattern.

V. Development of secondary and minor crops.

VI. Improvement of cropping methods.

VII. Integration of agriculture and animal husbandry.

VIII. Study of cropping systems in the Delta.

IX. Study of cropping systems in village irrigation areas.

X. Evaluation of rice-sorghum intercropping in areas at risk for rice cultivation in the Delta.

XI. Development of anti-erosion and agroforestry techniques.

XII. Improvement of storage and processing techniques for agricultural products.

XIII. Collection of local millet germ plasm.

XIV. Research on cropping systems practiced during flood recession.

XV. Data collection on Glaberrima rice.

This list of topics will be subject to modifications and clarifications following the several investigations, studies and analyses which the DRSPR research team must perform to corroborate or invalidate some of these topics.

Among the 15 proposed subjects, one notes the absence of fisheries activities. This is explained by the fact that the Operation Peche Mopti is collaborating with the hydrobiology laboratory in conducting a study attempting to identify the impact of fishing practices on the fisheries ecosystems in the Diafarabe, Aka, Mopti, and other, zones. Elsewhere, the hydrobiology laboratory is also collaborating with ORSTOM in a multidisciplinary study on fishing activities. This laboratory envisions the establishment of a permanent research team to follow the development of fishing. This is why all involvement of the DRSPR in the fisheries sub-sector must be identified and carried out in close collaboration with the laboratory and other institutions in Mopti responsible for developing the fisheries sector. Similarly, involvement of the DRSPR in market gardening on the Bandiagara plateau must be in coordination with all the organizations interested in the development of market gardening in the aforementioned region.

For the implementation or development of most of these research or study subjects, more importance was given to the Seno plain which is the best rainfed agriculture zone. In fact, in the Seno zone and in a part of the Bandiagara plateau, a formal study was organized with the goal of verifying the data collected informally in this zone. This was not the case in the Delta zone for rice production, dryland cropping and animal husbandry, nor for market gardening on the Bandiagara plateau. It will therefore be necessary for the DRSPR team to undertake more in-depth studies to verify the subjects already selected and eventually to identify new research subjects.

The annual plan for study and research activities is presented below in Table 4.21. In the table, the first year is reserved for construction of quarters to serve as offices and housing for the DRSPR team. During the first year it is also possible to begin the two market studies (subjects I and II) simultaneously with the construction work on living quarters. The research program begins in the second year after the team has settled in, collaboration has been established with development organizations in the Mopti region, and after the preliminary

surveys have been initiated. The 15 research or study subjects can be classified into two large groups, depending on whether or not they rely on the market studies (subjects I and II). In fact, the market study results should permit better orientation and clarification of research subjects III, IV, V and XII. As for the other subjects, their implementation is not dependent on the market study results. These subjects can be implemented as soon as they are verified by a rapid assessment survey.

TABLE 4.21. RESEARCH PROGRAM ON RURAL PRODUCTION SYSTEMS IN MALI'S FIFTH REGION.

Year 1	SUBJECTS	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
BUILDING CONSTRUCTION	I	S	S	R							
	II	S	S	R							
	III		T	T	T	P	P	E			
	IV		T	T	T	P	P	E			
	V			T	T	T	P	P	E		
	VI			T	T	T	P	P	P	E	
	VII		T	T	T	P	P	E			
	VIII				S	S	S	R			
	IX			S	T	T	T	P	E		
	X			T	T	T	P	P	E		
	XI			T	T	T	P	P	P	E	
	XII					S	T	T	P/R		
	XIII	S	O/T	O/T	O/T	P	P	E			
	XIV				S	T	T	T	P	P	E
	XV	S	O/T	O/T	T	T	T	P	E		

Legend: (1) The roman numbers refer to the list of research subjects.
S : Studies
P : Pre-extension
R : Recommendation
O : On-station research
T : On-farm tests
E : Extension

NB : -Subjects I and II may begin in Year 1 of the program.
-Feed-back on research and development will be made throughout the program.

Source : IER-USAID-MSU project.

C. RESEARCH STRATEGY AND RESOURCES.

The objective of research projects on rural production systems is to achieve an impact on the agricultural and social framework, and not only to demonstrate an impact on production. It involves working with farmers to learn about the processes of technology generation, adaptation, and adoption (Caldwell, 1983). To achieve this objective it is necessary to establish research priorities that are going to generate technologies that members of rural households can and want to adopt (Norman, 1983). The "ability to adopt" is a necessary condition which requires an analysis of the biological, social, cultural, economic, and institutional factors of the environment in which the production system operates. The "willingness to adopt" is a sufficient condition which requires an analysis of the objectives and constraints at the farm level, for each area of recommendation (Caldwell, 1983).

The market studies constitute an important element of the production systems research in the Fifth Region. In fact, several of the identified research subjects depend on the market study results for input stocks and outflow of crop and livestock products. Under adequate rainfall conditions the primary problems in agriculture and livestock production are marketing problems. Results of the study conducted by Cisse (1987) in the CMDT zone indicated that a program focusing on improved marketing was necessary to allow villagers to benefit more from new technologies introduced into their production system. This study's results also indicated that credit services, for production inputs as well as consumption, should constitute an important element of the development program. Caldwell (1983) showed that if environmental constraints are modified by improving infrastructure and by more efficient institutional support, the adoption of technology packages will be easier and will have a positive impact on farm-family welfare. If such modifications are not possible, then the proposed technologies must take that into account.

For the extension of the DRSPR in the Fifth Region, several particular issues are worth taking into consideration:

1. Project funds proposed in the project document for extension of the research at Mopti extend over seven years (AID, 1985). But, according to the work schedule established by the feasibility study team, after seven years some research topics will be at the pre-extension stage, while others will be still at the testing stage. The DRSPR's experience in this area in the Mali-South zone showed that, in addition to the time required for a preliminary survey, seven years of research are sometimes necessary to develop a technical package and submit it to pre-extension testing.

2. For the extension of the DRSPR in the Fifth Region a multidisciplinary research team is foreseen, consisting of four Malians (1 agricultural economist, 1 sociologist, 1 agronomist, and 1 animal scientist) and two expatriates during four years (1 agronomist and 1

agricultural economist). Nevertheless, in view of the number of research subjects proposed by the feasibility study team in the Fifth Region, and the diversity and complexity of the zone, it will be necessary to reinforce this multidisciplinary team. The need to reinforce the team will be felt in the fourth project year when the market studies will have specified the paths to diversification and intensification of agricultural and livestock production in the Fifth Region. It is actually at this time that the research subjects which depend on the study results are going to begin. To meet personnel needs at this juncture, a sociologist, an animal scientist, and an agronomist who will focus primarily on rice will be required. After the two expatriates leave, they must eventually be replaced by Malians to assist the Malian agronomist and agricultural economist with their tasks.

3. Good collaboration with the ODR, other NGOs and research institutions is indispensable for expediting the work of the DRSPR team in the Fifth Region.

a. Collaboration with the ODR and other NGOs will be established at the same time as the research team's installation in the Fifth Region. This collaboration will facilitate:

1. obtaining certain data already available to them,

2. introducing team members in their project zones,

3. elaboration of the research program,

4. the processes of technology diffusion.

b. Collaboration with the on-station research institutions is necessary to carry out certain research subjects for which there are few results available at this time. Some subjects proposed by the feasibility study team comprise aspects which must first be studied through on-station research. For these subjects, the DRSPR will collect the information necessary to specify the material needs for the on-station research. The on-station research program will be carried out by specialized research institutions upon demand and with the support of the DRSPR in the region.

4. The team's motivation for the success of the DRSPR's activities in the Fifth Region must be a priority due to the extent, diversity, and complexity of the region. Collinson (1988) showed that most governments in East and South Africa have not considered agricultural research as a priority in public investment. This attitude had, as a consequence, a negative effect on researchers -- that is, derisive salaries, and in addition, a lack of or insufficient funds with which to carry out research programs. Projects were often compromised and even abandoned because allocated funds were insufficient and disbursement methods too rigid. The lack of motivation caused, in some countries, poor management, corruption, and professional flight out of the country.

5. The logistical structures proposed in the "Project Document" confine the offices and housing to Sevare, and guest housing to the Point d'Appui de Recherche (PAR of Koporo). Nevertheless, in view of the distance and road conditions, it is necessary to plan for some guest rooms at Djenne to facilitate the team's work in the South-Delta zone. Note that Djenne is already 120 km from Sevare. Moreover, with Djenne being a tourist center, it will become expensive for the team to use administrative lodging. It is also necessary to note that during the rainy season, access to the flood zones in the Delta is practically impossible by road. Actually, to go into Mema (Western Delta), one must cross the active Delta. It is therefore necessary to plan to have a barge with a motor and some transit quarters at Tenenkou or at Dioura if the team must conduct studies in this zone.

6. Sanitation problems are worth emphasizing, considering the poor road conditions and the presence of noxious insects. Two members of the feasibility study team did, in fact, suffer serious attacks from blister beetles. To palliate these incidents which can impede the researchers in their work, the transit quarters should be stocked with small medicine kits, in the absence of adequate health facilities in the area.

7. To allow communications between the field team and headquarters at Sevare, two-way radio equipment is also necessary. This ability to communicate can reduce considerably transportation costs and can maintain the research team's moral during long stretches in the field.

In conclusion, this chapter has proposed 15 subjects of research for the DRSPR in Mali's Fifth Region. The diversity of these research subjects reflects the complexity and the numerous interrelationships inherent to constraints that farming systems face in the Fifth Region. The research subjects are organized into a 9-year research program and a strategy to implement this program is suggested. The next chapter evaluates the financial and economic feasibility of some research subjects, considering only those which can be included in a standard benefit-cost evaluation and which are expected to show positive benefits in the near future. The technical coefficients and the price figures for the proceeding evaluation are drawn from this chapter.

V. EVALUATION OF THE RESEARCH PROGRAM.

The preceding chapter has indicated some research themes which could be developed by the DRSPR in the Fifth Region. The benefits that these research themes could give rise to, once developed and promoted within the rural community, have been presented in a qualitative way. This chapter, consisting of the formal economic evaluation of expanding the DRSPR into the Fifth Region, shows quantitatively the expected benefits and costs of this expansion.

The benefits and costs of expanding the DRSPR into the Fifth Region are estimated using the method presented by J. Price Gittinger in Economic Analysis of Agricultural Projects (2nd ed., Baltimore: Johns Hopkins University Press for the World Bank, 1984). This method of evaluating projects is widely used by the World Bank and numerous other multilateral and bilateral organizations. The method is based on the estimation of three components. The first component consists of the incremental benefits to be gained for the target groups as a result of the project. In the present context, the increased incomes accruing to farm households as a result of the transfer and adoption of new technical packages, developed and tested by the research system, represent the main incremental benefits. Benefits that accrue to groups other than farmers as a result of the project will be indicated but not estimated. The second component is the incremental costs of production (or processing or marketing) incurred by project target groups as a result of adopting technical packages developed and tested by the research system. The third component represents the costs of the project and complementary investments necessary for the project to affect target groups. The relevant period over which these benefits are estimated is that for which the project will continue to have an impact on the target groups. For each year during this period the incremental net benefits (net cash flow) are calculated by subtracting from the incremental benefits accruing to target groups the incremental costs of production, the costs of the project, and the complementary investments necessary for the project to have an impact (credit system, extension, seed production, etc.)

The incremental net benefits are then discounted using a discount rate generally between 8% and 15%. This discount rate is chosen according to the cost of capital in the country benefiting from the project (termed the opportunity cost of capital) or according to the degree of preference of society for present rather than future returns (termed the social rate of time preference). Discounting allows costs and benefits that accrue at different points in the future to be compared in terms of their value in today's currency. The value of a project can also be expressed as the ratio of the present value of the benefit stream to the present value of the cost stream (benefit-cost ratio) or the ratio of the present value of the net benefits[1] to the present value of the

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[1]/ i.e. the incremental net benefits each year after the net cash flow becomes positive.

investment outlay[2] (net benefit-investment ratio). Finally, the value of a project is also commonly expressed using the Internal Rate of Return (IRR), which is that discount rate that, when applied to the net cash flow over the project life, will yield a net present value of zero. The IRR represents, therefore, the annual yield on resources invested in the project. A project with a higher internal rate of return than the threshold rate of return is therefore attractive. The threshold rate of return generally corresponds to the opportunity cost of capital (Gittinger, 1984).

The three measures of project value mentioned above can be estimated in financial or economic terms. The financial approach uses those prices and interest rates operating in markets where the project is to be implemented. These are the prices which the project's target groups actually receive or pay. The economic approach uses those prices from which all subsidies or taxes have been deducted. The economic approach considers all subsidies and taxes to be transfer payments between groups of producers or consumers in the same country. Furthermore, if any inputs or products are imported, then not only must taxes and subsidies be removed in the valuation of these inputs or products but an adjustment must also be made for the rate of exchange. In the case of Mali, the exchange rate is determined by the Monetary Union of West African States (UMOA). Due to the balance of payments deficit and the structure of taxes and subsidies, the CFA franc is overvalued in Mali vis-à-vis the US dollar. Taking into account solely the balance of payments deficit, the overvaluation or exchange rate subsidy was on the order of 33% for the period 1981-1985 (Stryker et al., 1987). An overvalued exchange rate favors imports at the expense of exports. Economic analysis corrects this bias in order that the evaluation of the project be based on the opportunity cost[3] to the country as a whole of the resources invested in the activities of the project and on the value in use[4] to the country of the outputs of the activities, not the distorted prices faced by individual actors in the economy.

The financial approach is nevertheless useful for determining the profitability to target groups of proposed changes, and consequently for estimating how widely recommendations made by the project for these groups will be adopted.

2/ i.e. the incremental net benefits during the early years before the net cash flow becomes positive.

3/ The opportunity cost of a scarce resource is the benefit foregone as a result of not employing that resource in its next best alternative use (Gittinger, 1984).

4/ The value in use is that sum of money that a purchaser is prepared to pay in order to obtain the final good or service (Gittinger, 1984).

This chapter is organized in four sections. The first section presents the assumptions on which the financial and economic evaluations of the project is based. These assumptions relate to the project, the technical packages, and to the prices and adoption of technical packages. The second section contains the financial analysis. Financial budgets for each technical package included in the project evaluation are presented, together with sensitivity analyses. The third section contains the project economic analysis itself. This shows the contribution of each technical package to the economic value of the project. The economic value of the project is then presented using the three commonly used criteria of evaluation: the net present value, the internal rate of return and the net benefit-investment cost ratio. The economic value of the project is tested using sensitivity analysis in which the major assumptions are allowed to vary. The fourth section draws conclusions from these analyses.

A. ASSUMPTIONS UNDERLYING THE EVALUATION.

1. Assumptions Relating to the Project.

Project costs used for the economic evaluation of expanding the DRSPR in the Fifth Region are those given in the project document (AID, 1985) which have already been presented in tables 1,2, and 3 in chapter II. The project document envisages seven years of finance for the expansion of the DRSPR. Given that nine rather than seven years are required for the development and pilot extension of the research themes proposed, the cost of two additional years have been added to the seven initially anticipated. These two additional years include only recurrent costs, those budgeted in the seventh year of the project.

Only buildings are considered to have a salvage value, estimated in year nine 50% of their initial cost.

The number of scientists, whether expatriate or Malian, is kept at the level proposed in the project document, although in view of the large number of viable research themes it would be desirable to strengthen the research team. The sensitivity analysis will show the impact of increasing the cost of the project on the economic value of the project.

The time required to develop a technical package, test it and mount a pilot extension program is that proposed in the section of the preceding chapter dealing with the research program. The program has been developed on the basis of experience gained by the two longest standing sections of the DRSPR (the Fonsebougou Section and the Bougouni-Sikasso Section), and on the basis of the manpower resources available for the expansion.

The transfer of technical packages depends as much on the support services to the rural community and the private sector as it does on the research system. The costs of providing and distributing inputs and agricultural credit are included in the input prices and interest rates

used. Nevertheless, an important assumption underlying this evaluation is that the support services and private sector function and manage to provide and distribute inputs in the quantities required and at the estimated prices, along with the necessary credit. For this reason the research theme involving a study of the input and credit markets is important, in order to identify constraints and take account of them in the development of new technologies.

2. Assumptions Relating to the Technical Packages.

Four technical packages have been included in the financial and economic analysis of the expansion of the DRSPR in the Fifth Region. They are the following:

- millet-cowpea intercropping;
- sole millet and cowpea cropping pattern;
- groundnut-millet-groundnut rotation;
- sesame cultivation.

Each of these four technical packages integrates several of the research themes proposed in the preceding chapter. For example, the millet-cowpea intercropping package involves not only the research theme on intensifying millet-cowpea mixtures but also the complementary themes on input markets and agricultural credit, marketing and transactions in of crops and livestock, improved husbandry practices, and the integration of crop and livestock production. Similarly, the technical package for the sole millet and cowpea cropping pattern integrates research on the intensification of millet and cowpea cultivation in pure stands as well as the complementary issues mentioned above. This is equally true for the last two packages included in the analysis. Based on the research theme of developing secondary crops, these two packages also require market studies, improvement of husbandry practices, and the integration of crop and livestock production.

These four technical packages were included in the analysis of expanding the DRSPR in the Fifth Region for several reasons. First, the components that make up the four technical packages are based on a relatively sound foundation. There already exists a body of scientific knowledge from station research and multilocation trials that indicates that the development of such packages will yield positive results (see research themes 3,4, and 5 in the preceding chapter). This research also provides the necessary technical coefficients with which to construct budgets for each of the technical packages. Second, because a solid research base already exists, these technical packages can be developed and promoted relatively quickly. Obtaining concrete results quickly, in terms of technical transfer, has a major impact on the present value of the project because the method of discounting incremental net benefits weights early gains more heavily than those obtained later. Third, it is

anticipated that these four technical packages will be adoptable by the relatively larger target groups in terms of number of farm households and area cultivated.

A number of the proposed research themes for the expansion of the DRSPR have not been included in the economic analysis. While these themes are important and justified, several reasons prevent their inclusion in this analysis. First, it is difficult to predict with any degree of certainty the results that could be expected from the pursuit of several of these themes. This applies primarily to themes such as the study of cropping systems in the Delta, the development of soil conservation techniques and agro-forestry, and the improvement of crop processing methods. Practically speaking, there is no data base for estimating ex ante the benefits that could be obtained from the development and transfer of theses research themes. Taking the development of soil conservation and agro-forestry techniques for example, the recent evaluation of the village reforestation project in the Fifth Region (AID, 1988; Christopherson and Karch, 1988) drew attention to the lack of data and recommended that the project identify and test appropriate and profitable techniques. Given that such techniques are highly specific to the agro-climatic and socio-economic environment it would be wrong to extrapolate results obtained elsewhere (e.g. the Majjia valley in Niger) to the Fifth Region of Mali.

The second reason is that the results expected from the development and transfer of some of these research themes will take relatively longer to materialize than those included in this evaluation. This is particularly true of research themes relating to flood recession agriculture and to the establishment of a local germplasm collection for millet and Oryza glaberrima. Effectively, such themes first require a disciplinary approach before being studied in a systems framework.

The third reason is that the results expected from the development and transfer of some research themes will be applicable only to relatively small target groups in terms of population and cultivated area, or where quantification is difficult. Research themes in this category are the study of cropping patterns on irrigated village perimeters, the results of which would apply to a maximum of 840 ha supervised by ORM and 540 ha under the management of local development committees, and the evaluation of rice-sorghum intercropping in at-risk rice producing areas of the Delta where it is difficult to estimate a priori the area to which the results might be applicable.

For these three reasons this evaluation of the expansion of the DRSPR is partial, being based essentially on four technical packages. These packages all relate to rainfed agriculture. The evaluation team does not mean to suggest that research in the Fifth Region should focus uniquely on rainfed agriculture. Rather, to the extent that one can expect any return to these four technical packages for which quantitative estimates are made, then the overall estimates of the project value that will be provided below are underestimated. Chapter IV, however, discusses the importance and the opportunity that the research themes not

included in the economic analysis represent. Despite the fact that these themes do not easily lend themselves to economic evaluation for the reasons given above, the benefits of these themes should not be assumed to be zero.

The technical packages included in the analysis are evaluated in terms of the increase in value of output or the reduction in costs of production to the farm. The indirect (or secondary) benefits are not separated out in this analysis. According to the terminology in Gittinger (1984, p.478), indirect benefits are "changes in income that accrue to sellers of project inputs (...) or to buyers of project outputs used as intermediate goods (...)." These indirect benefits are implicitly included in the economic evaluation when valuing inputs and outputs at their shadow prices, representing either the opportunity cost in the case of intermediate goods and services, or the value in use in the case of final goods and services.

This economic evaluation does not take into account intangible effects of the project. In terms of the target groups of an expansion of the DRSPR, these effects could include a reduction in outmigration from rural areas, the distribution of income among and within farm households, regional development, national integration, and conservation of the environment from soil erosion and declining soil fertility. In regard to the DRSPR itself, such effects would be primarily the training of scientists and the strengthening of the institutionalization of a systems approach to research in Mali. While important, these effects are difficult to quantify in monetary terms. However, they should be borne in mind by evaluators and decision makers.

The reduction in food aid following an increase in cereal production and incomes in the Fifth Region is not taken into account. In recent years, food aid has been provided mostly to the population living on the Bandiagara plateau and might be reduced if coarse grain, cowpeas and Bambara nut production increases. Afterwards, food aid reduction would stimulate local cereal production[5], enhance national independence, and reduce donor expenditures on this form of aid. Food aid and outmigration reductions are likely to be the most important external benefits of the project.

The four technical packages included in the economic analysis are given in detail in annex F. They are presented for each agro-climatic zone and compared to both traditional local practices (i.e., farms without animal traction) and improved local practices, called also transitional practices (i.e., farms with animal traction). The technical coefficients used are mainly those given in the presentation of the research themes. The technical coefficients for the "millet-cowpea intercropping" package (table F.1 in annex F) are those given in the

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5/ Local coarse grain producers, particularly those from the South Seno, tend to perceive food aid negatively because it depresses prices on the weekly assembly markets.

proposals for a research theme on the intensification of millet-cowpea intercropping; coefficients for the "sole millet and cowpea cropping pattern" (table F.2 in annex F) are those given in the proposals for a research theme on the intensification of pure stands of millet and cowpeas; and those for the "groundnut-millet-groundnut rotation" package (tables F.3 and F.4 in annex F) and for "sesame cultivation" (table F.5 in annex F) are those given in the proposals for a research theme on the development of secondary crops.

3. Assumptions About Prices.

An important distinction must be made between economic and financial prices. Financial or market prices are those that farm households pay or receive. These are used in constructing financial budgets for, and carrying out a financial analysis of, technical packages. Financial analysis provides an estimate of the profitability of a package to the farmer, and consequently the likelihood of the package being accepted or rejected. The economic price, on the other hand, also known as the economic value (Gittinger, 1984, p.469), is the amount by which production of a project output or use of a project input changes national income, i.e., its contribution to the national economy. This sum can be the market price (if this price is unaffected by taxes or subsidies) or an estimate of the opportunity cost or value in use according to whether the product is respectively an intermediate or a final good or service.

For both the economic and financial analyses, market prices are used at their 1988 levels. Doing all analysis in real prices, in 1988 terms, does not assume an absence of inflation in the future, but it does assume that there will be no change in relative prices.

The distinction between economic and financial prices applies equally to the calculation of amortization charges on capital items. To simplify the calculation, constant annuities are used, a capital recovery factor being applied to the value of the initial investment[6]. The real financial interest rate charged by the BNDA (i.e., the nominal BNDA interest rate less the rate of inflation) is used for the financial analysis, whereas a rate reflecting the value of money over time (estimated at 12%) is used for the economic analysis.

6/ The capital recovery factor corresponds to the annual repayment on a loan of one currency unit for x years with compound interest charged on the unpaid balance (Gittinger, 1984).

a. Financial Prices (see table E.3 in annex E).

The financial prices of inputs are generally those charged by the OPSS, the SMPC, the CMDT, the OHV, and the SMECMA, increased by 10% to allow for transport and distribution costs in the Fifth Region. The price of local seed is taken to be the price observed in weekly markets during the hungry period (June to September).

The cost of daily labor used to evaluate financial value of the technical packages is determined according to the opportunity cost of the labor. The cost of daily labor used to estimate the financial value of the first two technical packages (millet-cowpea intercropping and the sole millet and cowpea cropping pattern) is determined according to the daily return to labor for work on millet-cowpea intercropping, the most widespread rainy season crop in the project area. The cost of daily labor used to estimate the financial value of the proposed groundnut-millet-groundnut rotation is the one determined according to the daily return to labor for work on a local millet-millet-millet rotation that is expected to be replaced by the proposed rotation. The cost of daily labor used to estimate the financial value of the proposed sesame cultivation is the one determined according to the daily return to labor for work on the millet crop of a second year of a local millet-millet-millet rotation. The second year millet crop is expected to be replaced by the proposed sesame cultivation. These costs are also estimated according to the agro-climatic zone and method of cultivation (with or without plow).

Prices of agricultural products were determined according to the agro-climatic zone and analytical situation. For example, it is considered that the prices of millet, cowpea and groundnut used in the evaluation of proposed technical packages should reflect the average price over the year because, through improving storage conditions and diversifying production, the farmer would be able to market product throughout the year rather than being forced to sell immediately after the harvest period. By contrast, when the traditional local practices and improved local practices are analyzed, the prices for millet, cowpea and groundnut are those prevailing at harvest time.

Whether the prices used for millet, cowpeas and groundnuts are annual averages or post harvest, all estimates are based on observations made by the evaluation team, with the exception of the annual average price for millet. This information was gathered by the evaluation team during the 1986-87 and 1987-88 agricultural seasons on the Fifth Region's assembly weekly markets. The 1986-87 season was a good one whereas that of 1987-88 was mediocre. The average annual price of millet was determined on the basis of monthly price statistics for millet gathered by the Early Warning System (SAP) for the period October 1986 to September 1988 (see table E.1 in annex E). These statistics were contrasted to the observations made by the evaluation team and were found out to correspond. This annual average price has, however, been reduced arbitrarily by 10% in order to take account of the fact that the SAP statistics are retail not wholesale prices.

The price of sesame is based on that offered by CMDT (90 FCFA/kg to the producer), reduced by 20% to take account of the distance from the Fifth Region.

b. Economic Prices (see table E.4 in annex E).

The financial prices of inputs have been adjusted to arrive at their economic value. There are two categories of inputs. On the one hand, the financial prices of locally produced inputs must have the value of taxes removed and subsidies added to arrive at their economic value. On the other hand, there are inputs that are essentially imported but have value added locally (through processing, assembly, marketing, etc.). For this second category of inputs, the customs duty on the imported component must first be removed, and then an exchange rate premium added to the duty free imported component in order to take account of the overvaluation of the CFA franc vis-a-vis other currencies. As a final step, any domestic taxes applied must be deducted and any subsidies added to arrive at the economic price.

The first category of inputs includes mainly improved seed (millet and cowpea from OPSS, groundnuts from ODIPAC, and sesame from CMDT), locally raised draft animals, and Tilemsi rock phosphate produced locally. In Mali, the costs of seed production exceed their sale price, the subsidy having been arbitrarily set at 20%[7]. The economic value of draft animals is taken to be the market price in the Fifth Region. The economic price of domestically produced Tilemsi rock phosphate is the same as its financial price.

The second category of inputs includes mainly pesticides, fertilizer and agricultural equipment. The economic values of these inputs are shown in table E.4 of annex E. An 8% subsidy on agricultural equipment in Mali has been taken into account in determining the economic value.

The economic value of millet, cowpea and groundnut is estimated at their respective market prices in the expectation that these three agricultural products will be consumed within the Fifth Region. These products are currently not subject to significant cross border trade. Sesame, by contrast, will be produced specifically for export. The economic value of sesame is obtained by adding export taxes to the

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7/ Even if this subsidy has been set incorrectly this should not significantly affect the results of the economic analysis because the cost of seed accounts for only a small proportion of the costs of production of rainfed crops, with the exception of groundnut cultivation.

producer price[8] and applying the exchange rate premium to take account of the overvaluation of the CFA franc.

The economic cost of daily labor is determined the same way the financial cost of daily labor is determined with the exception that the financial values of the inputs and outputs used in the determination of the cost of daily labor are replaced by their corresponding economic values.

c. Amortization Charges (see tables E.5 and E.6 in annex E).

The calculation of financial amortization charges is presented in table E.5 of annex E. In order to derive a constant annuity, a capital recovery factor is employed. For agricultural equipment, the capital recovery factor is determined on the basis of the repayment period permitted by the BNDA and not the working life of the equipment. While this method overestimates the annual cost, it is used in order to take account of the farmer's financial obligations to the BNDA.

The calculation of economic amortization charges is presented in table E.6 in annex E. It is carried out in the same manner as for financial amortization charges, except for the use of economic prices instead of financial prices, an opportunity cost of capital estimated at 12% instead of the real financial rate of interest charged by BNDA and a longer recovery period, based on the expected life of the equipment.

4. Assumptions Regarding the Size of Target Groups and Rates of Adoption.

As the technical packages included in the analysis of an expansion of the DRSPR have been identified according to the agro-climatic zones for rainfed agriculture, it is first of all necessary to estimate the area cultivated in these zones. Furthermore, within each agro-climatic zone there exist several producer target groups for which the adoption rates of the technical packages will vary. These target groups are characterized according to their farming system (mixed farming or pastoral) and level of technical (with or without plows). Consequently, it is also necessary to estimate the area for each of these target groups in their respective agro-climatic zones.

After estimating the area cultivated for each target group by agro-climatic zone, this section then presents the method for estimating rates of adoption. The adoption of technical packages is assumed to depend primarily on the package itself (i.e., the financial profitability and complexity of the package), secondly on the agro-climatic zone, and thirdly the relevant target group.

8/ Export taxes are added to the producer price because they are considered as a transfer of payment from producers to the government.

a. Estimation of Target Group Sizes.

As the four technical packages all apply to rainfed agriculture, estimation of the area potentially benefiting from these packages is based on statistics from the Opération Mil Mopti (OMM). For the "millet-cowpea intercropping" and "sole millet and cowpea cropping pattern" packages the area estimated by OMM as being cultivated to millet is used. However, for this analysis the area is limited to the four agro-climatic zones (Seno North, Center, South and Plateau) where the four packages are likely to be most widely adopted. Estimates of the area cultivated in millet for these four zones are given in table J.1 in annex J. The population of these four agro-climatic zones accounts for 57% of the population in zones with rainfed agriculture and 30% of the total population of the Fifth Region (376,000 out of 1,261,000 inhabitants). Thus the four technical packages included in the analysis pertain to approximately 30% of the population of the Fifth Region. This percentage represents that part of the population that can benefit quickly from an expansion of the DRSPR in the Fifth Region, and hence that part to which this economic analysis applies.

As an underlying assumption of this analysis is that the rate of adoption of technical packages will vary according to the target group, their size is estimated next. Target groups are characterized according to their farming system and level of technical.

The relative size of the two farming systems has been estimated for each of the agro-climatic zones and is presented in table J.1 in annex J. This estimate has been determined with the help of estimates on the relative size of ethnic groups (Kassambara, 1980) or made at the time of sampling for the formal survey. The Peul ethnic group practices a pastoral farming system; the Dogon, Daffin, Mossi and Bambara a mixed farming system.

The level of mechanization is estimated for each farming system in each agro-climatic zone. The level of mechanization was estimated at the time of sampling for the formal survey and is presented for each farming system in table J.1 of annex J.

Having estimated the proportion of the total area of each agro-climatic zone accounted for by the two farming systems, and their corresponding level of mechanization, it is now possible to estimate the size of the target groups in terms of population and area cultivated. This information is presented in table J.2 of annex J.

For these estimates to be correct, the area cultivated by the farm household must be independent of the type of farming system and level of technology. This independence could not have been tested with the available secondary and formal survey data. The only available information from the formal survey is that the number of active members per household ranges from 6 to 13 with no statistically significant differences among farming systems and level of technology within agroclimatic zones. As indicated by other studies in other regions of

Mali[9], it is likely that such an independence does not hold. If mechanized farmers farm proportionally more land than non-mechanized farmers, then in that case a correction factor should have been applied to take account of a possible overestimation of the area cultivated by non-mechanized target groups, and underestimation in the case of the mechanized target group.

b. Estimation of Adoption Rates.

A baseline adoption coefficient reflecting the expected rate of acceptance[10] of the technical packages has been chosen for the four technical packages included in the analysis. A baseline coefficient of 2 was initially assumed and subsequently proved to be adequate to represent the expected ceiling adoption rates of the four technical packages. The expected ceiling adoption rates correspond to those observed for the diffusion of animal traction in the corresponding agro-climatic zones. An adoption coefficient valued at 2 means that during the early years the area benefiting from adoption of the package doubles. As this area approaches a ceiling the rate of adoption falls by half. The characteristic "S" curve obtained using this technique has frequently been observed during the process of adoption of innovations. In effect, adoption is slow at the beginning, then accelerates, and finally slows down (Rogers, 1957).

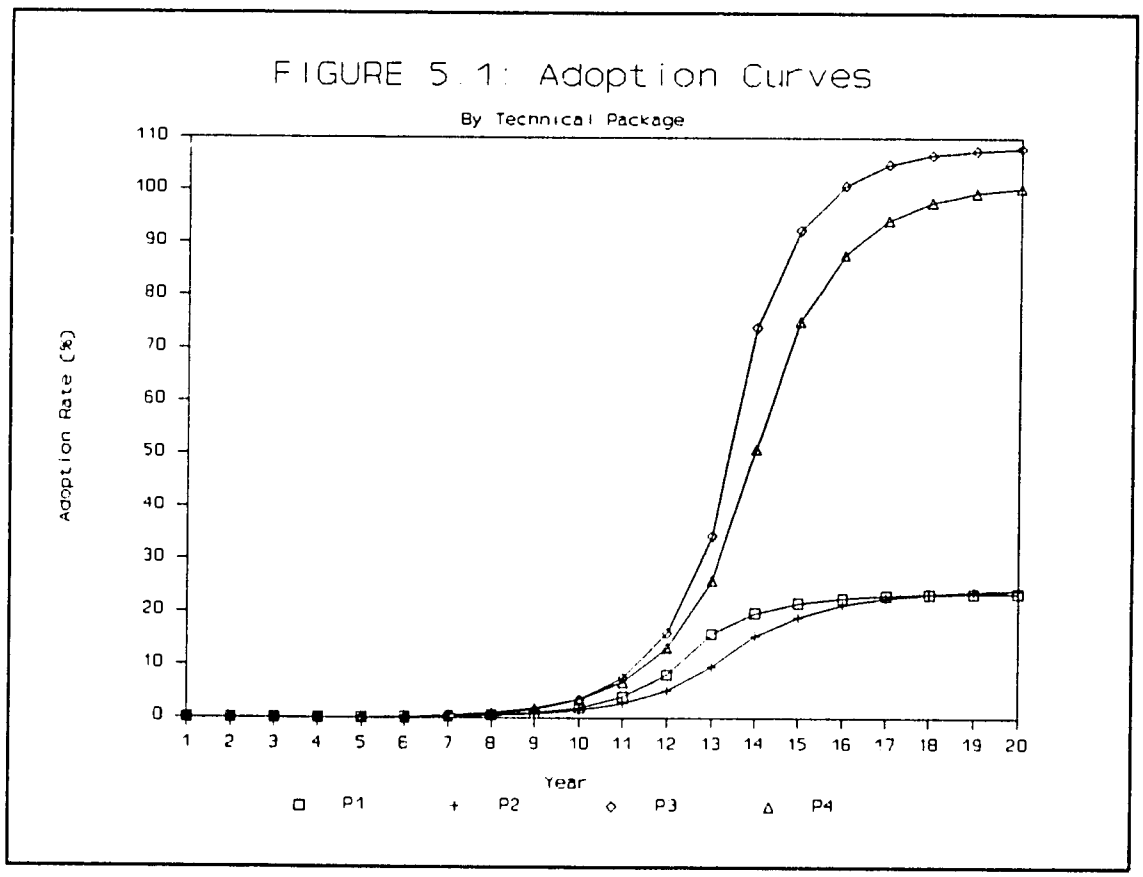
9/ In the OHV and CMDT zones it has been observed that mechanized farms are characterized by a larger number of persons and a larger cultivated area than non-mechanized households (D'Agostino, 1988).

10/ The estimation of the expected aggregate area that will benefit every year from each of the four technical packages is based on a mathematical simplification of the following logistic function used by Griliches (1957) to represent the diffusion of hybrid corn in the United States:

$$P(t) = K/[1+e^{-(a+bt)}]$$

where P represents the proportion of land benefiting from the new technology and is a function of time t; K is the long-run upper limit on adoption aggregate; the slope, b, is a measure of the rate of acceptance of the new technology; and the intercept, a, reflects aggregate adoption at the start of the estimation period.

The expected adoption curves are shown on figure 5.1. During the pilot extension phase, only a small proportion of area will be affected by the proposed packages[11]. That proportion of area reflects the aggregate adoption at the start of the estimation period. After several years of extension the rate of adoption accelerates and subsequently slows down between 7 and 10 years after first being introduced. For the majority of technical packages a ceiling is reached approximately 14 years after the first year of pilot extension. The ceiling represents the long-run upper limit on adoption aggregate. For the groundnut-millet-groundnut rotation and the sesame cultivation, the ceiling adoption rate is greater than 100% as it is expected that the area benefiting from these two technical packages will be superior to the area presently devoted to groundnut and sesame respectively.



Legend: P1 : "Millet-cowpea intercropping".
P2 : "Sole Millet-cowpea cropping pattern".
P3 : "Groundnut-millet-groundnut rotation".
P4 : "Sesame cultivation".

11/ Adoption is supposed to begin during the first year of the pilot extension phase.

The baseline adoption coefficient is modified, however, according to the financial and technical characteristics of the package, the agro-climatic zone, the farming system and level of technology of the target group, in order to take account of several factors affecting the rate of acceptance. These factors are the profitability and financial stability of technical packages (see next section), the complexity of technical packages, the socio-professional characteristics of the adopter, and the climatic, socio-economic and institutional environment. As a rule of thumb the adoption coefficient is adjusted upward for mechanized target groups; for less complex packages closer to existing local practices; for highly profitable packages; and for the Seno Center and Plateau areas characterized by the best soils (although rainfall is higher in Seno South), by better transport and commercial infrastructure, and by a higher population pressure on good arable land where the packages will bring about intensified land use. The adoption coefficient is adjusted downwards for target groups not benefiting from those characteristics which facilitate adoption.

Once the adjustment of the adoption coefficient has been determined for each target group and technical package, three additional variables have an effect on the area benefiting each year from adoption of the package. The first variable is the area on which the package is adopted in the first year, the second the area benefiting in the last year, and the third variable is the year in which the adoption rate declines as opposed to increases. Once two of these variables are established they determine the third. These three variables have been determined in an iterative manner to arrive at realistic values for all three.

For example, the area benefiting from the technical package in the first year of adoption, corresponding to the first year of pilot extension, is fixed realistically between 5 and 40 ha. This area varies according to the technical package and the target group. Then, the area benefiting from the technical package in the last year is determined by multiplying the expected upper limit aggregate adoption rate by the area cultivated actually in the crop for which the technical package applies.

The estimated upper limit aggregate adoption rate is presented in table 5.1 for each of the technical packages. To convert this adoption rate into area terms, OMM estimates of cultivated areas are used. For the first two packages, "millet-cowpea intercropping" and "sole millet and cowpea cropping pattern", the area benefiting at the end of the adoption process is effectively estimated by multiplying the estimated area cultivated in millet for each target group by the chosen upper limit aggregate adoption rate. For the "groundnut-millet-groundnut rotation" package, 5% of the area cultivated to millet is multiplied by the chosen upper limit aggregate adoption rate because, according to OMM, the area cultivated in groundnut represents 5% of the area cultivated to millet. For the "sesame cultivation" package, 10% of the area cultivated in millet is multiplied by the chosen upper limit aggregate adoption rate because, according to Soumano (SRCVO, personal communication, October 1988), the area cultivated in Sesame corresponds to 10% of the area cultivated in millet in the Fifth Region.

TABLE 5.1: Estimates of the upper limit area benefiting from a technical package at the end of the adoption process.

Technical Packages	Initial Area (Ha)	Estimated Upper Limit Adoption Rate (%)	Upper Limit Area Benefiting (Ha)
"Millet-cowpea intercropping"	126278	23.5	29724
"Sole Millet-cowpea cropping pattern"	126278	24.1	30412
"Groundnut-millet-groundnut rotation"	6314	108.0 (1)	6820
"Sesame cultivation"	12628	100.5 (2)	12690
TOTAL	145220	54.8	79646

(1) It is anticipated that the area in pure stand belonging to the proposed groundnut-millet-groundnut rotation would be greater than the area grown actually in groundnut.
(2) It is anticipated that the area presently grown in sesame would expanded.

Sources: Using the technique developed above and the tables J.3 to J.6 of annex J.

The third variable is the year which sees the rate of adoption begin to diminish. This year corresponds to the inflection point of the "S" shaped adoption curve. This variable is determined in an iterative manner according to the value of the two preceding ones, taking account of the fact that packages and target groups with lower rates of adoption will generally take longer to reach the inflection point. Thus the adoption coefficient for the "sole millet and cowpea cropping pattern" package is smaller than that for the "millet-cowpea intercropping" package to reflect the fact that the type of cropping pattern proposed is less familiar to potential adopters than is intercropping. On the other hand, the inflection point for the "sole millet and cowpea cropping pattern" package is delayed two to three years to reflect the fact that this technical will eventually be adopted on a larger scale because of its higher profitability compared to that for the "millet-cowpea intercropping" package. It is assumed that the "groundnut-millet-groundnut rotation" package has the same potential adoption characteristics as the "sole millet and cowpea cropping pattern" package and consequently the same rate of acceptance. The "sesame cultivation" package is characterized by both high profitability and low complexity and is consequently assigned a relatively high acceptance rate compared to the other technical packages. Compared to the "groundnut-millet-groundnut rotation" package, however, "sesame cultivation" will reach its

inflection point earlier, taking account of the fact that its diffusion may be constrained by export possibilities. It would be desirable to examine the international vegetable oil market in order to more accurately determine the possibilities for this new venture in the Fifth Region.

This section has presented the four types of assumption which underlie the following economic analysis. The majority of these assumptions are subjected to sensitivity analyses. Table 5.2 indicates the variables to be included in the analyses of the sensitivity of the project's financial and economic value for each type of assumption.

TABLE 5.2: Variables included in the sensitivity analyses.

Type of Assumption	Variables Tested
Pertaining to the project	Costs of the project
	Success of systems research
	Progress of research themes to the extension stage
Pertaining to the technical packages	Life of the innovation
	Increase in yields
Pertaining to prices	Increase in farm gross benefits
	Increase in farm costs
Pertaining to adoption	Rate of adoption
	Adoption ceiling

B. FINANCIAL ANALYSIS.

This section presents first the financial budgets of the proposed technical packages with regard to the traditional and improved traditional technologies, and second the results of the sensitivity analysis.

1. Financial Budgets.

Financial budgets for each of the technical packages are presented in tables G.1 to G.5 in annex G. For each package the incremental gross benefits, incremental costs, incremental average returns to labor, and finally the incremental net benefits are estimated. These estimates are calculated in relation to the traditional technology and improved traditional technology or transitional technology (using animal traction). For example, the "sole millet-cowpea intercropping" and the "millet-cowpea cropping pattern" technical packages are compared with the traditional and improved traditional millet-cowpea intercropping. The "groundnut-millet-groundnut rotation" technical package is compared with the traditional and improved traditional millet-millet-millet rotation. The "sesame cultivation" technical package is compared with the millet crop of the second year of the traditional and improved traditional millet-millet-millet rotation. Breaking up the financial analysis into three groups of farm enterprises has two advantages. First, it is consistent with the farmers' strategies of diversification in order to provide food grains and income while reducing the risk of total crop failure. Second, it allows each proposed package to be compared directly with the production techniques currently used by farmers for the relevant enterprise. Budgets are estimated for each agro-climatic zone where a package is to be introduced.

Potential labor savings are counted as gross benefits and valued at the current opportunity cost of labor employed in the traditional or improved traditional technology. When estimating labor savings for the proposed technical package compared to traditional technology (non-mechanized farms), the opportunity cost of labor is that estimated for the traditional technology. When estimating labor savings for the proposed technical package compared to the improved traditional technology (mechanized farms), the opportunity cost of labor is that estimated for the improved technology. This method of valuing potential labor savings is preferred because the majority of the packages reduce labor input per unit of cultivated area compared to the existing technology.

The financial budgets of the proposed technical packages are analyzed with respect to three criteria: the marginal rate of return (MRR), the average return to labor and the marginal return per man day. While the MRR reflects the additional profit earned by the additional capital and labor invested in the package, the marginal return per man day isolates the effect of additional labor from other factors of

production. Since capital and labor are the two most limiting factors of production for farm households in the Fifth Region, both merit special attention.

a) The Marginal Rates of Return of the Technical Packages.

The results in tables G.1 to G.5 of annex G are summarized in tables 5.3 to 5.5. These three tables show the estimated marginal rates of return (MRR) to the technical packages by agroclimatic zone[12]. As shown on the tables, the marginal analysis is performed for substitutable crop enterprises in the same way the financial budgets were presented above: the "millet-cowpea intercropping" technical package, the "sole millet-cowpea cropping pattern" technical package and the traditional and the improved traditional millet-cowpea intercropping together; the "groundnut-millet-groundnut rotation" technical package and the traditional and improved traditional millet-millet-millet rotation together; the "sesame cultivation" technical package and the millet crop of the second year of the traditional and improved traditional millet-millet-millet rotation together.

For the northern zone, on table 5.3, the marginal analysis eliminates the "sesame cultivation" technical package because the proposed package is dominated by the existing technologies. Despite the low MRR of the "millet-cowpea intercropping" technical package for both the non-mechanized and mechanized farms, this technical package is retained because of its familiarity. It requires few changes vis-à-vis traditional and improved traditional practices. It is expected that the adoption of this technical package would be faster than the adoption of the "sole millet-cowpea cropping pattern" technical package but the latter will eventually catch up. The same reasoning applies for these two technical packages in the center, plateau and the southern zones on tables 5.4 and 5.5.

12/ The marginal rate of return is the ratio of the marginal net benefit to the marginal cost, expressed as a percentage. In order to determine the MRR, the different packages along with existing practices need to be ranked according to their net benefits and their total costs. Any activity that has net benefits less than or equal to those of an activity with lower costs is said to be dominated, and therefore eliminated from the marginal analysis. The marginal rate of return is estimated between technologies of incremental cost. A marginal rate of return of 50% indicates, for example, that for every additional franc invested in the proposed package the farmer can expect to recover the franc invested and earn 50 centimes more profit. CIMMYT (1988) considers a rate between 50 and 100% to be the minimum rate at which a technology package will be adopted. The threshold depends on the degree of complexity and unfamiliarity of the technical package proposed (CIMMYT, 1988).

For the center and plateau zones, the "groundnut-millet-groundnut rotation" technical package with Tilemsi rock phosphate (TRP) and the "sesame cultivation" technical package are more profitable than the existing technologies and are, therefore, retained in addition to the "millet-cowpea intercropping" and the "sole millet-cowpea cropping pattern" technical packages.

TABLE 5.3: Synthesis of the financial budgets for farms in the northern zone.

Technical Package(1)	Net Benefit (FCFA)	Total Cost (FCFA)	Marginal Net Benefit (FCFA)	Marginal Cost (FCFA)	MRR (%) (2)	Average Rate of Return %
A) NON-MECHANIZED FARM:						(3)
Improved M-C intercropping	32437	18537	1501	5735	26	76
Improved M-C cropping pattern	30936	12802	7761	5472	142	100
M-C interc. transitional practice	23175	7330	3878	6127	63	63
M-C interc. traditional practice	19297	1203				
2nd year of M-M-M trad. practice	14337	663				
2nd year of M-M-M trans. practice	14428	6790	Dominated (5)			
Improved sesame cultivation	13344	9902	Dominated (5)			
B) MECHANIZED FARM:						(4)
Improved M-C intercropping	22883	18537	796	5735	14	72
Improved M-C cropping pattern	22087	12802	7267	5472	133	133
M-C interc. transitional practice	14820	7330				
2nd year of M-M-M trans. practice	8210	6790				
Improved sesame cultivation	7080	9902	Dominated (5)			

(1) M-C: Millet-Cowpea
M-M-M: Millet-Millet-Millet rotation
Transitional practice: Mechanized practice with no external inputs.
Traditional practice: Non-mechanized practice with no external inputs.
(2) From preceding to following.
(3) From the traditional practice.
(4) From the transitional practice.
(5) A technical package is dominated if it incurs higher costs but no additional net benefit.
Source: From tables G.1. to G.5. in annex G.

TABLE 5.4: Synthesis of the financial budgets for farms in the center and plateau zones.

Technical Package(1)	Net Benefit (FCFA)	Total Cost (FCFA)	Marginal Net Benefit (FCFA)	Marginal Cost (FCFA)	MRR (%) (2)	Average Rate of Return %
A) NON-MECHANIZED FARM:						(3)
Improved M-C intercropping	42781	24325	3972	7157	55	73
Improved M-C cropping pattern	38809	17168	7329	9110	80	80
M-C interc. transitional practice	31480	8058	5573	6965	80	80
M-C interc. traditional practice	25907	1093				
Improved G-M-G rotation with TRP	23626	16964	8006	16318	49	49
M-M-M rot. traditional practice	15620	646				
Improved G-M-G rotation w/o TRP	15357	13179	Dominated (5)			
M-M-M rot. transitional practice	14869	7611	Dominated (5)			
Improved sesame cultivation	22717	13015	6530	12402	53	53
2nd year of M-M-M trad. practice	16187	613				
2nd year of M-M-M trans. practice	15829	7578	Dominated (5)			
B) MECHANIZED FARM:						(4)
Improved M-C intercropping	29980	24325	3255	7157	45	56
Improved M-C cropping pattern	26725	17168	5833	9110	64	64
M-C interc. transitional practice	20892	8058				
Improved G-M-G rotation with TRP	18008	16964	8377	3785	221	100
Improved G-M-G rotation w/o TRP	9631	13179	976	5568	18	18
M-M-M rot. transitional practice	8655	7611				
Improved sesame cultivation	16283	13015	7061	5437	130	130
2nd year of M-M-M trans. practice	9222	7578				

(1) M-C: Millet-Cowpea
G-M-G: Groundnut-Millet-Groundnut rotation
M-M-M: Millet-Millet-Millet rotation
TRP: Tilemsi Rock Phosphate
Transitional practice: Mechanized practice with no external inputs.
Traditional practice: Non-mechanized practice with no external inputs.
(2) From preceding to following.
(3) From the traditional practice.
(4) From the transitional practice.
(5) A technical package is dominated if it incurs higher costs but no additional net benefit.
Source: From tables G.1. to G.5. in annex G.

TABLE 5.5: Synthesis of the financial budgets for farms in the southern zone.

Technical Package(1)	Net Benefit (FCFA)	Total Cost (FCFA)	Marginal Net Benefit (FCFA)	Marginal Cost (FCFA)	MRR (%) (2)	Average Rate of Return %
A) NON-MECHANIZED FARM:						(3)
Improved M-C intercropping	39431	35166	2870	10982	26	50
Improved M-C cropping pattern	36561	24184	9756	17044	57	61
M-C interc. transitional practice	26805	7140	4418	6127	72	72
M-C interc. traditional practice	22387	1013				
Improved G-M-G rotation w/o TRP	14500	12267	1030	11637	9	9
Improved G-M-G rotation with TRP	14347	16053	Dominated (5)			
M-M-M rot. traditional practice	13470	630				
M-M-M rot. transitional practice	12306	6757	Dominated (5)			
Improved sesame cultivation	30130	12177	14785	5487	269	127
2nd year of M-M-M trans. practice	15345	6690	8	6127	0	0
2nd year of M-M-M trad. practice	15337	563				
B) MECHANIZED FARM:						(4)
Improved M-C intercropping	29893	35166	2077	10982	19	42
Improved M-C cropping pattern	27816	24184	9756	17044	57	57
M-C interc. transitional practice	18060	7140				
Improved G-M-G rotation w/o TRP	10308	12267	2965	5510	54	54
Improved G-M-G rotation with TRP	10041	16053	Dominated (5)			
M-M-M rot. transitional practice	7343	6757				
Improved sesame cultivation	23990	12177	14780	5487	269	269
2nd year of M-M-M trans. practice	9210	6690				

(1) M-C: Millet-Cowpea
G-M-G: Groundnut-Millet-Groundnut rotation
M-M-M: Millet-Millet-Millet rotation
TRP: Tilemsi Rock Phosphate
Transitional practice: Mechanized practice with no external inputs.
Traditional practice: Non-mechanized practice with no external inputs.

(2) From preceding to following.

(3) From the traditional practice.

(4) From the transitional practice.

(5) A technical package is dominated if it incurs higher costs but no additional net benefit.

Source: From tables G.1. to G.5. in annex G.

For the southern zone, the "groundnut-millet-groundnut rotation" technical package is eliminated because the MRR is very low for the non-mechanized farmers and because it would not be worthwhile for the project to invest time and energy in the development of a technical package for such a small target group as the southern mechanized farmers. With the highest marginal rate of return, sesame cultivation in the southern zone is particularly attractive. This is due in part to the fact that the ratio of sesame and millet prices is more favorable to sesame cultivation in Seno South than other areas. In order to maintain the profitability of the package as production will increases, new market outlets will need to be found.

Looking at the MRR between the traditional technology and the improved traditional technology estimated for the first group of financial budgets on tables 5.3 to 5.5, it is useful to note that the marginal rate of return is highest (80%) in those zones where mechanization is particularly widespread (mechanization rates are 46% in Seno Center and 32% in the Plateau, results from sampling prior to the formal survey) and lowest but still attractive (MRRs of 72% and 63%) in the zones where mechanization is less widespread (mechanization rates are 15.5% in the Seno South and 17.5% in the Seno North). These attractive MRR for the mechanized technologies provide further evidence of the complementary need for the provision of agricultural equipment to increase profitability, particularly in the Seno Center and Plateau areas where the effective denmand for equipment is not yet met because of lack of equipment availability.

b) <u>The Average Returns to Labor and the Marginal Returns per Man Day for the Technical Packages.</u>

On table 5.6, both the average return to labor and the marginal return per man day are estimated. First, the total return to labor is determined by the difference between the gross benefit and the total cost of production, excluding any labor cost or labor saving in the estimation of these two variables. The total cost of production includes an opportunity cost of capital of 25% to make sure that the difference between the gross benefit and the total cost of production is the return to the labor only and not to the capital invested in the production process. In the sensitivity analysis, the opportunity cost of capital is increased to 50%. The size of these two opportunity costs of capital approximately corresponds to the range in seasonal (5 to 6 months) loan rates given by private merchants to farmers during the cropping season. These imply a range in annual rates between 50 and 100%. Second, the average return to labor is calculated by dividing the total return to labor by the number of days of work.

Once the average return to labor is estimated, the marginal return per man day is estimated in the following two steps. First, the marginal return to labor is estimated between enterprises with

TABLE 5.6: Average return to labor and marginal return per man day with a opportunity cost of capital of 25%.

Technical Package(1)	Gross Benefit (FCFA) (2)	Total Cost (FCFA) (3)	Return to Labor (FCFA)	Labor Input (day)	Incremental Labor Day (day)	Average Return To Labor (4) (FCFA/day)	Marginal Return to Labor(FCFA)	Marginal Return per man day(5) (FCFA/day)
A) NORTHERN ZONE:								
Improved M-C intercropping	46000	23171	22829	36.0	5.0	634	2056	411
Improved M-C cropping pattern	36775	16003	20773	31.0	3.5	670	7785	2224
M-C interc. traditional practice	20500	1504	18996	48.5	21.0	392	Dominated (6)	
M-C interc. transitional practice	22150	9163	12988	27.5		472		
2nd year of M-M-M trad. practice	15000	829	14171	41.5	6.5	341	5549	854
Improved sesame cultivation	21000	12378	8623	35.0	11.5	246	2110	183
2nd year of M-M-M trans. practice	15000	8488	6513	23.5		277		
B) CENTRAL AND PLATEAU ZONES:								
Improved M-C intercropping	62600	30406	32194	47.5	4.4	678	4154	944
Improved M-C cropping pattern	49500	21460	28040	43.1	9.1	651	9163	1007
M-C interc. traditional practice	27000	1366	25634	57.5	23.5	446	Dominated (6)	
M-C interc. transitional practice	28950	10073	18878	34.0		555		
Improved G-M-G rotation with TRP	40640	21205	19435	51.0	.7	381	3976	5679
M-M-M rot. traditional practice	16267	808	15460	50.3	.6	307	4690	1303
Improved G-M-G rotation w/o TRP	27243	16474	10769	46.7	16.4	231	4016	245
M-M-M rot. transitional practice	16267	9514	6753	30.3		223		
Improved sesame cultivation	33750	16269	17481	43.0	14.0	407	10154	725
2nd year of M-M-M trad. practice	16800	766	16034	49.0	20.0	327	Dominated (6)	
2nd year of M-M-M trans. practice	16800	9473	7328	29.0		253		
C) SOUTHERN ZONE:								
Improved M-C intercropping	68300	43958	24343	39.0	-25.0	624	Dominated (6)	
M-C interc. traditional practice	23400	1266	22134	64.0	6.5	346	Dominated (6)	
Improved M-C cropping pattern	52000	30230	21770	57.5	18.5	379	Dominated (6)	
M-C interc. transitional practice	25200	8925	16275	39.0		417	Dominated (6)	
M-M-M rot. traditional practice	14100	788	13313	50.0	.7	266	3152	4502
Improved G-M-G rotation with TRP	30227	20066	10161	49.3	.3	206	120	36
Improved G-M-G rotation w/o TRP	25375	15334	10041	46.0	16.0	218	4388	274
M-M-M rot. transitional practice	14100	8446	5654	30.0		188		
Improved sesame cultivation	42000	15221	26779	49.0	19.0	547	19241	1013
2nd year of M-M-M trad. practice	15900	704	15196	50.0	20.0	304	Dominated (6)	
2nd year of M-M-M trans. practice	15900	8363	7538	30.0		251		

(1) M-C: Millet-Cowpea.
M-M-M: Millet-Millet-Millet rotation.
G-M-G: Groundnut-Millet-Groundnut rotation.
TRP: Tilemsi Rock Phosphate.
Transitional practice: Mechanized practice with no external inputs.
Traditional practice: Non-mechanized practice with no external inputs.
(2) Labor gain excluded.
(3) Labor cost excluded, but including a 25% opportunity cost of capital for the cropping season.
(4) Return to labor divided by total labor days.
(5) Marginal return to labor divided by the incremental labor day.
(6) A technical package is dominated if it incurs more labor input but no additional net benefit.
Source: From tables F.1. to F.5. in annex F and tables G.1. to G.5. in annex G.

incremental labor input[13]. Second, the marginal return to labor is divided by the number of additional man-days employed to arrive at the marginal return per man day, which indicates how much the additional work day is worth when invested in a more labor intensive crop enterprise.

(1) The average return to labor.

As indicated by table 5.6, both the "sole millet-cowpea cropping pattern" and the "millet-cowpea intercropping" technical packages increase the average return to labor vis-à-vis the traditional and improved traditional technologies for the northern, center and plateau zones, the former package increasing average returns the most. In the central and plateau zone, the "groundnut-millet-groundnut" technical package also increases the average return to labor. For the southern zone, only the "millet-cowpea intercropping" and the "sesame cultivation" technical packages increase the average return to labor vis-à-vis the traditional and improved traditional technologies. There, the "sole millet-cowpea cropping pattern" technical package ranks between the traditional and improved traditional technologies. For all zones, the mechanization of the traditional technology increases the average return to labor for the millet-cowpea intercropping as expected, but not for the millet-millet-millet rotation. This means that the average return to labor cannot be increased by mechanization when only millet is grown, mainly because the millet price is too low to cover the cost of mechanization.

In general, average returns to labor for non-mechanized target groups adopting either the proposed technical packages or the improved traditional technology (technologies with a mechanization component) are highest in the center and plateau zones, with the exception of the "sesame cultivation" technical package which has the highest average return to labor in the southern zone. This confirms why the center and plateau zones are actually the zones experiencing the highest equipment rate.

(2) The marginal return per man day.

The last column of table 5.6 shows the marginal return per man day for the technical packages. First of all, it is interesting to note that the traditional technology is generally dominated by the improved traditional technology and by the proposed technical packages, with the

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13/ The marginal return to labor is the difference in the returns to labor between two alternative activities. In order to calculate the marginal return to labor, the activities to be compared need to be ranked according to the size of their return to labor and the size of their labor input. Any activity that has a return to labor less than or equal to the return to labor of an alternative activity with lower labor input is said to be dominated and therefore eliminated from the marginal analysis.

exceptions of the "sesame cultivation" technical package in the northern zone and the "groundnut-millet-groundnut rotation" technical package in the center, plateau and southern zones. The "sesame cultivation" technical package in the northern zone and the "groundnut-millet-groundnut rotation" technical package in the southern zone have already been already rejected because of their low MRR to capital and labor. In contrast, the "groundnut-millet-groundnut rotation" technical package has a higher marginal return per day than the traditional technology in the center and plateau zones and is, therefore, retained as a profitable package.

To be accepted as a more profitable alternative, the proposed technical packages need to show a marginal return per man day greater than the present estimated opportunity cost of labor. In the northern zone, it is certainly the case for the "sole millet-cowpea cropping pattern" technical package. In the center and plateau zones, it is the case for all the proposed technical packages, i.e., the "millet-cowpea intercropping", the "sole millet-cowpea cropping pattern", the "groundnut-millet-groundnut rotation" and the "sesame cultivation" technical packages. In the southern zone, it is the case for the "millet-cowpea intercropping" and the "sesame cultivation" technical packages. The marginal return per man day for the "millet-cowpea intercropping" technical package in the northern zone and the average return to labor for the "sole millet-cowpea cropping pattern" technical package in the southern zone range between the opportunity cost of the traditional and the improved traditional technologies. These two packages will be retained because of their satisfactory average rate of return (see tables 5.3 and 5.5), but will have a low expected adoption rate in those zones where they do not provide a significantly higher return to labor to the traditional and the improved traditional technologies.

c) Conclusion.

Analysis of the financial budgets permits unprofitable or marginally profitable packages to be eliminated. Primarily on the basis of the estimated marginal rate of return, average return to labor and marginal return per man day the technical packages presented in table 5.7 are retained in the following sensitivity analysis.

2. Sensitivity Analysis of the Financial Budgets.

The sensitivity analysis has several objectives. One is to see how unexpected changes affect the profitability of the technical packages (Gittinger, 1984) and, therefore, to determine the stability of the financial (or economic) return when the values of key variables change. Another is to confirm the relative impact of particular variables on the financial (or economic) results. This signals to those responsible for evaluating or implementing the project which variables merit special attention, whether at the planning stage or during implementation.

TABLE 5.7: Technical packages included in the sensitivity analysis.

Zone and Level of Technology	Technical packages (1) P1	P2	P3	P4
Northern Zone				
Non-mechanized	x	x		
Mechanized	x	x		
Center and Plateau Zones				
Non-mechanized	x	x	x	x
Mechanized	x	x	x	x
Southern Zone				
Non-mechanized	x	x		x
Mechanized	x	x		x

(1) P1 : "Millet-cowpea intercropping".
P2 : "Sole Millet-cowpea cropping pattern".
P3 : "Groundnut-millet-groundnut rotation".
P4 : "Sesame cultivation"

Sensitivity analysis is carried out by varying a value or combination of values, and then determining the consequences of this change on the financial (or economic) results (Gittinger, 1984). The range in values is chosen according to what is realistic.

Two types of sensitivity analysis are carried out for the financial budgets of each technical package. The first sensitivity analysis tests the effects of two variables on the marginal rate of return. The first variable is the commodity price or yield for each of the proposed packages. Whether one varies the price or the yield, the sensitivity analysis is the same since, in both cases, the gross benefit is multiplied by the same factor. The second variable is the cost of purchased production inputs, excluding land and labor inputs.

The second type of sensitivity analysis looks at the change of the opportunity cost of capital on the average return to labor and the marginal return per man day. For both sensitivity analysis, changes are examined for each recommendation domain, i.e., according to agro-climatic zone and level of technology.

a) <u>On the Marginal Rates of Return of the Technical Packages.</u>

Results of the first sensitivity analysis are presented in tables I.1 to I.3. in annex I. The changes in output price or yield and input costs are carried out for the proposed technical packages and for the traditional and improved traditional technologies as well with a variation of ± 10%, ± 20% and ± 50%. This range of variation is the most likely to happen.

In the northern zone (table I.1 in annex I), the profitability of the "sole millet-cowpea cropping pattern" technical package is by far more

stable than the "millet-cowpea intercropping" technical package for both changes in price or yield and input costs. For a 20% reduction in output price or yield or for a 20% increase in input costs, the MRR of the "sole millet-cowpea cropping pattern" technical package is still attractive. The MRR is above 90% for both non-mechanized and mechanized farmers. Moreover, this technical package is never dominated by the other technologies in the observed range of variation. It is not the case for the "millet-cowpea intercropping" technical package which becomes dominated for a 20% variation. The same observations hold for the center and plateau zones. The "sole millet-cowpea cropping pattern" technical package has a MRR above 40% for a 20% reduction in output price or yield or for a 20% increase in input costs. These observations hold to a lesser extent for the southern zone. The "sole millet-cowpea cropping pattern" technical package has a MRR above 30% for a 20% reduction in output price or yield or for a 20% increase in input costs. However, the "millet-cowpea intercropping" technical package resists better in these zones than in the northern zone to the reductions in output price or yield and the increases in input costs. In the event of a 50% change, this package becomes dominated in the center, plateau and southern zones. In sum, the "sole millet-cowpea cropping pattern" technical package is more stable than the "millet-cowpea intercropping" technical package for reductions in output price or yield and for increases in input costs. This is even more true for the northern zone than for the other zones.

In the center and plateau zones, the "groundnut-millet-groundnut rotation with TRP" technical package stays very attractive for the mechanized farmers for a 20% reduction in output price or yield or for a 50% increase in input costs. In contrast, for a 10% reduction in output price or yield or for a 10% increase in input costs, the profitability of this technical package becomes questionable for the non-mechanized farmers . This difference in profitability between mechanized and non-mechanized farmers is due to the fact that animal traction used on a 3 years millet-millet-millet rotation is not profitable (it is dominated by the traditional technology) and that measuring the increase in profitability between this non-profitable technology and the "groundnut-millet-groundnut rotation with TRP" technical package inflates the profitability of the latter technology. In sum, with respect to profitability and stability, the "groundnut-millet-groundnut rotation with TRP" technical package might be ranked between the "sole millet-cowpea cropping pattern" technical package and the "millet-cowpea intercropping" technical package in the center and plateau zones.

Because of its higher profitability in the southern zone than in the center and plateau zones, the "sesame cultivation" technical package stays attractive in the southern zone even for a 50% reduction in output price or yield or for a 50% increase in input costs. In the center and plateau zones, this attractiveness disappears with a 20% variation. In sum, the "sesame cultivation" technical package might be ranked superior to the other packages in the southern zone for both non-mechanized and mechanized farmers. For the non-mechanized farmers of the center and plateau zones, this package might be ranked superior to the "groundnut-

millet-groundnut rotation with TRP" technical package but inferior to the "sole millet-cowpea cropping pattern" technical package. For the mechanized farmers of the center and plateau zones, this package might be ranked inferior to the "groundnut-millet-groundnut rotation with TRP" technical package but superior to the "sole millet-cowpea cropping pattern" technical package. These ranks are relative to both profitability and stability.

b) On Average Returns to Labor and Marginal Returns per Man Day for the Technical Packages.

As indicated by table I.4 in annex I, with a 50% opportunity cost of capital instead of a 25% opportunity cost of capital used in the base line analysis, both the "sole millet-cowpea cropping pattern" and the "millet-cowpea intercropping" technical packages increase the average return to labor vis-à-vis the traditional and improved traditional technologies in the northern, center and plateau zones, the former package increasing the average return to labor the most. In the center and plateau zones, the "groundnut-millet-groundnut" technical package does not increase any more the average return to labor. For the southern zone, only the "millet-cowpea intercropping" and the "sesame cultivation" technical packages increase the average return to labor vis-à-vis the traditional and improved traditional technologies. There, in the southern zone, the "sole millet-cowpea cropping pattern" technical package ranks now the lowest among the technical packages and the traditional and improved traditional technologies.

With a 50% opportunity cost of capital instead of a 25% opportunity cost of capital used in the base line analysis, some traditional technologies are not dominated any more and some proposed technical packages become dominated. Particularly, the traditional technology on the millet-cowpea intercropping in the southern zone has now a profitable marginal return per man day and supersedes the "millet-cowpea cropping pattern" and the "millet-cowpea intercropping" technical packages. In the same zone, the "groundnut-millet-groundnut" technical package is now dominated. Only the "sesame cultivation" technical package stays attractive in that zone. In the northern zone, only the "sole millet-cowpea cropping pattern" technical package has an attractive marginal return per man day. In the center and plateau zones, only the "sole millet-cowpea cropping pattern" and the "sesame cultivation" technical packages have an attractive marginal return per man day while the "millet-cowpea intercropping" and the "groundnut-millet-groundnut" technical packages are not attractive any more in terms of marginal return per man day. In sum, only the "sole millet-cowpea cropping pattern" technical package in the northern, center and plateau zones and the "sesame cultivation" technical package in the southern, center and plateau zones have an attractive marginal return per man day with a 50% opportunity cost of capital.

c) Conclusions.

A summary of the instability of the proposed technical packages is presented on table 5.8.

TABLE 5.8: Instability of rates of return by technical package (1).

Zone and Level of Technical	Technical packages (2) P1	P2	P3	P4
Northern Zone				
Non-mechanized	-	+		
Mechanized	-	+		
Central and Plateau Zones				
Non-mechanized	-	+	±	±
Mechanized	-	±	+	+
Southern Zone				
Non-mechanized	-	±		+
Mechanized	-	±		+
Weighted Instability	-	±	±	+

(1)Instability is measured in terms of the change in the marginal rate of return and the marginal return per man day for a given change in the prices or yields of agricultural products and in costs of purchased inputs.
+ : relatively stable.
± : relatively unstable.
- : highly unstable.
(2) P1 : "Millet-cowpea intercropping".
P2 : "Sole Millet-cowpea cropping pattern".
P3 : "Groundnut-millet-groundnut rotation".
P4 : "Sesame cultivation".

The financial profitability of the "millet-cowpea intercropping" technical package is unstable when confronted with changes in prices or yields and input costs. The financial profitability of the "sole millet-cowpea cropping pattern", the "groundnut-millet-groundnut rotation" and the "sesame cuultivatoion" technical packages are relatively more stable.

This instability is mitigated, however, by the fact that when yields from the technical packages are low, in a year of inadequate rainfall for example, the prices of commodities tend to increase. However, the compensatory effect of yield and price works to the advantage of stability of gross farm income only if the price at the local market place is determined by the local production level. Since the market of coarse grain in Mopti is relatively well integrated to those in the

southern area of the country (Bamako, Koutiala, Sikasso; see table 4.2 in Chapter IV), the compensatory effect might be low. This suggests that the instability of the financial outcomes resulting from variation in prices and yields stays critical and calls for the systems research in the Fifth Region to study agricultural commodity markets and identify what agricultural innovations could help stabilize gross farm incomes.

In addition, the instability induced by potential changes in costs of production indicates how important it is that systems research in the Fifth Region study the market for agricultural inputs, not only to ensure their availability at farm level but also to reduce the costs of production and distribution of inputs. For example, the initial financial budgets were constructed on the basis of a gross commercial mark up of 10% for the transport and distribution of inputs in the Fifth Region. If this mark up could be reduced to 5% the financial profitability of the proposed technical packages could be significantly improved.

In conclusion, the sensitivity analysis for the financial budgets of the proposed technical packages, varying prices or yields and the costs of production, reveals most of the proposed packages to be unstable and reinforces the viewpoint expressed in the preceding chapter in which the research themes were presented. The achievements of systems research in the Fifth Region are heavily dependent on the agricultural input and product markets. It is therefore desirable that systems research gives this priority.

C. ECONOMIC ANALYSIS.

The economic analysis is carried out in five steps. The first step consists of transforming financial budgets, which have been estimated per unit area for each package and for each zone, into economic budgets presented on tables H.1 to H.5 in annex H. The economic budgets are expressed in CFA francs per hectare per year (CFA/ha/year) for each technical package for each target group[14]. Only the increases in gross margin, costs of production and net benefits are retained for the second step.

The second step consists of multiplying these economic results, expressed in CFA/ha/year, by the annual cumulative area benefiting each year from a proposed package. This area is determined for each technical package and target group by applying an annual adoption rate to the potentially available area. Estimates of the area potentially available and anticipated rates of adoption for each technical package and target group have been presented in the first section of this chapter. The economic results of this second step are expressed in CFA per year (CFA/year) for each technical package and target group. This second step consequently gives rise to an annual flow of gross incremental benefits, incremental costs of production and incremental net benefits aggregated for each technical package and target group. These results are given in tables J.3 to J.6 in annex J.

The third step consists of summing annually and individually the incremental gross benefit, incremental costs of production and incremental net benefits which have been estimated annually for each target group and package. This step gives a flow of annual incremental gross benefits, a flow of annual incremental costs of production and a flow of annual incremental net benefits aggregated for all target groups and proposed technical packages.

The fourth step consists of bringing together the results of the third step with the costs of expanding the DRSPR in the Fifth Region. This step is accomplished in table K.1 in annex K. In this table, the incremental annual gross benefits accruing to farms constitute the inflows, while incremental costs of production at the farm level and the annual costs of expanding the DRSPR constitute the outflows. The flow of annual incremental net benefits (net cash flow) is calculated by subtracting the outflows from the inflows.

The fifth step consists of calculating three measures of the economic value of expanding the DRSPR in the Fifth Region. The first measure is the net present value at the chosen opportunity cost of

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14/ As a reminder, target groups are defined according to agroclimatic zone, farming system and level of technology.

capital of 12%[15]. The second measure is the internal rate of return. The third measure is the net benefit-investment ratio at the chosen opportunity cost of 12%[16]. The value of these three measures is given at the bottom of table K.1 in annex K.

1. Results of the Economic Analysis.

The results of the economic analysis of an expansion of the DRSPR in the Fifth Region are summarized in table 5.9. At an opportunity cost of capital of 12% the project has a net present value of $US 648,000. A project's economic rate of return is the maximum rate of interest it could pay if all resources were borrowed. This rate of return is therefore a measure of the profitability of resources employed in the project (Gittinger, 1984). The estimated economic rate of return for an expansion of the DRSPR in the Fifth Region is 14%. This rate of return is sufficient to cover the chosen opportunity cost of capital. However, this is not a very high rate of return given the risky foundation on which it is estimated. These risks relate principally to the assumptions presented in the first section of this chapter, and for which a sensitivity analysis follows. Figure 5.2 shows graphically the net present values of the project by discount rate.

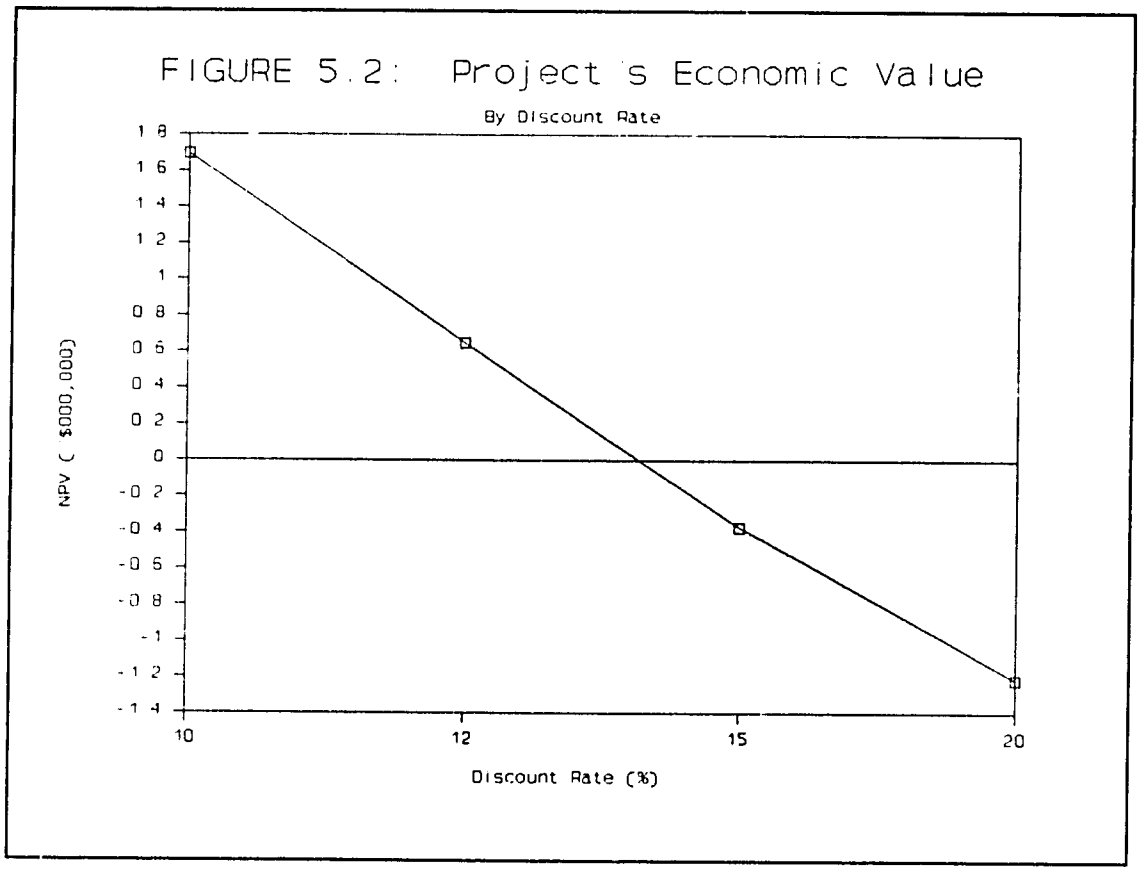
TABLE 5.9: Economic value of the project.

MEASURE	VALUE
NET PRESENT VALUE (thousands of US dollars)	
at 10%	1696
at 12%	648
at 15%	-372
at 20%	-1216
INTERNAL RATE OF RETURN (%)	14
NET BENEFIT-INVESTMENT RATIO (at a 12% opportunity cost of capital)	1.2

Source: Synthesis of table K.1 in annex K.

15/ The choice of opportunity cost has been discussed in the introductory part of this chapter. Gittinger (1984) gives more details.

16/ The significance of these measures and method of calculating them has been discussed at the beginning of this chapter. Gittinger (1984) gives more details.



When compared to rates achieved by other types of investment, such as transport, power or water control infrastructure, a rate of 14% is relatively low. It is nevertheless realistic in view of the agro-climatic, institutional and socio-economic realities in the Fifth Region of Mali.

It must be heavily underlined, however, that this rate of return to systems research in the Fifth Region has been calculated on the basis of currently available commodity research results for a difficult agro-climatic zone, having a rainfall of only 300 to 600mm.

Given that the commodity research results currently available for such a zone are limited in number and potential, it is not surprising that the rate of return to systems research based on these results should be equally low. However, this rate of return to systems research in the Fifth Region reflects only one part of a two way flow between commodity and systems research, that of results from commodity research to systems research.

In the long run, if coordination between commodity and systems research is strengthened, systems research will hopefully benefit from feeding back its own results to commodity research. Moreover, given the major institutional and marketing constraints in the Fifth Region it is strongly recommended that systems research seek to identify the causes

of such constraints and propose, support and encourage policy decisions which could enhance the level of output and commercialization of the agricultural sector. It is through strengthening the flow of information from systems research to commodity researchers and policy makers that the economic rate of return of expanding the DRSPR in the Fifth Region could be improved.

The net benefit-investment ratio has been included in table 5.9 because it enables different projects to be ranked. It is particularly useful where a donor has several possible projects to choose from. The net benefit-investment ratio is estimated to be 1.2.

The contribution of each technical package to the economic value of an expansion of the DRSPR in the Fifth Region can be estimated using table K.1 in annex K. The increase in gross benefits, costs of production and net benefits, aggregated across target groups, are presented in table 5.10 in thousands of CFA francs and in table 5.11 in thousands of US dollars. The technical package contributing the most to the economic value of an extension is the "millet-cowpea intercropping" (34%), followed closely by the "sesame cultivation" package (32%), then the "sole millet and cowpea cropping pattern" package (24%), and finally the "groundnut-millet-groundnut rotation" package (10%).

The low contribution of the "groundnut-millet-groundnut rotation" package to the economic value of an expansion of the DRSPR is due to its low financial return being attractive only to farmers in the Seno Center and Plateau zones, and potential market saturation problems if greater areas are cultivated in this way. It is nevertheless possible that other types of rotation including a secondary cash crop can be developed and tested by the DRSPR. At the present time, however, no promising results for a more profitable package are available.

TABLE 5.10: Economic comparison of technical packages (CFA F '000)

TECHNICAL PACKAGES	INCREASE IN (1) GROSS BENEFITS	COSTS	NET BENEFITS	%
1. "Millet-cowpea intercropping"	1374005	1005294	368712	34
2. "Sole millet-cowpea cropping pattern"	889204	620989	268215	24
3. "Groundnut-millet-groundnut rotation"	222745	115252	107493	10
4. "Sesame cultivation"	494015	144532	349483	32
TOTAL	2979970	1886066	1093904	100

(1) Based on a discount rate of 12%.
Source: Synthesis of tables J.3 to J.6 of annex J.

TABLE 5.11: Economic comparison of technical packages (US $'000).

TECHNICAL PACKAGES	INCREASE IN (1) GROSS BENEFITS	COSTS	NET BENEFITS	%
1. "Millet-cowpea intercropping"	4580	3351	1229	34
2. "Sole millet-cowpea cropping pattern"	2964	2070	894	24
3. "Groundnut-millet-groundnut rotation"	742	384	358	10
4. "Sesame cultivation"	1647	482	1165	31
TOTAL	9933	6287	3646	100

(1) Based on a discount rate of 12%.
Source: Synthesis of table K.1 of annex K.

The "sesame cultivation" package makes a solid contribution to the economic value of expanding the DRSPR. However, the marketing and export possibilities have yet to be determined. Future farming systems research in the Fifth Region will need to address specifically the marketing side of the development and adoption of the technical packages to avoid market saturation problems.

The contribution of each recommendation domain to the economic value of an expansion of the DRSPR in the Fifth Region can also be estimated. Table 5.12 shows the aggregate net benefits for each recommendation domain, and compares the contribution of each domain in the economic value of the project. These contributions indicate those recommendation domains for which systems research will have the largest and most immediate results. Table 5.12 shows that it would be the mixed farmers of the Seno South, Seno Center and Plateau zones who would contribute most to the economic value of the project if the technical packages were adopted. Their contribution is estimated at 76% of the economic value of the expansion.

The relative contribution of recommendation domains to the economic value of an expansion is not, however, necessarily due solely to the technical packages proposed for each of them. Population and area cultivated also have an effect. The last two columns of table 5.12 give the relative share of each recommendation domain in terms of population and area.

TABLE 5.12: Comparison of aggregate net benefits from technical packages for each recommendation domain.

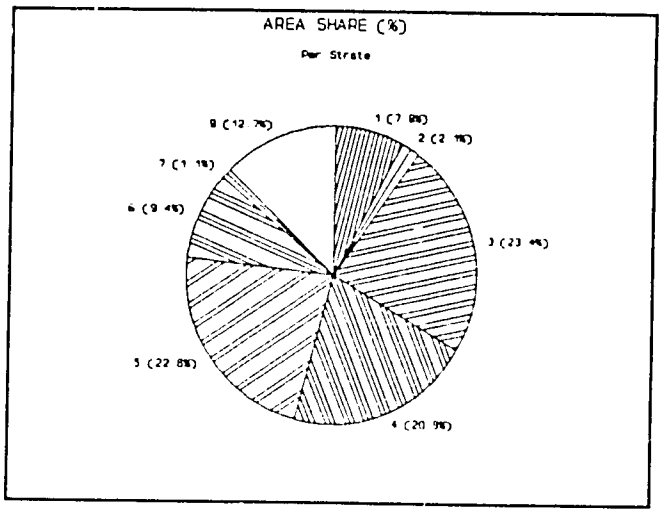
RECOMMENDATION DOMAIN	NET ECONOMIC BENEFITS (1).						AREA	POPULATION
	P1	P2	P3	P4	P1 to P4	%	%	%
Northern non-mechanized mixed farmers	50890	31914	0	0	82804	8	16	12
Northern mechanized mixed farmers	11859	10089	0	0	21948	2	4	3
Center&Plat. non-mech. mixed farmers	118442	72171	19264	37587	247464	23	20	24
Center&Plat. mech. mixed farmers	91805	52177	26907	50626	221515	21	15	18
Southern non-mech. mixed farmers	56171	57547	0	125946	239663	23	23	23
Southern mechanized mixed farmers	13857	24257	0	61283	99398	9	6	6
Northern non-mech. livestock farmers	5826	6129	0	0	11954	1	5	4
Northern mechanized livestock farmers	1148	936	0	0	2084	0	0	0
Southern non-mech. & mech. farmers	18713	41963	0	74042	134718	13	11	11
TOTAL	368712	297182	46171	349483	1061548	100	100	100

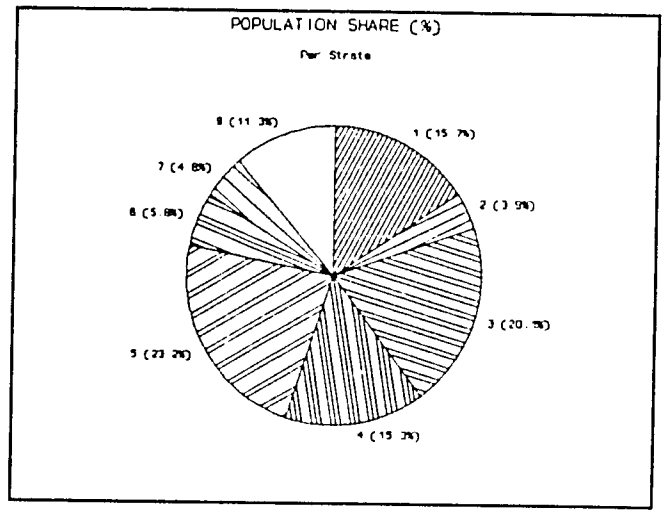
(1) In thousands of CFA francs based on a discount rate of 12%.
P1 : "Millet-cowpea intercropping".
P2 : "Sole millet-cowpea cropping pattern".
P3 : "Groundnut-millet-groundnut rotation".
P4 : "Sesame cultivation".
Source: Synthesis of tables J.3 to J.6 of annex J.

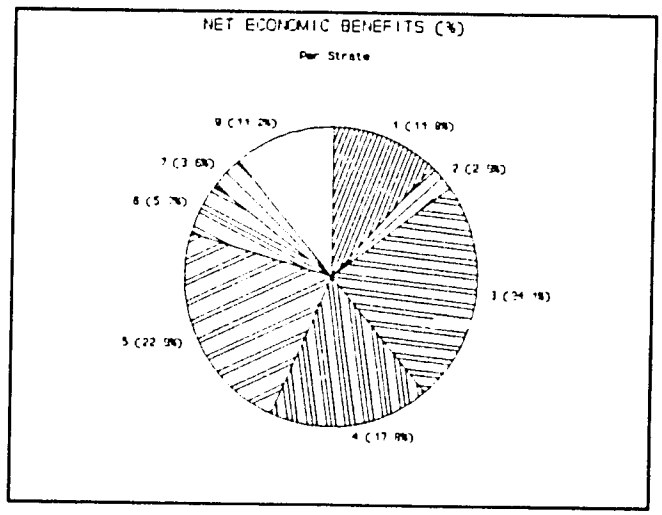
The mixed farmers of the Seno South and Seno Center and Plateau zones account for 71% of the population and 64% of the area cultivated in the project areas. Consequently, their contribution of 77% of the economic value of an expansion of the DRSPR in the Fifth Region represents a slightly higher proportion than the availability of factors of production, i.e. labor and land, would indicate.

Comparison of the last three columns of table 5.12 implicitly indicate whether the increased incomes which would result from an expansion of the DRSPR favor some recommendation domains at the expense of others. Although the inequality in distribution of increased incomes is not really very great, the mixed farmers of Seno North are relatively disadvantaged. This comparison is better visualized with the presentation of the following pies on figure 5.3.

FIGURE 5.3: Share of the Project's Net Benefits by Group of Producers.







Legend:

1. Northern non-mechanized mixed farmers
2. Northern mechanized mixed farmers
3. Center and Plateau non-mechanized mixed farmers
4. Center and Plateau mechanized mixed farmers
5. Southern non-mechanized mixed farmers
6. Southern mechanized mixed farmers
7. Northern non-mechanized livestock farmers
8. Northern mechanized livestock farmers
9. Southern non-mechanized and mechanized farmers

Table 5.13 gives a clearer picture of the distribution of increased incomes according to the three criteria for distinguishing recommendation domains, i.e. agro-climatic zone, farming system and level of technical. The Seno Center, Plateau and Seno South zones are relatively advantaged compared to the Seno North. Mixed farmers and mechanized farms are also relatively advantaged.

All this would suggest that if the work of the DRSPR in the Fifth Region is constrained by human and financial resources, and if the project seeks maximum economic returns, then it should concentrate on the mechanized mixed farmers in the Seno Center, Plateau and Seno South zones. Such an option would, however, be to the disadvantage of other recommendation domains.

The distribution of income within agricultural households could be improved by raising the earnings of women. This could be achieved by improving the productivity of secondary crops such as groundnut and sesame. The "groundnut-millet-groundnut rotation" technical package contributes 10% of the economic value of the project and the "sesame cultivation" technical package contributes 32%. The women's incomes are therefore not penalized by the project. Improving the productivity of the millet and cowpea crops might also raise the earnings of women since they are involved in the processing and the marketing of these two crops. Systems research in the Fifth Region should, therefore, study the women's participation in marketing and intra-family income distribution.

TABLE 5.13: Comparison of the shares in aggregate net economic benefits according to three criteria of stratification (1).

ZONE:	NORTH	CENTER & PLATEAU	SOUTH
Population (%)	19	42	40
Net Benefit (%)	11	44	46

FARMING SYSTEM:	MIXED FARMING	LIVESTOCK
Population (%)	85	15
Net Benefit (%)	86	14

MECHANIZATION:	NON-MECHANIZED	MECHANIZED
Population (%)	73	27
Net Benefit (%)	69	31

(1) In percentages based on a discount rate of 12%.
Source: Adapted from table 5.12.

2. Sensitivity analysis of the economic evaluation.

The method used for sensitivity analysis of the economic value of the project is taken from Bottomley and Contant (1988). The results of this sensitivity analysis are presented in tables K.2 to K.4 in annex K.

The variables included in the sensitivity analysis have been presented in table 5.2, and are as follows:

1) the increase in yields or farm gross benefits,
2) the increase in farm costs,
3) the rate of adoption,
4) the adoption ceiling,
5) the life of the innovation,
6) the cost of the project,
7) the success of systems research,
8) the time needed to move from developing research themes to the extension stage.

The range in values of the variables included in the sensitivity analysis is primarily determined by extremes in the prices of agricultural and livestock products in the weekly markets of the Fifth Region. These extreme values are plus or minus 50% of the median value used in the economic analysis. In order to identify which variables have the greatest potential to render the economic value of the project unstable, the range in values must be the same for each variable included in the sensitivity analysis. For each sensitivity test, the economic value is recalculated at a discount rate of 12%.

a. Sensitivity Analysis Technique.

The increase in gross farm benefit, the increase in farm costs and the cost of the project are the easiest variables to change. Increases and decreases of 10, 20, and 50% suffice.

To avoid numerous and tedious manipulations on every recommendation domain's and technical package's adoption curve, sensitivity analyses for the rate of adoption is carried out on coefficients of an fitted aggregate incremental on-farm net benefits flow. The fitted aggregate incremental on-farm net benefits flow is estimated by regressing the logistic function form presented under the footnote 10 on the aggregate incremental on-farm net benefits flow given on table K.1 in annex K (i.e., total entries - total on-farm costs). This regression gives the fitted coefficients for the logistic function, i.e., the fitted aggregate incremental on-farm net benefits flow. The sensitivity analysis for the rate of adoption is performed by varying the estimated aggregate rate of acceptance 'b' on a ± 10%, ± 20% and ± 50% range, but keeping the aggregate adoption ceiling fixed at its initial value. For each change, the NPV at 12% discount rate is

recorded. This method has been chosen for its simplicity, as otherwise it would have been necessary to vary each adoption coefficient for each recommendation domain and technical package and smooth every adoption curve to keep the initial adoption ceiling unchanged.

The adoption ceiling represents the maximum area on which the proposed technical packages would be employed. To simplify estimation of the change in area resulting from a change in the adoption ceiling, the aggregate incremental on-farm net benefits are increased and decreased by 10, 20, and 50%, starting at the inflexion point. Only for the 50% decrease, the incremental on-farm net benefits flow is reajusted to keep a smooth flow.

The life of an innovation is the period over which it is in use before being superseded by another. Given the current assumption that an innovation has a life of 14 to 15 years[17], increasing or decreasing this by one year represents a 7% change in longevity. One year is taken as approximating a 10% variation. Similarly, a three year increase or decrease in the life of the innovation represents a 20% change, and 7 years 50%.

The success of systems research is best measured by the development of technical packages which can have a significant impact on agricultural incomes, i.e. by an increase in the net benefits accruing to farm households. If the increase in net benefits is small, it could be said that systems research has failed to develop a technical package superior to that already in use. If the increase in net benefits is very large on the other hand, then systems research would have succeeded in its primary task. Net incomes are increased or decreased by 10%, 20%, and 50% to account for the possibility of success or failures in systems research. This technique is used to take account of possible failures that are frequently encountered in research activities, and also differs from that proposed by Bottomley and Contant (1988).

Finally, the time needed to move from developing research themes to the extension stage can be brought forward or delayed according to advances or setbacks in the proposed research program. Given that a minimum of 5 to 6 years is necessary for technical packages developed and tested through systems research to be passed on to pilot extension (see the research program proposed in the preceding chapter), a delay or advance of one year very roughly approaches a 10% variation. A delay or advance of two years approaches a 20% variation, and three years 50%[18]. According to whether the first year of pilot extension is brought

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17/ From the first year of pilot extension (year 6 or 7 of the project) to the last year included in the economic analysis of the project (year 20), there are 14 to 15 years.

18/ It is not possible to choose a better approximation if we want to keep a variation of 10%, 20%, and 50% while maintaining a round number of years.

forward or delayed, so the number of years for the research program is decreased or increased. In the case of a reduction in the time required for the progress of a package to the pilot extension stage of one, two or three years, the cost of the project is reduced accordingly and the salvage value of buildings is brought forward by the same period. In the case of an increase in the period to pilot extension of one, two or three years, the cost of the project is increased accordingly and the salvage value of the buildings is realized later.

b. Results of the Sensitivity Analysis.

Results of the sensitivity analysis of the economic value of the project are given in table K.2 in annex K. This analysis shows that a decrease in the adoption rate of 10% among target groups is sufficient to render the project no longer economically profitable. In the event that incremental gross benefits at farm level decrease by 10%, or costs of production at farm level increase by 10%, the expansion of the DRSPR will become barely profitable. For the other variables a change of at least 20% is necessary to significantly affect the economic profitability of the expansion.

The relative changes in the net present value achieved by an expansion of the DRSPR in the Fifth Region as a result of changes in the eight variables included in the sensitivity analysis are presented in table K.3 in annex K. The eight variables are ranked according to their impact on the project net present value in table K.4 in annex K. This method of ranking is from Bottomley and Contant (1988).

According to this method it is the change in benefits at farm level which renders the net present value most unstable. Next follow, the time needed to move from developing research themes to the extension stage, the change in costs at farm level and the rate of adoption. As indicated in table K.3 in annex K, the other variables have a relatively smaller effect on the stability of the net present value than those mentioned above. Thus, the economic value of an expansion of the DRSPR is highly unstable in regard to the change in gross benefits at farm level, the time needed to move from developing research themes to the extension stage, the change in costs at farm level and the rate of adoption. The variation in the cost of the project, on the other hand, has the least influence on the stability of the project's economic value.

In the design and implementation of the systems research program for the Fifth Region, particular attention must be given to the development of economically profitable and readily adopted technical packages. The economic profitability of a package can be enhanced by developing packages that are not only financially profitable, but

require few imported inputs and yield an exportable product[19]. Adoption of a technical package can be facilitated if the proposed package is simple and financially attractive, and if the institutional and socio-economic environment is supportive. It is therefore desirable that systems research adopts an approach which incorporates both the micro and macro aspects of the Fifth Region's problems, in order to take account of all the factors which have a bearing on the economic value of an expansion of the DRSPR in the Fifth Region. For example, if the marketing margin for inputs in the Fifth Region were halved, the net present value of an expansion of the DRSPR would increase from 648 to 963 thousand US dollars at an opportunity cost of 12%. The internal rate of return would increase by 0.7%.

D. CONCLUSIONS.

This chapter has presented an economic analysis of the research program proposed in the fourth chapter. By not including all the proposed research themes, the economic analysis is partial, and does not reflect all the expected benefits of an expansion of the DRSPR in the Fifth Region. The research themes which were financially evaluated, and subsequently included in the economic analysis, are those relating to rainfed agriculture in the Fifth Region. This choice is the result of the following circumstances. Firstly, the research themes that were selected are based on the most accurate and promising results available. Secondly, development of these themes should lead most rapidly to the achievement of concrete results in terms of increased production. Thirdly, these research themes pertain to large groups of rural producers. Fourthly, these research themes are those which have received most attention from the feasibility study team, given the time and manpower constraints. Although the economic analysis is partial, given the first three circumstances mentioned above this should not materially affect the economic value of an expansion of the DRSPR in the Fifth Region.

The research themes relating to rainfed agriculture have been brought together in four technical packages that the DRSPR could develop and expand among rural people. The four technical packages that have been included in the financial and economic analysis of the expansion of the DRSPR in the Fifth Region, were the following:

- millet-cowpea intercropping;
- sole millet and cowpea cropping pattern;
- groundnut-millet-groundnut rotation;
- sesame cultivation.

19/ By encouraging exports while decreasing imports the economic value of the project is increased at a stroke because the CFA franc in Mali is overvalued compared to other currencies.

A financial analysis of each package valued the incremental gross benefits and incremental costs of production per hectare if these packages were adopted by farmers in the Fifth Region. In order to carry out this analysis, coefficients from the results of station and multilocation trials were adapted to the agro-climatic conditions of farms in the Fifth Region. The prices of inputs are those actually being charged at the present time, and the price of agricultural products are the average annual prices observed in the Fifth Region over the last two years.

Financial analysis of these four technical packages reveals marginal rates of return of between 14 and 269% according to the package, the zone and the level of technical currently used (mechanized or not) by a potential adopter. The marginal return per man day ranks between 411 and 5679 CFA francs (for a opportunity cost of capital of 25%), a figure generally higher than the present opportunity cost of labor. Unprofitable or marginally profitable packages are eliminated for the sensitivity analysis.

The financial results of most of the technical packages are unstable in regard to 10 to 20% changes in prices, yields or costs of production. This indicates that the adoption of these technical packages will be difficult if the market for agricultural products and the technical coefficients of the proposed packages are not stabilized. This implies that increased production from rainfed agriculture in the Fifth Region is conditional upon the reliability of agricultural produce outlets and the yields of technical packages.

The economic analysis of an expansion of the DRSPR in the Fifth Region has been carried out by comparing the increase in gross benefits resulting from adoption of the financially profitable technical packages by groups of producers (defined as recommendation domains) in the Fifth Region to the increase in costs of production and the cost of the expansion of the DRSPR in the Fifth Region. The rates of adoption of technical packages among groups of producers are determined using a realistic baseline, with the important condition that a distribution system for agricultural inputs is working and that market outlets can absorb output at a price equivalent to the average prices recorded during 1987 and 1988. For the economic analysis, financial prices have been adjusted to their economic level.

The economic value of the expansion of the DRSPR in the Fifth Region is estimated to be US $ 648,000 (194 million CFA francs at a rate of exchange of 300 FCFA per 1$ US) at an opportunity cost of capital of 12%. The internal rate of return is estimated to be 14%. The economic value of the expansion of the DRSPR is undervalued since some research themes that the DRSPR might develop in addition to those estimated in this economic analysis are not included in the economic value of the project. Intangible effects of the project also were not included in the economic value of the project. It was hypothesized that the most important external benefits of the project would be food aid and outmigration reductions.

The net benefits resulting from adoption of the technical packages are distributed more or less proportionately to the contribution of each group of producers, in terms of area cultivated and labor. If the expansion of the DRSPR were constrained by manpower or budgetary resources, it would have its greatest impact on mixed farmers located in the Seno Center and South zones and in the Plateau zone.

The distribution of net economic benefits is favorable to women since the technical packages which would mainly affect them contribute 41% of the total net economic benefits. In addition to the direct effects of productivity increases of the secondary crops on women's earnings, some indirect effects are likely to rise from the productivity increases of the food crops, such as millet and cowpea. This should be confirmed by a more detailed study on the women's participating in processing and marketing and on intra-family income distribution.

The economic value of the expansion of the DRSPR in the Fifth Region is highly unstable with regard to changes in incremental gross benefits, the time needed to move from developing research themes to the extension stage, costs of production and the rate of adoption. This implies that the economic value of an expansion of the DRSPR is heavily dependent on the technical packages developed and the socio-economic and institutional environment of the Fifth Region. Systems research in the Fifth Region should therefore focus on the development of simple and financially attractive packages, while taking account of the socio-economic and institutional constraints and proposing measures for enhancing production.

The economic value of the expansion of the DRSPR is increased when the development of technical packages gives rise to incremental output that can be exported. However, for export oriented production to be financially attractive, fiscal measures are necessary in order to compensate for the overvaluation of the CFA franc.

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ANNEXES

ANNEXE A: STATISTIQUES GENERALES DE LA CINQUIEME REGION.

TABLEAU A.1. PLUVIOMETRIE DES CHEFS LIEUX DE CERCLE DE LA REGION DE MOPTI.
COMPARAISON DE LA MOYENNE 1979-87 AVEC LA MOYENNE INTERANNUELLE HISTORIQUE.

SECTEURS	Moyenne interannuelle historique				Moyenne de la deerniere decade		
	Annees	Nbre d'an.	mm	Nbre jrs.	Annees	mm	Nbre jrs.
Bankass	1956-75	19	568.4	48.6	1979 a 1987	458.4	35.2
Koro	1961-75	14	603.1	37.4	1979 a 1987	475.9	31.8
Douentza	1926-75	49	487.1	36.9	1979 a 1987	335.9	29.5
Mopti	1926-75	49	539.4	52.1	1979 a 1987	388.4	37.2
Djenne	1926-75	49	598.2	42.4	1979 a 1987	468.7	34.4
Bandiagara	1926-75	49	565.5	45	1979 a 1987	404.6	33
Tenenkou	1951-75	24	415.4	31.1	1980 a 1987	375.3	28.6
Youwarou	-	-	-	-	1984, 1985, 1987	205.5	18

Source : Rapports Annuels de l'OMM, Mopti.

ANNEXE A.

TABLEAU A.2. SUPERFICIE, POPULATION ET DENSITE DE LA CINQUIEME REGION DU MALI.

Cercles	Superficie (1)	Population (2)	Densite	Nombre d' arrondists
Mopti	7262	243245	33	9
Bandiagara	8219	182869	22	8
Bankass	9504	155999	16	7
Djenne	4561	126083	28	6
Douentza	18903	150608	8	6
Koro	10918	211988	19	7
Tenenkou	11297	114405	10	6
Youwarou	7139	76186	11	6
5eme region	77803	1261383	16	55

Sources : (1) "Recensement Administratif et Fiscal du 2 Mai 1986".Ministere de l'Administration Territoriale et du Developpment a la Base. Republique du Mali.

(2) "Recensement General de la Population et de l'Habitat (du 1er avril au 14 avril 1987)". Ministere de l'Administration Territoriale et du Developpement a la Base. Republique du Mali. Juillet 1987.

ANNEXE A.

TABLEAU A.3. SUPERFICIE, PRODUCTION ET RENDEMENT DU RIZ PADDY EN CINQUIEME REGION (1975-1986).

ANNEES	SUPERFICIE (ha)			PRODUCTION (T)			RENDEMENT (T/Ha)		
	5e Region	Mali	%	5e Region	Mali	%	5e Region	Mali	%
1974/75	68755	137331	50	72351	178643	41	1.052	1.301	81
1975/76	83765	233301	36	51328	196036	26	0.613	0.840	73
1976/77	105511	175448	60	166882	298229	56	1.582	1.700	93
1977/78	101138	244162	41	85049	303203	28	0.841	1.242	68
1978/79	47437	111674	42	33548	158293	21	0.707	1.417	50
1979/80	88411	242534	36	80965	240117	34	0.916	0.990	92
1980/81	60059	142823	42	23988	121553	20	0.399	0.851	47
1981/82	43609	115593	38	31294	134756	23	0.718	1.166	62
1982/83	72660	181624	40	29107	152634	19	0.401	0.840	48
1983/84	76094	187731	41	64045	215986	30	0.842	1.151	73
1984/85	55384	165176	34	4654	109354	4	0.084	0.662	13
1985/86	58708	175355	33	72615	231769	31	1.237	1.322	94
1986/87	69551	215254	32	53818	235852	23	0.774	1.096	71
Moyenne	71861	182556	40	58108	199815	26	0.759	1.106	65
CV(%)	-	24	-	74	31	50	55	25	41
Tendance(%)	-4.0	NSig.	-3	NSig.	NSig.	NSig.	NSig.	NSig.	NSig.

Source : Office Statistique des Communautes Europeennes (Statistique de Base Cereales-Elevage).
Bamako, Mali. Fevrier 1988.

TABLEAU A.4. SUPERFICIE, PRODUCTION ET RENDEMENT DU MIL-SORGHO-FONIO EN CINQUIEME REGION (1974-1986).

ANNEES	SUPERFICIE (ha)			PRODUCTION (T)			RENDEMENT (T/Ha)		
	5e Region	Mali	%	5e Region	Mali	%	5e Region	Mali	%
1974/75	382672	968098	40	278940	963918	29	0.729	0.996	73
1975/76	310714	946553	33	181942	952904	19	0.586	1.007	58
1976/77	319376	931885	34	223427	874336	26	0.700	0.938	75
1977/78	239275	924139	26	171439	1012845	17	0.716	1.096	65
1978/79	266420	1017661	26	171879	949238	18	0.645	0.933	69
1979/80	219978	985533	22	82523	762875	11	0.375	0.774	48
1980/81	286460	1155412	25	167861	734022	23	0.586	0.635	92
1981/82	298467	1337108	22	157922	999097	16	0.529	0.747	71
1982/83	360208	1407861	26	136024	1080240	13	0.378	0.767	49
1983/84	223154	1271938	18	204195	1146889	18	0.915	0.902	101
1984/85	224002	1106827	20	95248	900874	11	0.425	0.814	52
1985/86	188060	946671	20	151679	1245080	12	0.807	1.315	61
1986/87	228436	1262238	18	145230	1287570	11	0.636	1.020	62
Moyenne	263713	1107819	24	157447	995498	16	0.608	0.903	67
CV(%)	18	-	-	29	-	-	33	29	26
Tendance(%)	NSig.	3.0	-5.7	NSig.	5.6	-6.4	NSig.	NSig.	NSig.

Source : Office Statistique des Communautes Europeennes (Statistique de Base Cereales-Elevage).
Bamako, Mali. Fevrier 1988.

ANNEXE A.

TABLEAU A.5. LES SUPERFICIES CULTIVEES (HA) EN MIL-SORGHO-MAIS PAR CERCLE EN CINQUIEME REGION: 1979-1986.

SECTEUR	1979 (1)	%	1980 (1)	%	1981 (1)	%	1982 (1)	%	1983 (1)	%	1984 (2)	%	1985 (2)	%	1986 (1)	%
Mopti	35800	12	39250	12	14100	6	35000	11	35000	12	35875		33000		28000	12
Bandiagara	25400	8	32648	10	12858	5	30950	10	32600	11	31200		32600		28800	12
Douentza	55100	19	60900	18	47550	20	56100	18	49600	17	-		-		36100	15
Bankass	56200	18	62500	19	58200	24	60700	19	54800	19	59860		59250		49500	21
Djenne	23840	8	24000	7	17650	7	23550	7	24200	8	-		-		29300	12
Koro	88700	29	90150	27	73350	30	86500	28	87000	30	82065		35800		62810	26
Tenenkou	16300	5	19940	6	18000	7	21250	7	11200	4	-		-		3940	2
Youwarou	-		-		-		-		-		-		-		-	
Total	305340	100	329388	100	241748	100	314050	100	294400	100	-		-		238450	100

TABLEAU A.6. PRODUCTION DE MIL-SORGHO-MAIS (tonnes) PAR CERCLE EN CINQUIEME REGION : 1979-1986.

SECTEUR	1979(1-2)	%	1980 (1)	%	1981 (1)	%	1982 (1)	%	1983 (1)	%	1984 (2)	%	1985 (2)	%	1986 (2)	%
Mopti	18450		19348	14	6810	5	9100	12	14500	13	18350		11500		10400	11
Bandiagara	-		6945	5	5293	4	2583	3	7400	6	3040		10116		4571	5
Douentza	-		26000	19	26152	18	2438	3	15660	14	-		-		6324	7
Bankass	31470		29000	21	36900	26	3860	5	26300	23	26735		32050		31535	34
Djenne	-		4446	3	8300	6	9000	12	10900	9	-		-		15000	16
Koro	37400		44981	32	51235	36	41316	54	33000	28	14686		26625		22000	24
Tenenkou	-		8631	6	9000	6	8270	11	8100	7	-		-		1970	2
Youwarou	-		-		-		-		-		-		-		-	
Total	-		139351	100	143690	100	76567	100	115360	100	-		-		91800	100

TABLEAU A.7. RENDEMENT DE MIL-SORGHO-MAIS (kg/ha) PAR CERCLE EN CINQUIEME REGION : 1979-1986.

SECTEUR	1979(1-2)	1980 (1)	1981 (1)	1982 (1)	1983 (1)	1984 (2)	1985 (2)	1986 (2)
Mopti	515	493	483	260	414	511	348	371
Bandiagara	-	213	412	83	227	97	310	159
Douentza	-	427	550	43	316	-	-	175
Bankass	560	464	634	64	480	447	541	637
Djenne	-	185	469	382	450	-	-	512
Koro	422	499	699	478	379	179	310	350
Tenenkou	-	433	500	389	723	-	-	500
Youwarou	-							
Moyenne	-	388	535	243	427	-	-	386

Sources: (1) Rapports Annuels de la Direction de l'Operation Mils Mopti.
(2) Rapports Annuels des Secteurs de Developpement Rural ONM.

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ANNEXE A.

TABLEAU A.8. LE CHEPTEL BOVIN, OVIN ET CAPRIN EN 5eme REGION (1977-1987).

ANNEES	BOVINS			OVINS - CAPRINS		
	5e Region	Mali	%	5e Region	Mali	%
1977	1320589	4536747	29	2024000	8532000	24
1978	954000	4603000	21	1553000	8652000	18
1979	1028000	4665000	22	2158000	9933000	22
1980	1426000	5850000	24	2548000	11587000	22
1981	1539000	6396000	24	2384000	12393000	19
1982	1789000	6663000	27	2505000	12437000	20
1983	1352000	5676000	24	2264000	11244000	20
1984	1249000	7137000	18	2130000	10382000	21
1985	852000	4344000	20	1955000	12553000	16
1986	866000	4475000	20	2014000	10340000	19
1987	916600	4600000	20	2316000	11000000	21
Moyenne	1210199	5358704	23	2168273	10823000	20
CV(%)	24	18	15	12	12	10

Source : Office Statistique des Communautes Europeennes (Statistique de Base Cereales - Elevage). Bamako, Mali. Fevrier 1988.

ANNEXE A.

TABLEAU A.9. LE CHEPTEL BOVIN PAR CERCLE DE LA 5eme REGION : 1977-1986.

CERCLES	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Mopti	197975	233000	191000	240000	250000	233000	239000	229000	145000	183000
Djenne	242971	75000	89000	90000	100000	350000	100000	99000	80000	86000
Tenenkou	249720	173000	181000	202000	207000	211000	211000	199000	140000	144000
Youwarou	-	-	-	132000	150000	175000	160000	147000	120000	122000
DELTA	690666	481000	461000	664000	707000	969000	710000	674000	485000	535000
Bandiagara	95613	98000	98000	98000	115000	115000	60000	55000	47000	47000
Douentza	238471	175000	175000	230000	242000	250000	230000	202000	100000	100000
Bankass	106862	100000	114000	250000	290000	270000	192000	181000	130000	125000
Koro	188977	100000	180000	184000	185000	185000	160000	137000	90000	79000
SENO/PLAT.	629923	473000	567000	762000	832000	820000	642000	575000	367000	351000
5e REGION	1320589	954000	1028000	1426000	1539000	1789000	1352000	1249000	852000	886000

Source : Office Statistique des Communautes Europeennes : Statistique de Base Cereales-Elevage. Bamako, Fevrier 1988.

ANNEXE A.

TABLEAU A.10. LE CHEPTEL OVIN-CAPRIN PAR CERCLE DE LA 5eme REGION : 1978-1986.

CERCLES	1978	1979	1980	1981	1982	1983	1984	1985	1986
Mopti	216000	728000	230000	150000	200000	239000	240000	220000	233000
Djenne	143000	151000	700000	80000	120000	80000	110000	90000	90000
Tenenkou	201000	202000	109000	109000	115000	115000	110000	100000	100000
Youwarou	-	-	874000	650000	600000	600000	600000	550000	500000
DELTA	560000	1081000	1913000	989000	1035000	1034000	1060000	960000	923000
Bandiagara	270000	286000	270000	275000	275000	200000	200000	190000	210000
Douentza	289000	306000	350000	385000	500000	475000	470000	450000	477000
Bankass	184000	185000	280000	370000	330000	335000	180000	150000	204000
Koro	250000	300000	365000	365000	365000	220000	220000	205000	200000
SENO/PLAT.	993000	1077000	1265000	1395000	1470000	1230000	1070000	995000	1091000
5e REGION	1553000	2158000	2548000	2384000	2505000	2264000	2130000	1955000	2014000

Source : Office Statistique des Communautes Europeennes : Statistique de Base Cereales-Elevage. Bamako, Fevrier 1988.

ANNEXE A.

TABLEAU A.11. EVOLUTION DE L'EXPORTATION (1) CONTROLEE DU BETAIL SUR PIED

Annees	Bovins	Ovins-Caprins
1980	23357	66597
1981	18058	66247
1982	9587	31084
1983	22704	29737
1984	21399	30895
1985	14383	57797
1986	11979	45110

(1) Pour la Cote d'Ivoire, le Ghana, le Burkina Faso et le Liberia.

Source : Rapports annuels de l'ODEM, Mopti.

ANNEXE A.

TABLEAU A.12. EVOLUTION DE LA COMMERCIALISATION DU POISSON FUME ET SEC.

Annees	Exportation		Interieur		Total Commercialise
	Tonnes	%	Tonnes	%	(Tonne)
1970	5148	46	6048	54	11196
1971	3868	44	4975	56	8843
1972	2850	36	5005	64	7855
1973	1504	29	3719	71	5223
1974	988	28	2586	72	3574
1975	2837	37	4798	63	7635
1976	2747	30	6329	70	9076
1977	1952	25	5754	75	7706
1978	1321	23	4538	77	5859
1979	1954	27	5204	73	7158
1980	2113	24	6754	76	8867
1981	1237	22	4363	78	5600
1982	1270	24	3966	76	5236
1983	543	17	2590	83	3133
1984	399	20	1596	80	1995
1985	376	20	1518	80	1894
1986	796	22	2862	78	3658

Note : De 1970 a 1976 : pour l'ensemble de l'OPM.
De 1977 a 1986 : pour uniquement le port de Mopti.

Source : Rapports annuels de l'OPM, Mopti.

ANNEXE B.

TABLEAU B.1. LES HUITS REGIONS NATURELLES EN 5e REGION REGROUPEES EN TROIS ZONES NATURELLES.

Régions Naturelles	Caractéristiques Principales	Zones Naturelles	Superficie (km2) (a)	Population (b)	Densité hbts/km2
Nord Delta (Bas Delta)	Lacs permanents-Zone inondable limitée-Elevage transhumant et culture de décrue.				
Centre Delta (Moyen Delta)	Zone inondable importante-Elevage transhumant - Riziculture et culture sèche.				
Sud Delta (Haut Delta)	Zone inondable importante-Importance de la riziculture à côté de la culture sèche et pêche.	DELTA(1)	35.889(46%)	606.011(48%)	17
Ouest Delta (Bord du Haut Delta)	Zone exondée proche du Delta-correspond à la zone d'attente pour les transhumants-Riziculture. Culture sèche et pêche.				
Sud Gourma	Zone exondée-Elevage-Culture sèche et en mares.	PLAINE du SENO et SUD-GOURMA (2)			
Séno-Mango	Zone exondée très sableuse-Elevage-Culture extensive de mil et niébé.		33695(43%)	472.503(37%)	14
Séno-Gondo	Zone exondée-Culture de mil et niébé.				
Plateau Dogon	Faible disponibilité en terres cultivables. Culture intensive de mil et maraîchage.	PLATEAU DOGON (3)	8219 (11%)	182.869(15%)	22
La Cinquième Région			77803(100%)	1261383(100%)	16

(1) Cercles de Mopti, Djenné, Ténénkou, Youwarou et les arrondissements de Boré et NGouma du cercle de Douentza.
(2) Cercles de Bankass, Koro et les arrondissements de Boni, Mondoro, Hombori, Douentza Central du cercle de Douentza.
(3) Cercle de Bandiagara.

Sources : Tableau inspiré de "Contribution à l'étude des aspects écologiques, sociaux et techniques de quelques systèmes de production en 5ème Région". Division des Etudes Techniques. Institut d'Economie Rurale. Octobre 1978. Bamako.
Chiffres calculés à partir de :
(a) "Recensement Administratif et Fiscal du 2 Mai 1986". Ministère de l'Administration Territoriale et du Développement à la Base. République du Mali.
(b) "Recensement Général de la Population et de l'Habitat (du 1er au 14 Avril)". Ministère de l'Administration Territoriale et du Développement à la Base. République du Mali. Juillet 1987.

ANNEXE B.

TABLEAU B.2. LES ZONES AGROPEDOCLIMATIQUES DU DELTA INTERIEUR DU NIGER EN CINQUIEME REGION.

Zones	Limites administratives approximatives	Superficies (1)		Population (2)		Densite (hab/km2)
		km2	%	Effectifs	%	
Zone I DELTA-NORD	Cercle de Youwarou, arrondissements de Sendegue et Korientze (cercle de Mopti) et arrondissements de Bore et N'Gouma (cercle de Douentza)	14009	39	148411	25	11
Zone II DELTA-OUEST	Arrondissement de Dioura (Cercle de Tenenkou)	4246	12	13396	2	3
Zone III DELTA CENTRAL	Cercle de Mopti moins arrondissements de Sendegue, Korientze, Soye	5187	14	201199	33	39
	Cercle de Tenenkou moins arrondissements de Dioura et Diafarabe	6161	17	89525	15	15
	Total Zone III	11348	31	290724	48	26
Zone IV DELTA SUD	Cercle de Djenne, arrondissements de Soye (cercle de Mopti) et Diafarabe (cercle de Tenenkou)	6286	18	153480	25	25
DELTA	Cercles de Mopti, Djenne, Tenenkou, Youwarou, arrondissements de Bore et N'Gouma (cercle de Douentza)	35889	100	606011	100	17

Sources : (1) Recensement administratif et fiscal du 2 Mai 1986, Ministere de l'Administration Territoriale et du Developpement a la Base.
(2) Recensement General de la Population et de l'Habitat du 1er au 14 avril 1987. Ministere de l'Administration Territoriale et du Developpement a la Base.

ANNEXE B.

TABLEAU B.3. POTENTIEL DE PRODUCTION DES ZONES AGROPEDOCLIMATIQUES DU DELTA INTERIEUR DU NIGER EN CINQUIEME REGION.

Zones	Pluviometrie(1) Longueur saison agricole (2)	Types de sols et leurs carateristiques (2)	Facteurs limitants(2)	Activites essentielles(2)	Pression Agricole(2)
Zone I DELTA-NORD	200-300 mm (25-45 jrs)	Dunes mortes et/ou aplanies a l'ouest de Dogo et Gatielounou Terrains peu profonds(0-50 cm) Lacs et mares importants	Temperatures elevees. Faible pluviometrie. Terrains hydromorphes mal draines et souvent sales dans les bassins des lacs	Essentiellement elevage. Peche dans les lacs. Culture de decrue	Moyenne a forte autour des lacs et des plaines rizicoles ou a decrue (50-75%). Ailleurs la pression est saisonniere
Zone II DELTA-OUEST	200-450 mm (45-90 jrs)	Dunes aplanies a plaines sableuses au nord de Dioura. Plaines limono-sableuses a argiles au sud, argileuses au sud de Dioura (vertisols dominants). Sol moyennement profond (50-100 cm)	Faible pluviometrie. Erosion eolienne au nord	Cultures pluviales (mil-sorgho, arachide, fonio). Elevage sedentaire et transhumant (zone d'attente).	Nulle a faible au nord et a l'ouest dans le Mema Dioura (0-30%). Faible a moyenne autour de Dioura (30-50%)
Zone III DELTA CENTRAL	300-500 mm (45-90 jrs)	Terrains inondes (50-70%) Plaines limono-argileuses a sable-argileuses. Sol profond (50-100 cm). Terrains hydromorphes (10-30%) dans les bas-fonds du Niger et Bani.	Pluviometrie de plus en plus faible	Riziculture (controlee et naturelle). Cultures pluviales. Peche Elevage. Maraichage.	Forte autour des casiers rizicoles (50-75%) Moyenne sur les plaines exploitees en culture seche (30-50%)
Zone IV DELTA SUD	350-600 mm (90-120 jrs)	Terrains inondables importants Plaines limono-argileuses et argileuses. Sol profond (> 100 cm). Terrains hydromorphes (5-10%)	Peu de contraintes sur les sols mais les crues du Bani sont de plus en plus faibles	Riziculture (controlee et naturelle). Cultures pluviales. Peche Elevage. Maraichage.	Moyenne a forte (50-75%)

Sources : (1) Releves pluviometriques de l'OMM et de l'ORM.
(2) Inspire du PIRT 1983, 1986 et 1987.

ANNEXE B.

TABLEAU B.4. LES ZONES AGROPEDOCLIMATIQUES DE LA PLAINE DU SENO ET DES TERRES CULTIVABLES DU PLATEAU DE BANDIAGARA.

Zone	Limites Administratives (arrondissement)	Classes de sol	Aptitudes des terres	Pluviométrie 1977-1986 (mm)	Pression agricole(2) Densité de popul. (hab/km2)
1	Diankabou-Ouest, Madougou Ouest, Dourou-Est, Koporona-Ouest, Kani-Bonzon Est, Bankass central-Ouest Diallassagou Ouest, Sokoura Ouest, Ouenkoro Ouest, Séguè Est, Wo Est.	Dunes mortes	Très faible potentiel. Sérieuses limitations climatiques et du développement radiculaire. NB : Etroite bande de terres fertiles entre la falaise et les dunes mortes.	300 - 600	Excessive >/ 50
2 NORD	Diankabou Est, Dioungani, Dinangourou.	Dunes aplanies	Faible potentiel. Très sérieuses limitations climatiques.	300 - 400	Très élevée 5 - 15
3 CENTRE ET PLATEAU	Koro Central Nord, Koporona, Madougou, Goundaka, Wo en partie.	Plaine limono-sableuse	Potentiel moyen (1). Très sérieuses limitations climatiques.	400 - 450	Excessive 30 - 50
4 SUD	Toroli, Koro central Sud, Bankas central, Kani-Bonzon Est, Diallassagou Est Sokoura Est, Ouenkoro Centre.	Dunes aplanies	Potentiel moyen. Très sérieuses limitations climatiques et par endroit d'hydromorphie.	450 - 600	Excessive 20 - 40
5	Baye, Ouenkoro Est.	Plaine limoneuse	Potentiel très moyen. Très sérieuses limitations climatiques et d'hydromorphie	500 - 650	Moyenne 5 - 10
6	Bandiagara, Kendie.	Plaine limono-sableuse (sols peu profonds et hydromorphes).	Potentiel moyen. Très sérieuses limitations climatiques, du développement radiculaire et d'hydromorphie	300 - 450	Excessive 20 - 30
7	Douentza Central, Boni Hombori, Mondoro			200-400	

(1) Haut potentiel avec des limitaions climatiques moyennes autour de Koporona.
(2) Excessive : Toutes les cultures arables sont sous cultures mais aussi quelques terres non-arables.
Très élevée : La quasi totalité des terres arables peuvent être sous culture.
Moyenne : Jusqu'à 50 % des terres arables peuvent être actuellement sous culture.

Source : Selon technique de zonage à partir des données du PIRT et de l'OMM.

ANNEXE B.

TABLEAU B.5. Classification des systèmes de production rurale et l'activité de la pêche dans le Delta.

1. Système de production rurale.	Delta Sud	Delta Centre	Delta Ouest	Delta Nord
A) Système agro-pastoral:				
- Sous-système des cultures pluviales	+++	+	++	+
- Sous-système des cultures inondées				
. en submersion libre	++	+++	-	+
. en submersion contrôlée	++	+++	-	-
. en P.P.I.V	+	++	-	+
- Sous-système des cultures de décrue	-	-	-	+++
- Les agro-pêcheurs				
B) Système pastoral:				
- Sous-système nomade	-	-	+	+
- sous-système transhumant	++	++	++	++
2. Activité de la pêche:				
- Type nomade	+	+	-	++
- type semi-nomade	+	+	-	++

ANNEXE B.

TABLEAU B.6. LES SYSTEMES DE PRODUCTION IDENTIFIES POUR LA PLAINE DU SENO ET LES PLAINES CULTIVABLES DU PLATEAU DE BANDIAGARA.

Système	Groupe de producteurs	Situation Géographique	Pédo-morphologie	Pluviométrie (mm)	Accès aux Marchés	Pression agricole (1)
Agropastoral (Dogon)	I	Nord	Dunes aplanies	300-400	Enclavé	Très élevée
	II	Centre et Plateau	Plaine limono-sableuse	400-450	Désenclavé	Excessive
	III	Sud	Dunes aplanies	450-650	Enclavé	Excessive
Pastoral (Peul)	IV	Nord	Dunes aplanies	300-400	Enclavé	Très élevée
	V	Sud	Dunes aplanies	450-600	Enclavé	Excessive

(1) Selon le PIRT, 1986:
Très élevée : La quasi totalité des terres peuvent être sous culture.
Excessive : Toutes les cultures arables sont sous cultures mais aussi quelques terres non-arables.

Sources : Enquête informelle. Projet IER-USAID-MSU. Dernière décade du mois d'août 1987.

ANNEXE C: TESTS DU PNT SUR DEUX ROTATIONS TRIENNALES.

1. RESULTATS AGRONOMIQUES DE LA PREMIERE SERIE DE TESTS (1979-81).

TABLEAU C.1. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI EN PREMIERE ANNEE (1979).

Sites	Pluviometrie utile (mm)	Rendement en kg/ha			
		Arachide avec PNT	Arachide sans PNT	Mil avec PNT	Mil sans PNT
Tanoua-Iby	198	731	657	50	86
Ourokorolin	386	907	653	1189	375
Moyenne du Centre	292	819	655	619	230
Sokoro	445	856	584	1133	783
Moyenne du Sud	445	856	584	1133	783

Source : SAFGRAD, Rapport Annuel 1979, Bamako.

TABLEAU C.2. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI EN DEUXIEME ANNEE (1980).

Sites	Pluviometrie utile (mm)	Rendement en kg/ha			
		Mil avec PNT *	Mil sans PNT *	Mil avec PNT	Mil sans PNT
Tanoua-Iby	442	1094	352	909	281
Ourokorolin	373	1385	518	845	480
Moy. Seno Centre	408	1239	435	877	380
Sokoro	402	1037	842	1011	614
Moy. Seno Sud	402	1037	842	1011	614

* : Mil venant apres arachide.

Source : SAFGRAD, Rapport Annuel 1980, Bamako.

ANNEXE C.

TABLEAU C.3. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI EN TROISIEME ANNEE (1981).

Sites	Pluviometrie utile (mm)	Rendement en kg/ha			
		Arachide avec PNT	Arachide sans PNT	Mil avec PNT	Mil sans PNT
Tanoua-Iby	292	419	186	405	236
Ourokorolin	419	464	424	933	867
Moy. Seno Centre	356	441	305	669	551
Sokoro	482	264	209	800	158
Moy. Seno Sud	482	264	209	800	158

Source : SAFGRAD, Rapport Annuel 1981, Bamako.

ANNEXE C.

2. RESULTATS AGRONOMIQUES DE LA DEUXIEME SERIE DE TESTS (1980-82).

TABLEAU C.4. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI EN PREMIERE ANNEE (1980).

Sites	Pluviometrie utile (1) (mm)	Rendement en kg/ha			
		Arachide avec PNT	Arachide sans PNT	Mil avec PNT	Mil sans PNT
Diambadougou	468	425	775	770	389
Doundoun	469	926	666	749	618
Piron	508	848	699	1331	979
Moyenne du Plateau	482	1066	713	950	662
Diankabou	-	1082	949	614	275
Dioungani	434	370	311	1440	928
Moy. Seno Nord	434	1082	949	1027	601
Diomon	315	255	213	285	294
Bawema	355	370	351	531	214
Ourokoun	443	231 (N)	256 (N)	1030	835
Gomossagou	258	494	376	753	640
Koporo-Pen	561	101 (N)	104 (N)	755	253
Sogossin	288	352 (W)	197 (W)	598	554
Tere	575	620	696	602	656
Dangatene	389	11 (N)	7 (N)	1312	1363
Moy. Seno Centre	398	434	409	733	601
Toroly	495	74	59	928	864
Lessagou	336	524	524	1242	480
Moy. Seno Sud	416	299	291	1085	672

N = Niebe
W = Wandzou
(1) Selon Rapports Annuels de l'OMM.

Source : SAFGRAD, Rapport Annuel 1980, Bamako.

ANNEXE C.

TABLEAU C.5. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI EN DEUXIEME ANNEE (1981).

Sites	Pluviometrie utile (1) (mm)	Rendement en kg/ha			
		Mil avec PNT *	Mil sans PNT *	Mil avec PNT	Mil sans PNT
Diambadougou	200	370	183	179	113
Doundoun	241	113	54	99	41
Piron	284	483	273	205	127
Moyenne du Plateau	242	322	170	161	94
Diankabou	355	502	399	645	460
Dioungani	206	451	354	362	88
Moyenne du Nord	281	476	376	336	183
Diomon	341	729	638	768	762
Bawena	346	720	474	332	122
Ourokoun	302	894	619	532	307
Gomossagou	63°	149	157	139	121
Koporo-Pen	264	691	405	626	362
Sogossin	362	785	555	639	416
Tere	509	501	484	475	345
Dangateme	305	987	961	819	801
Moyenne du Centre	358	682	537	541	404
Toroly	444	659	633	621	467
Lessagou	450	713	508	755	456
Moyenne du Sud	447	686	570	688	461

* : Mil venant apres arachide.

Source : SAFGRAD, Rapport Annuel 1981, Bamako.

ANNEXE C.

TABLEAU C.6. RESULTATS AGRONOMIQUES DES TESTS DE PHOSHATE DE TILEMSI SUR ARACHIDE EN TROISIEME ANNEE (1982).

Sites	Pluviometrie utile (1) (mm)	Rendement en kg/ha	
		Arachide avec PNT	Arachide sans PNT
Piron	185	193	90
Moyenne du Plateau	185	193	90
Diankabou	240	414	377
Moyenne du Nord	240	414	377
Diomon	300	99	59
Bawena	129	422	333
Ourokoun	274	278	181
Sogossin	284	170	171
Tere	410	274	274
Dangatene	293	226	344
Moy. Seno Centre	282	245	227
Toroly	268	237	75
Lessagou	233	178	84
Moy. Seno Sud	250	207	79

Source : SAFGRAD, Rapport Annuel 1982, Bamako.

ANNEXE C.

TABLEAU C.7. RESULTATS AGRONOMIQUES DES TESTS DE PHOSPHATE DE TILEMSI SUR MIL EN TROISIEME ANNEE (1982).

Sites	Pluviometrie utile (1) (mm)	Rendement en kg/ha	
		Mil avec PNT	Mil sans PNT
Diambadougou	166	211	93
Doundoun	106	211	101
Piron	185	251	230
Moyenne du Plateau	152	224	141
Diankabou	240	348	274
Dioungani	209	532	526
Moyenne du Nord	224	440	400
Diomon	300	685	415
Bawema	129	837	133
Ourokoun	274	736	488
Gomossagou	367	192	141
Koporo-Pen	175	229	38
Sogossin	284	322	264
Tere	410	304	274
Dangateme	293	599	657
Moyenne du Centre	279	488	301
Toroly	250	407	252
Lessagou	233	186	71
Moyenne du Sud	241	296	161

Source : SAFGRAD, Rapport Annuel 1982, Bamako.

ANNEXE D: TEMPS DE TRAVAUX DES OPERATIONS CULTURALES.

TABLEAU D.1: TEMPS DE TRAVAUX DES OPERATIONS CULTURALES DE L'ASSOCIATION MIL-NIEBE (Revue de la literature).

REFERENCE:	COHEN	DPE		SHULMAN		VALLEE		BA	
DESCRIPTION DE L'UP:									
Population de l'UP	8.0	11.0	22.6						
Nbre d'actifs	5.8	6.0	12.2						
Equipement	daba	daba	charrue	daba	charrue	daba	charrue	daba	charrue
Sup. totale (ha)	8.3	6.4	8.0						
Sup. en mil (ha)	7.9	6.4	8.0						
OPERATIONS CULTURALES:									
Nettoyage		3.9	3.7				|	12.0	
Preparation du sol	0.1	0.2	0.1		6.3		5.0 |		6.0
Semis du mil	1.4	6.7	8.2	3.1	3.1			2.0	2.0
Semis du niebe	0.9								
Semis du dah	0.4								
Fertilisation	0.5								
Demariage								4.0	
1er sarclage	22.9 |	22.0	28.8	20.0	4.6	37.5	|	18.0	10.0
2eme sarclage	17.9 |			15.0	4.6		|		5.0
Traitement phytosanitaire									
Recolte du mil	6.9	6.9	8.1				|	25.0	27.0
Recolte du niebe	1.3								
Recolte du dah	0.6								
Battage et vannage							|		
Transport |	1.3	2.2	1.8				|		
Stockage |							|		
Sous total	54.0	41.9	50.7	38.1	18.6			61.0	50.0
Main d'oeuvre exterieure		1.3	1.0						
TOTAL	54.0	43.2	51.7	38.1	18.6			61.0	50.0
RENDEMENT (kg/ha):									
Mil	532.0	287.0	215.0		+ 20%	600.0	720.0		
Niebe	26.0								
Dah	11.0								

(1) Daba: houe manuelle
Charrue: charrue TM a traction bovine
Houe as.: Multiculteur a traction asine

Sources:
Cohen (1981): Village du Seno, 12 km sud de Bankass, 1978, 506mm, moyenne sur 19 champs de brousse mil-niebe et 18 champs de case mil-niebe-dah.
DPE (1986): ZER de Toroli (286mm) et Diallassagou (323mm), 1984, 34 UP non equipees et 14 UP equipees dans 6 villages.
Shulman (1979): Estimations generales pour le Mali.
Vallee et Simpara (1980): Estimations generales pour la plaine du Seno.
Ba, Zerbo and Diarra (1982): Mali Sud.

ANNEXE D.

TABLEAU D.1 (SUITE): TEMPS DE TRAVAUX DES OPERATIONS CULTURALES DE L'ASSOCIATION MIL-NIEBE (Revue de la literature).

REFERENCE:	DELGADO		OMM		DMA		ESTIMATIONS		
DESCRIPTION DE L'UP:									
Population de l'UP									
Nbre d'actifs									
Equipement	daba	charrue	daba	charrue	houe as.	charrue	daba	houe as.	charrue
Sup. totale (ha)									
Sup. en mil (ha)									
OPERATIONS CULTURALES:									
Nettoyage							2.0		
Preparation du sol	42.0	20.0				4.0		2.0	4.0
Semis du mil							3.0	3.0	3.0
Semis du niebe							1.0	1.0	2.0
Semis du dah									
Fertilisation									2.0
Demariage									
1er sarclage |	30.0	25.0			2.0		25.0	10.0	6.0
2eme sarclage |							16.0	10.0	6.0
Traitement phytosanitaire									2.0
Recolte du mil	29.0	34.0					7.0	7.5	10.0
Recolte du niebe							2.0	2.0	6.0
Recolte du dah									
Battage et vannage									
Transport							8.0	3.5	5.0
Stockage									
Sous total	101.0	79.0	63.0	50.0			64.0	39.0	46.0
Main d'oeuvre exterieure									
TOTAL	101.0	79.0	63.0	50.0			64.0	39.0	46.0
RENDEMENT (kg/ha):									
Mil		500.0	500.0	700.0			500.0	550.0	800.0
Niebe							40.0	45.0	180.0
Dah									

(1) Daba: houe manuelle
Charrue: charrue TM a traction bovine
Houe as.: Multiculteur a traction asine

Sources:
Delgado and McIntire (1982): Tenkodogo (BF) pour les UP manuelles et Segou pour les UP equipees.
OMM (1986-87): SDR de Koro, Bankass, Douentza, Bandiagara, Mopti (454mm) et Tenenkou, 1986-87, 30 UP par stade technologique.
DMA: Communication personnelle, aout 1988, A. Toure, Chef du centre d'experimentation, DMA.
ESTIMATIONS: Ajustement selon les sources ci-dessus.

ANNEXE E: VALEURS FINANCIERES ET ECONOMIQUES.

TABLEAU E.1: COURS DU PETIT MIL SUR LES MARCHES DES CERCLES DE LA CINQUIEME REGION, DE TOMBOUCTOU ET GAO
(Prix en F.CFA pour 1 kg de mil)

Mois	Mopti	Bandiagara	Bankass	Djenne	Douentza	Koro	Tenenkou	Youwarou	Tombouctou	Gao
Juillet 1986	65	70	60	60	85	65	55	100	100	95
Aout	75	96	60	60	90	65	NA	NA	100	110
Septembre	65	70	60	60	75	60	65	100	100	95
Octobre	65	65	50	NA	NA	65	60	80	140	85
Novembre	50	55	30	35	70	45	45	75	145	85
Decembre	55	55	25	35	75	40	60	75	100	75
Janvier 1987	55	45	28	35	75	45	50	70	115	70
Fevrier	40	45	30	35	70	35	50	65	90	60
Mars	40	45	30	35	NA	40	NA	60	110	60
Avril	55	50	NA	40	NA	40	50	65	80	75
Mai	55	60	45	50	60	35	50	NA	110	75
Juin	50	65	50	40	65	45	65	70	110	75
Juillet	65	60	45	40	70	50	50	80	135	80
Aout	80	75	65	60	75	55	65	80	110	80
Septembre	75	75	55	60	75	60	70	90	100	75
Octobre	65	65	55	55	65	55	65	85	100	75
Novembre	70	65	60	60	NA	60	75	80	100	90
Decembre	65	70	55	NA	NA	45	75	80	100	90
Janvier 1988	75	75	60	60	90	50	75	NA	100	85
Fevrier	100	85	80	70	100	80	75	120	115	100
Mars	105	100	90	95	120	100	100	130	135	125
Avril	110	105	90	95	120	100	110	140	135	125
Mai	100	115	100	90	125	100	125	150	150	125
Juin	130	135	110	110	NA	105	150	150	165	150
Juillet	150	200	130	160	160	160	165	165	165	160
Aout	135	165	125	160	NA	130	125	NA	185	150
Septembre	110	115	100	NA	135	120	80	130	165	130
Octobre 86 - Septembre 88:										
Moyenne	79	83	66	68	91	69	80	97	123	96
Ecart type	30	39	31	37	29	34	33	33	27	29
C.V. (%)	38	46	47	55	32	49	41	34	22	30

Source: Bulletins Mensuels. Systeme d'Alerte Precoce.
Ministere de l'Administration Territoriale et du Developpement a la Base.

ANNEXE E.

TABLEAU E.2: MARGE COMMERCIALE BRUTE (FCFA et %) POUR LE MIL ENTRE LES MARCHES DE MOPTI ET CEUX DE LA 5eme REGION, DE TOMBOUCTOU ET DE GAO

Mois	Bandiagara		Banbass		Djenne		Douentza		Koro		Tenenkou		Youwarou		Tombouctou		Gao	
	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%
Juillet 1986	-5	-8	5	8	5	8	-20	-31	0	0	10	15	-35	-54	-35	-54	-30	-46
Aout	-21	-28	15	20	15	20	-15	-20	10	13	NA	NA	NA	NA	-25	-33	-35	-47
Septembre	-5	-8	5	8	5	8	-10	-15	5	8	0	0	-35	-54	-35	-54	-30	-46
Octobre	0	0	15	23	NA	NA	NA	NA	0	0	5	8	-15	-23	-75	-115	-20	-31
Novembre	-5	-10	20	40	15	30	-20	-40	5	10	5	10	-25	-50	-95	-190	-35	-70
Decembre	0	0	30	55	20	36	-20	-36	15	27	-5	-9	-20	-36	-45	-82	-20	-36
Janvier 1987	10	18	27	49	20	36	-20	-36	10	18	5	9	-15	-27	-60	-109	-15	-27
Fevrier	-5	-13	10	25	5	13	-30	-75	5	13	-10	-25	-25	-63	-50	-125	-20	-50
Mars	-5	-13	10	25	5	13	NA	NA	0	0	NA	NA	-20	-50	-70	-175	-20	-50
Avril	5	9	NA	NA	15	27	NA	NA	15	27	5	9	-10	-18	-25	-45	-20	-36
Mai	-5	-9	10	18	5	9	-5	-9	20	36	5	9	NA	NA	-55	-100	-20	-36
Juin	-15	-30	0	0	10	20	-15	-30	5	10	-15	-30	-20	-40	-60	-120	-25	-50
Juillet	5	8	20	31	25	38	-5	-8	15	23	15	23	-15	-23	-70	-108	-15	-23
Aout	5	6	15	19	20	25	5	6	25	31	15	19	0	0	-30	-38	0	0
Septembre	0	0	20	27	15	20	0	0	15	20	5	7	-15	-20	-25	-33	0	0
Octobre	0	0	10	15	10	15	0	0	10	15	0	0	-20	-31	-35	-54	-10	-15
Novembre	5	7	10	14	10	14	NA	NA	10	14	-5	-7	-10	-14	-30	-43	-20	-29
Decembre	-5	-8	10	15	NA	NA	NA	NA	20	31	-10	-15	-15	-23	-35	-54	-25	-38
Janvier 1988	0	0	15	20	15	20	-15	-20	25	33	0	0	NA	NA	-25	-33	-10	-13
Fevrier	15	15	20	20	30	30	0	0	20	20	25	25	-20	-20	-15	-15	0	0
Mars	5	5	15	14	10	10	-15	-14	5	5	5	5	-25	-24	-30	-29	-20	-19
Avril	5	5	20	18	15	14	-10	-9	10	9	0	0	-30	-27	-25	-23	-15	-14
Mai	-15	-15	0	0	10	10	-25	-25	0	0	-25	-25	-50	-50	-50	-50	-25	-25
Juin	-5	-4	20	15	20	15	NA	NA	25	19	-20	-15	-20	-15	-35	-27	-20	-15
Juillet	-50	-33	20	13	-10	-7	-10	-7	-10	-7	-15	-10	-15	-10	-15	-10	-10	-7
Aout	-30	-22	10	7	-25	-19	NA	NA	5	4	10	7	NA	NA	-50	-37	-15	-11
Septembre	-5	-5	10	9	NA	NA	-25	-23	-10	-9	30	27	-20	-18	-55	-50	-20	-18
Octobre 86 - Septembre 88:																		
Moyenne	-4	-4	15	21	11	18	-12	-19	10	15	1	1	-19	-28	-44	-69	-17	-26
Ecart type	13	13	7	13	12	13	10	20	10	13	13	16	9	15	20	49	8	18

Source: Bulletins Mensuels. Systeme d'Alerte Precoce.
Ministere de l'Administration Territoriale et du Developpement a la Base.

ANNEXE E.

TABLEAU E.3: HYPOTHESE DES PRIX FINANCIERS SELON LES ZONES AGROCLIMATIQUES (FCFA financiers).

PRODUITS ET INTRANTS	SUD		CENTRE/PLATEAU		NORD	
	BUDGETISE	ACTUEL(9)	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Semence de mil (FCFA/kg) (1)	69	50	69	55	69	60
Semence de niebe (FCFA/kg)	200	150	200	160	200	180
Semence d'arachide (FCFA/kg)	80	50	80	60	80	80
Semence de sesame (FCFA/kg)	150		150		150	
APRON + (FCFA/sachet)	300		300		300	
Thioral (FCFA/sachet) (2)	63	63	63	63	63	63
Decis (FCFA/L)	1870		1870		1870	
Actellic (FCFA/sachet)	220		220		220	
Phostoxin (FCFA/comprime)	200		200		200	
Sac plastique (FCFA/sac)	500		500		500	
Phosphate naturel Tilemsi(FCFA/kg)(3)	35		35		35	
Phosphate d'amoniaque (FCFA/kg) (3)	170		170		170	
Phosphate super simple(FCFA/kg) (4)	70		70		70	
Uree (FCFA/kg) (3)	160		160		160	
Appareil T 15 (FCFA/unite) (4)	19130		19130		19130	
Charrue TM Smecma (FCFA/unite) (5)	44200		44200		44200	
Houe asine Smecma (FCFA/unite) (5)	39400	39400	39400	39400	39400	39400
Paire de boeufs de labour (FCFA)	80000	80000				
Ane (FCFA)	20000	20000	25000	25000	20000	20000
Mil (FCFA/kg)	50	30	60	40	70	50
Niebe (FCFA/kg)	100	60	110	70	120	80
Arachide (FCFA/kg)	50	35	55	40	60	40
Sesame (FCFA/kg)	70		75		70	
Betail sur pied (FCFA/kg)	200	200	250	250	200	200
Fane de niebe (FCFA/kg)	12	12	15	15	12	12
Fane d'arachide (FCFA/kg)	12	12	15	15	12	12
Opportunite de la main d'oeuvre (FCFA/jour):						
(6)	350	350	451	451	398	398
(7)	463	463	614	614	539	539
Opportunite du fumier (FCFA/T)	1000	1000	1500	1500	1000	1000
Inflation estimee (%) (8)	6	6	6	6	6	6

(1) Prix de vente OPSS (1988) augmente de 10% pour le transport en 5eme region.
(2) Prix de vente SMPC (1988) augmente de 10% pour le transport en 5eme region.
(3) Prix comptant aux producteurs CMDT (1988) augmente de 10% pour le transport en 5eme region.
(4) Prix d'achat OHV (1988) augmente de 10% pour le transport en 5eme region.
(5) Prix sorti usine SMECMA (1988) augmente de 10% pour le transport en 5eme region.
(6) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle.
(7) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle amelioree (equipe).
(8) Estimation utilisee pour le calcul du taux d'interet reel.
(9) ACTUEL: Valeurs observees lors des enquetes et utilisees pour les budgets relatifs a la technologie traditionnelle et la technologie traditionnelle amelioree.
BUDGETISE: Valeurs estimees et utilisees pour les budgets relatifs aux paquets technologiques proposes.

ANNEXE E.

TABLEAU E.4: HYPOTHESE DES PRIX ECONOMIQUES ET DES COUTS D'OPPORTUNITE SELON LES ZONES AGROCLIMATIQUES (FCFA economiques) en utilisant la methode du taux de change de reference (Gittinger, 1985).

PRODUITS ET INTRANTS	%	SUD		CENTRE/PLATEAU		NORD	
		BUDGETISE	ACTUEL	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Prime de change(%) (1)	33						
Semence de mil (FCFA/kg) (2)		69	50	69	55	69	60
Subvention	20	14		14		14	
Valeur economique(FCFA/kg)		83	50	83	55	83	60
Semence de niebe (FCFA/kg)		200	150	200	160	200	180
Subvention	20	40		40		40	
Valeur economique(FCFA/kg)		240	150	240	160	240	180
Semence d'arachide (FCFA/kg)		80	50	80	60	80	80
Subvention	20	16		16		16	
Valeur economique(FCFA/kg)		96	50	96	60	96	80
Semence de sesame (FCFA/kg)		150		150		150	
Subvention	20	30		30		30	
Valeur economique(FCFA/kg)		180		180		180	
APRON + (FCFA/sachet)		300		300		300	
Element importe	80	240		240		240	
Element national	20	60		60		60	
Droit entree (3)	0	0		0		0	
CPS (4)	5	12		12		12	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/kg)		363		363		363	
Thioral (FCFA/sachet) (5)		63	63	63	63	63	63
Element importe	80	50	50	50	50	50	50
Element national	20	13	13	13	13	13	13
Droit d'entree	0	0	0	0	0	0	0
CPS	5	3	3	3	3	3	3
Autres taxes	0	0	0	0	0	0	0
Subvention	0	0	0	0	0	0	0
Valeur economique(FCFA/kg)		76	76	76	76	76	76
Decis (FCFA/L)		1870		1870		1870	
Element importe	80	1496		1496		1496	
Element national	20	374		374		374	
Droit d'entree	0	0		0		0	
CPS	5	75		75		75	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/L)		2264		2264		2264	
Actellic (FCFA/sachet)		220		220		220	
Element importe	80	176		176		176	
Element national	20	44		44		44	
Droit d'entree	0	0		0		0	
CPS	5	9		9		9	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/L)		266		266		266	

ANNEXE E.

TABLEAU E.4(SUITE): HYPOTHESE DES PRIX ECONOMIQUES ET DES COUTS D'OPPORTUNITE SELON LES ZONES AGROCLIMATIQUES (FCFA economiques) en utilisant la methode du taux de change de reference (Gittinger, 1985).

PRODUITS ET INTRANTS	%	SUD		CENTRE/PLATEAU		NORD	
		BUDGETISE	ACTUEL	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Phostoxin (FCFA/comprime)		200		200		200	
Element importe	80	160		160		160	
Element national (6)	20	40		40		40	
Droit d'entree	0	0		0		0	
CPS	5	8		8		8	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/unite)		242		242		242	
Sac plastique (FCFA/sac)		500		500		500	
Element importe	80	400		400		400	
Element national	20	100		100		100	
Droit d'entree	0	0		0		0	
CPS	5	20		20		20	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/unite)		605		605		605	
Phosphate naturel Tilemsi(FCFA/kg)(7)		35		35		35	
Subvention	0	0		0		0	
Valeur economique(FCFA/kg)		35		35		35	
Phosphate d'amoniaque (FCFA/kg) (7)		170		170		170	
Element importe	80	136		136		136	
Element national	20	34		34		34	
Droit d'entree	0	0		0		0	
CPS	5	7		7		7	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/kg)		206		206		206	
Phosphate super simple (FCFA/kg) (8)		50		60		70	
Element importe	80	40		48		56	
Element national	20	10		12		14	
Droit d'entree	0	0		0		0	
CPS	5	2		2		3	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/kg)		61		73		85	
Uree (FCFA/kg) (7)		160		160		160	
Element importe	80	128		128		128	
Element national	20	32		32		32	
Droit d'entree	0	0		0		0	
CPS	5	6		6		6	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/kg)		194		194		194	
Appareil T 15 (FCFA/unite) (8)		19130		19130		19130	
Element importe	80	15304		15304		15304	
Element national	20	3826		3826		3826	
Droit d'entree	0	0		0		0	
CPS	5	765		765		765	
Autres taxes	0	0		0		0	
Subvention	0	0		0		0	
Valeur economique(FCFA/unite)		23163		23163		23163	

ANNEXE E.

TABLEAU E.4(SUITE): HYPOTHESE DES PRIX ECONOMIQUES ET DES COUTS D'OPPORTUNITE SELON LES ZONES AGROCLIMATIQUES (FCFA economiques) en utilisant la methode du taux de change de reference (Gittinger, 1985).

PRODUITS ET INTRANTS	%	SUD		CENTRE/PLATEAU		NORD	
		BUDGETISE	ACTUEL	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Charrue TM Smecma (FCFA/unite) (9)		44200		44200		44200	
Element importe	80	35360		35360		35360	
Element national	20	8840		8840		8840	
Droit d'entree	0	0		0		0	
CPS	5	1768		1768		1768	
Autres taxes	0	0		0		0	
Subvention	8	3536		3536		3536	
Valeur economique(FCFA/unite)		57053		57053		57053	
Houe asine Smecma (FCFA/unite) (9)		39400	39400	39400	39400	39400	39400
Element importe	80	31520	31520	31520	31520	31520	31520
Element national	20	7880	7880	7880	7880	7880	7880
Droit d'entree	0	0	0	0	0	0	0
CPS	5	1576	1576	1576	1576	1576	1576
Autres taxes	0	0	0	0	0	0	0
Subvention	8	3152	3152	3152	3152	3152	3152
Valeur economique(FCFA/unite)		50858	50858	50858	50858	50858	50858
Paire de boeufs de labour (FCFA)		80000	80000				
Ane (FCFA)		20000	20000	25000	25000	20000	20000
Mil (FCFA/kg)		50	30	60	40	70	50
Niebe (FCFA/kg)		100	60	110	70	120	80
Arachide (FCFA/kg)		50	35	55	40	60	40
Ajust.prix front./c	0	0	0	0	0	0	0
Valeur economique(FCFA/unite)		50	35	55	40	60	40
Sesame (FCFA/kg)		70		75		70	
CPS (10)	3	2		2		2	
Taxe d'exportation	5	4		4		4	
Valeur economique(FCFA/unite)		101		108		101	
Betail sur pied (FCFA/kg)		200	200	250	250	200	200
Fane de niebe (FCFA/kg)		12	12	15	15	12	12
Fane d'arachide (FCFA/kg)		12	12	15	15	12	12
Opportunite de la main d'oeuvre (FCFA/jour):							
(11)		350	350	450	450	398	398
(12)		444	444	590	590	512	512
Opportunite du fumier (FCFA/T)		1000	1000	1500	1500	1000	1000
Taux d'interet economique(%)		12	12	12	12	12	12

(1) En tenant compte seulement du deficit de la balance de paiements et non de la structure de protection au Mali (Stryker et al., 1987).
(2) Prix de vente OPSS (1988) augmente de 10% pour le transport en 5eme region.
(3) Droit d'entree comprenant le droit de douane (DD), le droit fiscal d'importation (DFI) et la taxe de l'Office de Stabilisation et de Regularisation des Prix (OSRP).
(4) Contribution pour Prestations de Services particuliers rendus a l'importation.
(5) Prix de vente SNPC (1988) augmente de 10% pour le transport en 5eme region.
(6) La marge commerciale maximale autorisee est fixee a 20% sur la valeur importee hors taxe a la SMEEPC pour les engrais et les pesticides.
(7) Prix comptant aux producteurs CMDT (1988) augmente de 10% pour le transport en 5eme region.
(8) Prix d'achat OHV (1988) augmente de 10% pour le transport en 5eme region.
(9) Prix sorti usine SMECMA (1988) augmente de 10% pour le transport en 5eme region.
(10) Contribution pour Prestations de Services particuliers rendus a l'exportation.
(11) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle.
(12) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle ameliorée (equipe).

Note: Le prix economique des intrants est calcule de cette facon: (Prime de change en % / 100 + 1) * (Element importe - Droit d'entree - CPS) + (Element national - Autres taxes + Subvention).
Le prix economique des produits est calcule de cette facon:
(Prime de change en % / 100 + 1) * (Prix au producteur + Taxes d'exportation

ANNEXE E.

TABLEAU E.5: CALCUL DES CHARGES ANNUELLES FINANCIERES SELON LES ZONES AGROCLIMATIQUES(FCFA/HA/AN)(1).

EQUIPEMENT	SUD		CENTRE/PLATEAU		NORD	
	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Appareil T 15:						
Periode du pret(an)	4		4		4	
Taux d'interet nominal BNDA(%)	9		9		9	
Taux d'interet reel(%)	3		3		3	
Coeff. de recuperation du capital	0.27		0.27		0.27	
Annuite constante(FCFA/an)	5146		5146		5146	
Entretien(FCFA/an)	500		500		500	
Superficie (Ha)	4		4		4	
Charge annuelle(FCFA/Ha/an)	1412		1412		1412	
Materiel agricole:	CharrueTM	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.
Periode du pret(an)	4	4	4	4	4	4
Taux d'interet nominal BNDA(%)	9	9	9	9	9	9
Taux d'interet reel(%)	3	3	3	3	3	3
Coeff. de recuperation du capital	0.27	0.27	0.27	0.27	0.27	0.27
Annuite constante(FCFA/an)	11891	10600	10600	10600	10600	10600
Entretien(FCFA/an)	500	500	500	500	500	500
Superficie (Ha)	4	4	4	4	4	4
Charge annuelle(FCFA/Ha/an)	3098	2775	2775	2775	2775	2775
Animaux de trait:	2 boeufs	Ane	Ane	Ane	Ane	Ane
Periode active(an)	6	6	6	6	6	6
Taux de mortalite(%)	3	3	3	3	3	3
Periode ajustee(an)	5.8	5.8	5.8	5.8	5.8	5.8
Taux d'interet nominal BNDA(%)	9	9	9	9	9	9
Taux d'interet reel(%)	3	3	3	3	3	3
Coeff. de recuperation du capital	0.19	0.19	0.19	0.19	0.19	0.19
Annuite constante(FCFA/an)	15233	3808	4760	4760	3808	3808
Entretien(FCFA/an)	27600	9600	12000	12000	9600	9600
Superficie (Ha)	4	4	4	4	4	4
Charge annuelle(FCFA/Ha/an)	10708	3352	4190	4190	3352	3352
Phosphate naturel du Tilemsi:						
Periode du pret(an)	3		3			
Taux d'interet nominal BNDA(%)	9		9			
Taux d'interet reel(%)	3		3			
Coeff. de recuperation du capital	0.35		0.35			
Annuite constante(FCFA/an)	12		12			

(1) Pour simplifier le calcul, l'annuite est supposee constante en termes reels durant la periode du pret. L'annuite est calculee a l'aide du coefficient de recuperation de capital (capital recovery factor) en utilisant le taux d'interet applique par la BNDA diminue du taux d'inflation du pays. Cette methode de calcul est proche de la methode de la BNDA et des ODR puisque ces institutions chargent une annuite constante durant la periode du pret.

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ANNEXE E.

TABLEAU E.6: CALCUL DES CHARGES ANNUELLES ECONOMIQUES SELON LES ZONES AGROCLIMATIQUES(FCFA/HA/AN) (1).

EQUIPEMENT	SUD		CENTRE/PLATEAU		NORD	
	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL	BUDGETISE	ACTUEL
Appareil T 15:						
Periode du pret(an)	4		4		4	
Taux d'interet economique(%)	12		12		12	
Coeff. de recuperation du capital	0.33		0.33		0.33	
Annuite constante(FCFA/an)	7626		7626		7626	
Entretien(FCFA/an)	500		500		500	
Superficie (Ha)	4		4		4	
Charge annuelle(FCFA/Ha/an)	2031		2031		2031	
Materiel agricole:	CharrueTM	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.
Periode du pret(an)	6	6	6	6	6	6
Taux d'interet economique(%)	12	12	12	12	12	12
Coeff. de recuperation du capital	0.24	0.24	0.24	0.24	0.24	0.24
Annuite constante(FCFA/an)	13877	12370	12370	12370	12370	12370
Entretien(FCFA/an)	500	500	500	500	500	500
Superficie (Ha)	4	4	4	4	4	4
Charge annuelle(FCFA/Ha/an)	3594	3217	3217	3217	3217	3217
Animaux de trait:	2 boeufs	Ane	Ane	Ane	Ane	Ane
Periode active(an)	6	6	6	6	6	6
Taux de mortalite(%)	3	3	3	3	3	3
Periode ajustee(an)	5.8	5.8	5.8	5.8	5.8	5.8
Taux d'interet economique(%)	12	12	12	12	12	12
Coeff. de recuperation du capital	0.25	0.25	0.25	0.25	0.25	0.25
Annuite constante(FCFA/an)	19927	4982	6227	6227	4982	4982
Entretien(FCFA/an)	27600	9600	12000	12000	9600	9600
Superficie (Ha)	4	4	4	4	4	4
Charge annuelle(FCFA/Ha/an)	11882	3645	4557	4557	3645	3645
Phosphate naturel du Tilemsi:						
Periode du pret(an)	3		3		3	
Taux d'interet economique(%)	12		12		12	
Coeff. de recuperation du capital	0.42		0.42		0.42	
Annuite constante(FCFA/an)	15		15		15	

(1) Pour simplifier le calcul, l'annuite est supposee constante en termes reels durant la duree du pret. L'annuite est calculee a l'aide du coefficient de recuperation de capital (capital recovery factor) en utilisant le taux d'interet economique estime. Cette methode permetant d'obtenir une annuite constante n'introduit pas d'erreur d'estimation quand le taux d'actualisation utilise pour le calcul de la valeur nette actualisee du projet est le meme que le taux d'interet d'interet economique utilise ici.

ANNEXE F: COMPOSANTES DES PAQUETS TECHNOLOGIQUES EVALUES.

TABLEAU F.1: COMPOSANTES DES PAQUETS TECHNOLOGIQUES "ASSOCIATION MIL-NIEBE" SELON LES ZONES AGROCLIMATIQUES.

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE (1):	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL
Varietes:									
Mil	MKK	Locale	Locale	MKK	Locale	Locale	IBV 8001	Locale	Locale
Niebe	GoromGorom	Locale	Locale	GoromGorom	Locale	Locale	GoromGorom	Locale	Locale
Densite (poquets/Ha):									
Mil	26500	10000	10000	26500	10000	10000	26500	10000	10000
Niebe	13300	5000	5000	13300	5000	5000	13300	5000	5000
Quantite semences (kg/Ha):									
Mil	5	10	10	5	10	10	5	10	10
Niebe	8	3	3	8	3	3	8	3	3
Traitement des semences:									
Mil Produit commercial:	APRON +	Thioral	Thioral	APRON +	Thioral	Thioral	APRON +	Thioral	Thioral
Dose (gPC/kg)	5	2.5	2.5	5	2.5	2.5	5	2.5	2.5
Quantite (gPC/Ha)	25	25	25	25	25	25	25	25	25
Quantite(sachet/Ha)	1	1	1	1	1	1	1	1	1
Niebe Produit commercial:	Thioral			Thioral			Thioral		
Dose (gPC/kg)	2.5			2.5			2.5		
Quantite (gPC/Ha)	20			20			20		
Quantite(sachet/Ha)	1			1			1		
Engrais:									
Phosphate d'ammoniaque (kg/Ha)	50			50			25		
Uree (kg/Ha en localise)	25								
Traitements phytosanitaires sur niebe:									
2 traitements au Decis (L/Ha)	2			2			2		
Traitement des stocks de niebe:									
Phostoxin (1 comp./100kg)	2			2			1		
Sac plastique (1 sac/100kg)	2								
Appareil pulverisateur	T 15			T 15			T 15		
Materiel agricole	CharrueTM	Houe as.	Daba	Houe as.	Houe as.	Daba	Houe as.	Houe as.	Daba
Traction animale	2 boeufs	1 ane		1 ane	1 ane		1 ane	1 ane	
Entretien de l'attelage:									
Fane de niebe (kg sec/4 mois)	2300	800		800	800		800	800	
Main d'oeuvre (homme jour/Ha):									
Preparation du sol	4.0	2.0	2.0	6.0	2.0	2.0	2.0	2.0	2.0
Fertilisation (phosphate)	1.0			1.0			1.0		
Semis du mil	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Semis du niebe	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0
1er sarclage	6.0	10.0	25.0	8.0	8.0	22.0	6.0	6.0	18.0
Fertilisation (uree)	1.0								
2eme sarclage	6.0	10.0	16.0	8.0	8.0	14.0	6.0	6.0	12.0
1er trait. phytosanitaire	1.0			1.0			1.0		
2eme trait. phytosanitaire	1.0			1.0			1.0		
Recolte du mil	10.0	7.5	7.0	8.5	6.5	6.0	6.0	5.0	4.5
Recolte du niebe	6.0	2.0	2.0	5.0	2.5	2.5	5.0	2.0	2.0
Transport et stockage	5.0	3.5	8.0	4.0	3.0	7.0	3.0	2.5	6.0
Total main d'oeuvre (homme jour/Ha)	46.0	39.0	64.0	47.5	34.0	57.5	36.0	27.5	48.5
Gain de main d'oeuvre (homme jour/Ha)(2)	18	25		10	23.5		12.5	21	
Gain de main d'oeuvre (homme jour/Ha)(3)	-7			-13.5			-8.5		
Rendement (kg/Ha):									
Mil grains	800	550	500	650	440	400	400	275	250
Niebe grains	180	45	40	160	55	50	120	45	40
Fane de niebe	400	500	500	400	500	500	300	400	400
Gain de fumier (T/2 boeufs/an/Ha)	1.5								
Gain de poids vif (kg/2 boeufs/an/Ha)	20								

(1) Ameliore: paquet technologique a developper par la recherche systeme.
Traditionel ameliore: paquet technologique actuellement utilise par la plupart des producteurs equipes.
Traditionel: paquet technologique actuellement utilise par la plupart des producteurs non equipes.
(2) Vis-a-vis de la technologie traditionnelle. (3) Vis-a-vis de la technologie traditionnelle ameliorée.

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ANNEXE F.

TABLEAU F.2: COMPOSANTES DES PAQUETS TECHNOLOGIQUES "ASSOLEMENT MIL-NIEBE" SELON LES ZONES AGROCLIMATIQUES.

Superficie mil et niebe(Ha): 0.75 0.25 (1)

ZONE:	SUD		CENTRE/PLATEAU		NORD	
CULTURE PURE :	MIL	NIEBE	MIL	NIEBE	MIL	NIEBE
Varietes	HKK	Goron-Goron	HKK	Goron-Goron	IBV 8001	Goron-Goron
Densite (poquets/Ha)	15625	31250	15625	31250	10000	31250
Quantite de semences (kg/Ha)	5	25	5	25	5	25
Traitement des semences:						
Produit commercial	APRON +	Thioral	APRON +	Thioral	APRON +	Thioral
Dose (gPC/kg)	5	2.5	5	2.5	5	2.5
Quantite (gPC/Ha)	25	62.5	25	62.5	25	62.5
Quantite (sachet/Ha)	1	3	1	3	1	3
Engrais:						
PNT (kg/Ha)	300		300			
Phosphate super simple (kg/Ha)		65		65		32.5
Traitements phytosanitaires sur niebe:						
2 traitements au Decis (L/Ha)		7		7		7
Traitement des stocks de niebe:						
Phostoxin (1 comp./100kg)		6		5		4
Sac plastique (1 sac/100kg)		6		5		4
Appareil pulverisateur		T 15		T 15		T 15
Materiel agricole	CharrueTM	CharrueTM	Houe as.	Houe as.	Houe as.	Houe as.
Traction animale	2 boeufs	2 boeufs	1 ane	1 ane	1 ane	1 ane
Entretien de l'attelage:						
Fane de niebe (kg sec/4 mois)	2300	2300	800	800	800	800
Main d'oeuvre (homme jour/Ha):						
Preparation du sol	4.0	5.0	6.0	7.0	2.0	2.0
Fertilisation	1.0	1.0	1.0	1.0		1.0
Semis	3.0	2.0	3.0	2.0	3.0	2.0
1er sarclage	6.0	5.0	8.0	7.0	6.0	7.0
2eme sarclage	6.0	4.0	8.0	6.0	6.0	6.0
1er trait. phytosanitaire		1.0		1.0		1.0
2eme trait. phytosanitaire		1.0		1.0		1.0
Recolte	10.0	20.0	8.5	20.0	6.0	17.0
Transport et stockage	4.0	15.0	3.0	15.0	2.0	12.0
Total main d'oeuvre (homme jour/Ha)	34.0	54.0	37.5	60.0	25.0	49.0
Gain main d'oeuvre (homme jour/Ha)(2)	30.0	10.0	20.0	-2.5	23.5	-0.5
Gain main d'oeuvre (homme jour/Ha)(3)	5.0	-15.0	-3.5	-26.0	2.5	-21.5
Rendement (kg/Ha):						
Mil grains	800		600		350	
Niebe grains		600		500		400
Fane de niebe		500		400		300
Gain de fumier (T/2 boeufs/an)	6	6	6	6	6	6
Gain de fumier (T/2 boeufs/an/Ha)	1.5	1.5	1.5	1.5	1.5	1.5
Gain de poids vif (kg/2 boeufs/an)	80	80	80	80	80	80
Gain de poids vif (kg/2 boeufs/an/Ha)	20	20	20	20	20	20

(1). L'assolement preconise est une sole de 0.75 Ha de culture pure de mil et une sole de 0.25 Ha de culture pure de niebe.
(2) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle.
(3) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle ameliorée.

ANNEXE F.

TABLEAU F.3: COMPOSANTES DES PAQUETS TECHNOLOGIQUES "ROTATION ARACHIDE-MIL-ARACHIDE" POUR LE SENO CENTRE ET LE PLATEAU.

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:	AVEC PNT			SANS PNT			TRADITIONNEL AMELIORE			TRADITIONNEL		
Varietes:	47-10	Locale	47-10	47-10	Locale	47-10	Locale	Locale	Locale	Locale	Locale	Locale
Densite (poquets/Ha):		15625			15625		10000	10000	10000	10000	10000	10000
Quantite de semences (kg/Ha):	100	10	100	100	10	100	10	10	10	10	10	10
Traitement des semences au Thicral:												
Dose (gPC/kg)	2	2.5	2	2	2.5	2	2.5	2.5	2.5	2.5	2.5	2.5
Quantite (gPC/Ha)	200	25	200	200	25	200	25	25	25	25	25	25
Quantite (sachet/Ha)	8	1	8	8	1	8	1	1	1	1	1	1
Engrais:												
Phosphate de Tilemsi (kg/Ha)	300											
Traitement des stocks d'arachides a l'Actellic:												
Dose (gPC/kg)	50		50	50		50						
Quantite (gPC/Ha)	310		170	265		130						
Quantite (sachet/Ha)	3		2	3		1						
Materiel agricole	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.			
Traction animale	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane			
Entretien de l'attelage:												
Fane de niebe(kg sec/4 mois)	800	800	800	800	800	800	800	800	800			
Main d'oeuvre (homme jour/Ha):												
Preparation du sol	8.0	2.0	8.0	8.0	2.0	8.0	6.0	2.0	2.0	6.0	2.0	2.0
Fertilisation	2.0											
Decorticage des semences	8.0		8.0	8.0		8.0						
Semis	6.0	3.0	6.0	6.0	3.0	6.0	3.0	3.0	3.0	3.0	3.0	3.0
1er sarclage	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	22.0	22.0	22.0
2eme sarclage	6.0	8.0	6.0	6.0	8.0	6.0	8.0	8.0	8.0	14.0	14.0	14.0
Recolte	25.0	10.0	14.0	22.0	7.0	10.0	6.0	6.0	6.0	6.0	6.0	6.0
Transport et stockage	3.0	4.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total main d'oeuvre (h.j./Ha)	66.0	35.0	52.0	61.0	31.0	48.0	33.0	29.0	29.0	53.0	49.0	49.0
Gain main d'oeuvre (h.j./Ha)(1)	-13.0	14.0	-3.0	-8.0	18.0	1.0	20.0	20.0	20.0			
Gain main d'oeuvre (h.j./Ha)(2)	-33.0	-6.0	-23.0	-28.0	-2.0	-19.0						
Rendement (kg/Ha):												
Mil grains		960			480		410	420	390	410	420	390
Arachide graines	620		340	530		260						
Fane d'arachide 0.8	496		272	424		208						

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle ameliorée (equipee).

ANNEXE F.

TABLEAU F.4: COMPOSANTES DES PAQUETS TECHNOLOGIQUES "ROTATION ARACHIDE-MIL-ARACHIDE" POUR LE SENO SUD.

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:	AVEC PNT			SANS PNT			TRADITIONNEL AMELIORE			TRADITIONNEL		
Varietes:	47-10	Locale	47-10	47-10	Locale	47-10	Locale	Locale	Locale	Locale	Locale	Locale
Densite (poquets/Ha):		15625			15625		10000	10000	10000	10000	10000	10000
Quantite de semences (kg/Ha):	100	10	100	100	10	100	10	10	10	10	10	10
Traitement des semences au Thiral:												
Dose (gPC/kg)	2	2.5	2	2	2.5	2	2.5	2.5	2.5	2.5	2.5	2.5
Quantite (gPC/Ha)	200	25	200	200	25	200	25	25	25	25	25	25
Quantite (sachet/Ha)	8	1	8	8	1	8	1	1	1	1	1	1
Engrais:												
Phosphate de Tilemsi (kg/Ha)	300											
Traitement des stocks d'arachides a l'Actellic:												
Dose (gPC/kg)	50		50	50		50						
Quantite (gPC/Ha)	265		115	215		130						
Quantite (sachet/Ha)	3		1	2		1						
Materiel agricole	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.	Houe as.			
Traction animale	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane	1 ane			
Entretien de l'attelage:												
Fane de niebe(kg sec/4 mois)	800	800	800	800	800	800	800	800	800			
Main d'oeuvre (homme jour/Ha):												
Preparation du sol	8.0	2.0	8.0	8.0	2.0	8.0	6.0	2.0	2.0	6.0	2.0	2.0
Fertilisation	2.0											
Decorticage des semences	8.0		8.0	8.0		8.0						
Semis	6.0	3.0	6.0	6.0	3.0	6.0	3.0	3.0	3.0	3.0	3.0	3.0
1er sarclage	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	22.0	22.0	22.0
2eme sarclage	6.0	8.0	6.0	6.0	8.0	6.0	8.0	8.0	8.0	14.0	14.0	14.0
Recolte	24.0	10.0	10.0	18.0	8.0	10.0	8.0	7.0	3.0	8.0	7.0	3.0
Transport et stockage	3.0	4.0	2.0	3.0	4.0	2.0	2.0	2.0	1.0	2.0	2.0	1.0
Total main d'oeuvre (h.j./Ha)	65.0	35.0	48.0	57.0	33.0	48.0	35.0	30.0	25.0	55.0	50.0	45.0
Gain main d'oeuvre (h.j./Ha)(1)	-10.0	15.0	-3.0	-2.0	17.0	-3.0	20.0	20.0	20.0			
Gain main d'oeuvre (h.j./Ha)(2)	-30.0	-5.0	-23.0	-22.0	-3.0	-23.0						
Rendement (kg/Ha):												
Mil grains		860			700		720	530	160	720	530	160
Arachide graines	570		230	430		260						
Fane d'arachide 0.8	456		184	344		208						

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle amelioree (equipee).

ANNEXE F.

TABLEAU F.5: COMPOSANTES DU PAQUET TECHNOLOGIQUE DE LA CULTURE DE SESAME SELON LES ZONES AGROCLIMATIQUES.

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE:	SESAME	MIL(2eme annee)		SESAME	MIL(2eme annee)		SESAME	MIL(2eme annee)	
	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL
Varietes:	38-1-7	Locale	Locale	38-1-7	Locale	Locale	38-1-7	Locale	Locale
Densite (poquets/Ha):	166500	10000	10000	166500	10000	10000	166500	10000	10000
Quantite de semences (kg/Ha):	10	10	10	10	10	10	10	10	10
Traitement de semences de mil au Thioral:									
Dose (gPC/kg)		2.5	2.5		2.5	2.5		2.5	2.5
Quantite (gPC/Ha)		25	25		25	25		25	25
Quantite (sachet/Ha)		1	1		1	1		1	1
Engrais:									
Phosphate super simple (kg/Ha)	65			65			32.5		
Materiel agricole	Houe as	Houe as.	Daba	Houe as	Houe as.	Daba	Houe as.	Houe as.	Daba
Traction animale	1 ane	1 ane		1 ane	1 ane		1 ane	1 ane	
Entretien de l'attelage:									
Fane de niebe (kg sec/4 mois)	800	800		800	800		800	800	
Main d'oeuvre (homme jour/Ha):									
Preparation du sol	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Fertilisation au phosphate	1.0			1.0			1.0		
Semis	6.0	3.0	3.0	6.0	3.0	3.0	6.0	3.0	3.0
1er sarclage	10.0	8.0	22.0	8.0	8.0	22.0	6.0	6.0	18.0
2eme sarclage	10.0	8.0	14.0	8.0	8.0	14.0	6.0	6.0	12.0
Recolte	10.0	7.0	7.0	10.0	6.0	6.0	8.0	5.0	5.0
Transport et stockage	10.0	2.0	2.0	8.0	2.0	2.0	6.0	1.5	1.5
Total main d'oeuvre (homme jour/Ha)	49.0	30.0	50.0	43.0	29.0	49.0	35.0	23.5	41.5
Gain de main d'oeuvre (homme jour/Ha)	1.0	20.0		6.0	20.0		6.5	18.0	
Gain de main d'oeuvre (homme jour/Ha)	-19.0			-14.0			-11.5		
Rendement (kg/Ha):									
Mil grains		530	530		420	420		300	300
Sesame	600			450			300		

(1) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle ameliorée (equipee).

ANNEXE G: BUDGETS FINANCIERS DES PAQUETS TECHNOLOGIQUES.

TABLEAU G.1: BUDGETS FINANCIERS DE L'ASSOCIATION MIL-NIEBE AMELIOREE ET TRADITIONNELLE PAR ZONE (FCFA/HA/AN).

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE (1):	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL
BENEFICE BRUT (FCFA/Ha):									
Mil	40000	16500	15000	39000	17600	16000	28000	13750	12500
Niebe	18000	2700	2400	17600	3850	3500	14400	3600	3200
Fane de niebe	4800	6000	6000	6000	7500	7500	3600	4800	4800
Gain de poids vif	4000								
Fumier	1500								
Benefice brut	68300	25200	23400	62600	28950	27000	46000	22150	20500
Gain de main d'oeuvre * (2)	6296	8745		4506	10538		4973	8355	
Gain de main d'oeuvre * (3)	-3242			-8295			-4581		
Benefice brut total (2)	74596	33945		67106	39538		50973	30505	
Benefice brut total (3)	65058			54305			41419		
AUGMENTATION DU BENEFICE TOTAL BRUT (FCFA/HA):									
(2)	51196	10545		40106	12538		30473	10005	
(3)	39858			25355			19269		
COUTS VARIABLES (FCFA/HA):									
Semences: Mil	345	500	500	345	550	550	345	600	600
Niebe	1600	450	450	1600	480	480	1600	540	540
Trait. semences: Fongicide sur mil	300	63	63	300	63	63	300	63	63
Fongicide s/niebe	63			63			63		
Fertilisation: Phosphate	8500			8500			4250		
Uree	4000			0			0		
Trait. phytosanitaire au Decis	3740			3740			3740		
Trait. des stocks: Phostoxin	400			400			200		
Sac	1000			1000			500		
Couts variables totaux	19948	1013	1013	15948	1093	1093	10998	1203	1203
CHARGES ANNUELLES (FCFA/HA/AN):									
Appareil T 15	1412	0		1412	0		1412	0	
Materiel agricole	3098	2775		2775	2775		2775	2775	
Attelage	10708	3352		4190	4190		3352	3352	
Charges annuelles totales	15218	6127		8377	6965		7539	6127	
COUTS VAR.&CHARGES ANNUELLES(FCFA/HA/AN)	35166	7140	1013	24325	8058	1093	18537	7330	1203
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
(2)	34153	6127		23232	6965		17334	6127	
(3)	28026			16267			11207		
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
	518	463	350	566	614	451	566	539	398
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
(2)	168	113		215	164		168	141	
(3)	55			51			27		
BENEFICE NET (FCFA/HA):		18060	22387		20892	25907		14820	19297
(2)	39431	26805		42781	31480		32437	23175	
(3)	29893			29980			22883		
AUGMENTATION DU BENEFICE NET (FCFA/HA):									
(2)	17044	4418		16674	5573		13140	3878	
(3)	11833			9063			8063		

(1) Ameliore: paquet technologique a developper par la recherche systeme.
Traditionel ameliore: paquet technologique actuellement utilise par la plupart des producteurs equipes.
Traditionel: paquet technologique actuellement utilise par la plupart des producteurs non equipes.

(2) Vis-a-vis de la technologie traditionnelle. (3) Vis-a-vis de la technologie traditionnelle ameliorée.

* Le gain de main d'oeuvre est le produit du nombre de jours gagnes par le paquet technologique multiplie par le cout d'opportunite de la main d'oeuvre determine par la technologie traditionelle ou la technologie traditionelle ameliorée selon le cas. Ce gain de main d'oeuvre est ajoute au benefice brut pour obtenir le benefice brut total.

ANNEXE G.

TABLEAU G.2: BUDGETS FINANCIERS DE L'ASSOLEMENT MIL-NIEBE SELON LES ZONES AGROCLIMATIQUES(FCFA/HA/AN).

Superficie mil et niebe(Ha): 0.75 0.25 (1)

ZONE:	SUD		CENTRE/PLATEAU		NORD	
CULTURE PURE :	MIL	NIEBE	MIL	NIEBE	MIL	NIEBE
BENEFICE BRUT (FCFA/Ha):						
Mil	40000		36000		24500	
Niebe		60000		55000		48000
Fane de niebe		6000		6000		3600
Gain de poids vif	4000	4000	5000	5000	4000	4000
Fumier	1500	1500	2250	2250	1500	1500
Benefice brut de l'assolement mil-niebe	52000		49500		36775	
Gain de main d'oeuvre * (2)	10494	3498	9011	-1126	9350	-199
Gain de main d'oeuvre * (3)	2315	-6946	-2151	-15976	1347	-11587
Benefice brut total (2)	55994	74998	52261	67124	39350	55901
Benefice brut total (3)	47815	64554	41059	52274	31347	45513
Ben. brut total de assolement mil niebe(2)	60745		55977		43738	
Ben. brut total de assolement mil-niebe(3)	52000		43893		34889	
AUGMENTATION DU BENEFICE BRUT TOTAL POUR L'ASSOLEMENT MIL-NIEBE(FCFA/HA):						
(2)	37345		26977		23238	
(3)	26800		14943		12739	
COUTS VARIABLES (FCFA/HA):						
Semences	345	5000	345	5000	345	5000
Traitement des semences	300	189	300	189	300	189
Fertilisation au phosphate super simple		4550		4550		2275
Trait. phytosanitaire au Decis		13090		13090		13090
Trait. des stocks: Phostoxin		1200		1000		800
Sac plastique		3000		2500		2000
Couts variables totaux	645	27029	645	26329	645	23354
CHARGES ANNUELLES (FCFA/HA/AN):						
Fertilisation au PNT	3712		3712		0	
Appareil T 15		1412		1412		1412
Materiel agricole	3098	3098	2775	2775	2775	2775
Animaux de trait	10708	10708	4190	4190	3352	3352
Charges annuelles totales	17518	15218	10677	8377	6127	7539
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):						
Culture pure	18163	42247	11322	34706	6772	30893
Assolement mil-niebe	24184		17168		12802	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES POUR L'ASSOLEMENT MIL-NIEBE FCFA/HA/AN):						
(2)	23171		16075		11599	
(3)	17644		9110		5472	
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE POUR L'ASSOLEMENT MIL-NIEBE(FCFA/HOMME JOUR):						
	713		750		773	
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):						
(2)	363		299		375	
(3)	250		135		234	
BENEFICE NET (FCFA/HA):						
(2)	36561		38809		30936	
(3)	27816		26725		22087	
AUGMENTATION DU BENEFICE NET (FCFA/HA):						
(2)	14174		12902		11639	
(3)	9756		5831		7267	

(1) L'assolement preconise est une sole de 0.75 Ha de culture pure de mil et une sole de 0.25 Ha de culture pure de niebe.

(2) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle.

(3) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle ameliorée.

* Le gain de main d'oeuvre est le produit du nombre de jours gagnes par le paquet technologique multiplie par le cout d'opportunite de la main d'oeuvre determine par la technologie traditionnelle ou la technologie traditionnelle traditionnelle selon le cas. Ce gain de main d'oeuvre est ajoute au benefice brut pour obtenir le benefice brut total.

ANNEXE G.

TABLEAU G.3: BUDGETS FINANCIERS DE LA ROTATION ARACHIDE-MIL-ARACHIDE POUR LE SENO CENTRE ET LE PLATEAU (FCFA/HA/AN).

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:		AVEC PMT			SANS PMT		TRADITIONNEL		AMELIORE		TRADITIONNEL	
BENEFICE BRUT ANNUEL (FCFA/Ha):												
Mil grains		57600			28800		16400	16800	15600	16400	16800	15600
Arachide graines	34100		18700	29150		14300						
Fane d'arachide	7440		4080	6360		3120						
Benefice brut	41540	57600	22780	35510	28800	17420	16400	16800	15600	16400	16800	15600
Gain de main d'oeuvre (1)	-3860	4625	-915	-2375	5946	305	5938	6607	6097			
Gain de main d'oeuvre (2)	-8772	-1908	-6323	-7443	-636	-5223						
Benefice brut total (1)	37680	62225	21865	33135	34746	17725	22338	23407	21697	16400	16800	15600
Benefice brut total (2)	32768	55692	16457	28067	29164	12197	16400	16800	15600			
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):												
Moyenne sur 3 ans (1)		24323			12269			6214				
Moyenne sur 3 ans (2)		34972			22809							
COUTS VARIABLES ANNUELS (FCFA/HA):												
Semences	8000	690	8000	8000	690	8000	600	550	600	600	550	600
Traitement des semences	504	63	504	504	63	504	63	63	63	63	63	63
Trait. Actellic des stocks	660	0	440	660	0	220	0	0	0	0	0	0
Total	9164	753	8944	9164	753	8724	663	613	663	663	613	663
CHARGES ANNUELLES (FCFA/HA/AN):												
Materiel agricole	2775	2775	2775	2775	2775	2775	2775	2775	2775			
Attelage	4190	4190	4190	4190	4190	4190	4190	4190	4190			
Fertilisation au PMT	3712	3712	3712									
Total	10677	10677	10677	6965	6965	6965	6965	6965	6965			
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Annuel	19841	11430	19621	16129	7718	15689	7628	7578	7628	663	613	663
Moyenne sur 3 ans		16964			13179			7611			646	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Moyenne sur 3 ans (1)		16318			12532			6965				
Moyenne sur 3 ans (2)		9353			5567							
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):												
Annuelle	329	1319	61	318	680	36	266	318	275	297	330	305
BENEFICE NET (FCFA/HA) (1):												
Annuel	17839	50795	2244	17006	27028	2036	14710	15829	14069	15737	16187	14937
Moyenne sur 3 ans		23626			15357			14869			15620	
BENEFICE NET (FCFA/HA) (2):												
Annuel	12927	44262	-3164	11938	20446	-3492	8772	9222	7972			
Moyenne sur 3 ans		18008			9631			8655				
AUGMENTATION DU BENEFICE NET (FCFA/HA):												
Moyenne sur 3 ans (1)		8006			-264			-751				
Moyenne sur 3 ans (2)		9353			975							

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle amelioree (equipee).

ANNEXE G.

TABLEAU G.4: BUDGETS FINANCIERS DE LA ROTATION ARACHIDE-MIL-ARACHIDE POUR LE SENO SUD (FCFA/HA/AN).

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:		AVEC PNT			SANS PNT		TRADITIONNEL		AMELIORE		TRADITIONNEL	
BENEFICE BRUT ANNUEL (FCFA/Ha):												
Mil grains		43000			35000		21600	15900	4800	21600	15900	4800
Arachide graines	28500		11500	21500		13000						
Fane d'arachide	5472		2208	4128		2496						
Benefice brut	33972	43000	13708	25628	35000	15496	21600	15900	4800	21600	15900	4800
Gain de main d'oeuvre (1)	-3807	4601	-276	-761	5215	-276	7613	6135	1839			
Gain de main d'oeuvre (2)	-12694	-1535	1831	-9309	-921	1831						
Benefice brut total (1)	30165	47601	13432	24867	40215	15220	29213	22035	6639	21600	15900	4800
Benefice brut total (2)	21278	41465	15539	16319	34079	17327	21600	15900	4800			
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):												
Moyenne sur 3 ans (1)		14133			10500			3029				
Moyenne sur 3 ans (2)		26094			22575							
COUTS VARIABLES ANNUELS (FCFA/HA):												
Semences	8000	690	8000	8000	690	8000	600	500	600	600	500	600
Traitement des semences	504	63	504	504	63	504	63	63	63	63	63	63
Trait. Actellic des stocks	660	0	220	440	0	220	0	0	0	0	0	0
Total	9164	753	8724	8944	753	8724	663	563	663	663	563	663
CHARGES ANNUELLES (FCFA/HA/AN):												
Materiel agricole	2775	2775	2775	2775	2775	2775	2775	2775	2775			
Attelage	3352	3352	3352	3352	3352	3352	3352	3352	3352			
Fertilisation au PNT	3712	3712	3712									
Total	9839	9839	9839	6127	6127	6127	6127	6127	6127			
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Annuel	19003	10592	18563	15071	6880	14851	6790	6690	6790	663	563	663
Moyenne sur 3 ans		16053			12267			6757			630	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Moyenne sur 3 ans (1)		15406			11621			6110				
Moyenne sur 3 ans (2)		8441			4656							
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):												
Annuelle	230	926	-101	185	852	13	423	307	-80	381	307	92
BENEFICE NET (FCFA/HA) (1):												
Annuel	11162	37009	-5131	9796	33335	369	22423	15345	-151	20937	15337	4137
Moyenne sur 3 ans		14347			14500			12539			13470	
BENEFICE NET (FCFA/HA) (2):												
Annuel	2275	30873	-3024	1248	27199	2476	14810	9210	-1990			
Moyenne sur 3 ans		10041			10308			7343				
AUGMENTATION DU BENEFICE NET (FCFA/HA):												
Moyenne sur 3 ans (1)		-1274			-1121			-3081				
Moyenne sur 3 ans (2)		1386			1652							

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle ameliorée (equipee).

ANNEXE G.

TABLEAU G.5: BUDGETS FINANCIERS DE LA CULTURE DE SESAME COMPARES A LA 2eme CULTURE DE LA ROTATION MIL-MIL-MIL SELON LES ZONES ECOCLIMATIQUES (FCFA/HA/AN).

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE:	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL
BENEFICE BRUT (FCFA/Ha):									
Mil		15900	15900		16800	16800		15000	15000
Sesame	42000			33750			21000		
Benefice brut	42000	15900	15900	33750	16800	16800	21000	15000	15000
Gain de main d'oeuvre (1)	307	6135		1982	6607		2246	6218	
Gain de main d'oeuvre (2)	-5833			-4452			-4018		
Benefice brut total (1)	42307	22035	15900	35732	23407	16800	23246	21218	15000
Benefice brut total (2)	36167	15900		29298	16800		16982	15000	
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):									
(1)	26407	6135		18932	6607		8246	6218	
(2)	20267			12498			1982		
COUTS VARIABLES ANNUELS (FCFA/HA):									
Semences: Mil		500	500		550	550		600	600
Sesame	1500			1500			1500		
Traitement semences de mil	0	63	63	0	63	63	0	63	63
Fertilisation	4550	0	0	4550	0	0	2275	0	0
Couts variables totaux	6050	563	563	6050	613	613	3775	663	663
CHARGES ANNUELLES (FCFA/HA/AN):									
Materiel agricole	2775	2775	0	2775	2775	0	2775	2775	0
Attelage	3352	3352	0	4190	4190	0	3352	3352	0
Charges annuelles totales	6127	6127	0	6965	6965	0	6127	6127	0
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
	12177	6690	563	13015	7578	613	9902	6790	663
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
(1)	11614	6127		12402	6965		9239	6127	
(2)	5487			5437			3112		
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
	609	307	307	482	318	330	317	349	345
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
(1)	302	0		152	-12		-28	4	
(2)	302			164			-32		
BENEFICE NET (FCFA/HA):									
(1)	30130	15345	15337	22717	15829	16187	13344	14428	14337
(2)	23990	9210		16283	9222		7080	8210	
AUGMENTATION DU BENEFICE NET (FCFA/HA):									
(1)	14793	8		6530	-358		-993	91	
(2)	14780			7061			-1130		

(1) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle amelioree (equipee).

ANNEXE H: BUDGETS ECONOMIQUES DES PAQUETS TECHNOLOGIQUES.

TABLEAU H.1: BUDGETS ECONOMIQUES DE L'ASSOCIATION MIL-NIEBE AMELIOREE ET TRADITIONNELLE PAR ZONE (FCFA/HA/AN).

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE (1):	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL	AMELIORE	TRAD.AM.	TRADITIONNEL
BENEFICE BRUT (FCFA/Ha):									
Mil	40000	16500	15000	39000	17650	16000	28000	[illegible]	[illegible]
Niebe	18000	2700	2400	17600	3850	3500	14400	3600	[illegible]
Fane de niebe	4800	6000	6000	6000	7500	7500	3600	4800	4800
Gain de poids vif	4000								
Fumier	1500								
Benefice brut	68300	25200	23400	62600	28950	27000	46000	22150	20500
Gain de main d'oeuvre * (2)	6293	8740		4503	10583		4970	8350	
Gain de main d'oeuvre * (3)	-3107			-7963			-4349		
Benefice brut total (2)	74593	33940		67103	39533		50970	30500	
Benefice brut total (3)	65193			54631			41651		
Benefice brut total (4)									
AUGMENTATION DU BENEFICE BRUT (FCFA/HA):									
(2)	51193	10540		40103	12533		30470	10000	
(3)	39993			25681			19501		
COUTS VARIABLES (FCFA/HA):									
Semences: Mil	414	500	500	414	550	550	414	600	600
Niebe	1920	450	450	1920	480	480	1920	540	540
Trait. semences: Fongicide sur mil	363	76	76	363	76	76	363	76	76
Fongicide s/niebe	76			76			76		
Fertilisation: Phosphate	10292			10292			5146		
Uree	4843			0			0		
Trait. phytosanitaire au Decis	4528			4528			4528		
Trait. des stocks: Phostoxin	484			484			242		
Sac	1211			0			0		
Couts variables totaux	24132	1026	1026	18078	1106	1106	12690	1216	1216
CHARGES ANNUELLES (FCFA/HA/AN):									
Appareil T 15	2031	0		2031	0		2031	0	
Materiel agricole	3594	3217		3217	3217		3217	3217	
Attelage	11882	3645		4557	4557		3645	3645	
Charges annuelles totales	17507	6863		9806	7774		8894	6863	
COUTS VAR.&CHARGES ANNUELLES(FCFA/HA/AN)	41640	7889	1026	27884	8881	1106	21584	8079	1216
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
(2)	40613	6863		26778	7774		20368	6863	
(3)	33750			19003			13505		
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
	580	444	350	731	590	450	678	512	398
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
(2)	230	94		281	140		281	114	
(3)	136			141			167		
BENEFICE NET (FCFA/HA):		17311	22374		20069	25894		14071	19284
(2)	32953	26051		39219	30652		29386	22420	
(3)	23553			26747			20066		
AUGMENTATION DU BENEFICE NET (FCFA/HA):									
(2)	10579	3677		13326	4758		10102	3137	
(3)	6243			6678			5996		

(1) Ameliore: paquet technologique a developper par la recherche systeme.
Traditionel ameliore: paquet technologique actuellement utilise par la plupart des producteurs equipes.
Traditionel: paquet technologique actuellement utilise par la plupart des producteurs non equipes.
(2) Vis-a-vis de la technologie traditionnelle. (3) Vis-a-vis de la technologie traditionnelle ameliorée.
* Le gain de main d'oeuvre est le produit du nombre de jours gagnes par le paquet technologique multiplie par le cout d'opportunite de la main d'oeuvre determine par la technologie traditionelle ou la technologie traditionelle ameliorée selon le cas. Ce gain de main d'oeuvre est ajoute au benefice brut pour obtenir le benefice brut total.

ANNEXE H.

TABLEAU H.2: BUDGETS ECONOMIQUES DE L'ASSOLEMENT MIL-NIEBE SELON LES ZONES AGROCLIMATIQUES(FCFA/HA/AN).

Superficie mil et niebe(Ha): 0.75 0.25 (1)

ZONE:	SUD		CENTRE/PLATEAU		NORD	
CULTURE PURE :	MIL	NIEBE	MIL	NIEBE	MIL	NIEBE
BENEFICE BRUT (FCFA/Ha):						
Mil	40000		36000		24500	
Niebe		60000		55000		48000
Fane de niebe		6000		6000		3600
Gain de poids vif	4000	4000	5000	5000	4000	4000
Fumier	1500	1500	2250	2250	1500	1500
Benefice brut de l'assolement mil-niebe	52000		49500		36775	
Gain de main d'oeuvre * (2)	10488	3496	9007	-1126	9344	-199
Gain de main d'oeuvre * (3)	2219	-6658	-2066	-15347	1279	-11001
Benefice brut total (2)	55988	74996	52257	67124	39344	56901
Benefice brut total (3)	47719	64842	41184	52903	31279	46099
Ben. brut total de assolement mil-niebe(2)	60740		55973		43733	
Ben. brut total de assolement mil-niebe(3)	52000		44114		34984	
AUGMENTATION DU BENEFICE BRUT (FCFA/HA):						
(2)	37340		28973		23233	
(3)	26800		15164		12834	
COUTS VARIABLES (FCFA/HA):						
Semences	414	6000	414	6000	414	6000
Traitement des semences	363	229	363	229	363	229
Fertilisation au phosphate super simple		5509		5509		2755
Trait. phytosanitaire au Decis		15849		15849		15849
Trait. des stocks: Phostoxin		1453		1211		969
Sac plastique		3632		3027		2422
Couts variables totaux	777	32673	777	31825	777	28223
CHARGES ANNUELLES (FCFA/HA/AN):						
Fertilisation au PNT	4372		4372		0	
Appareil 7 15		2031		2031		2031
Materiel agricole	3594	3594	3217	3217	3217	3217
Attelage	11882	11882	4557	4557	3645	3645
Charges annuelles totales	19848	17507	12146	9806	6863	8894
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):						
Culture pure	20625	50180	12923	41631	7640	37117
Assolement mil-niebe	28014		20100		15009	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):						
(2)	26987		13994		13793	
(3)	20125		11220		6930	
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):						
	615		1045		1161	
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):						
(2)	265		595		763	
(3)	171		455		649	
BENEFICE NET (FCFA/HA):						
(2)	32726		35873		28724	
(3)	23986		24014		19975	
AUGMENTATION DU BENEFICE NET (FCFA/HA):						
(2)	10352		9980		9440	
(3)	6675		3944		5904	

(1) L'assolement preconise est une sole de 0.75 Ha de culture pure de mil et une sole de 0.25 Ha de culture pure de niebe.
(2) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle.
(3) Vis-a-vis de l'association mil-niebe avec la technologie traditionnelle ameliorée.
* Le gain de main d'oeuvre est le produit du nombre de jours gagnes par le paquet technologique multiplie par le cout d'opportunite de la main d'oeuvre determine par la technologie traditionnelle ou la technologi traditionnelle traditionnelle selon le cas. Ce gain de main d'oeuvre est ajoute au benefice brut pour obtenir le benefice brut total.

ANNEXE H.

TABLEAU H.3: BUDGETS ECONOMIQUES DE LA ROTATION ARACHIDE-MIL-ARACHIDE POUR LE SENO CENTRE ET LE PLATEAU (FCFA/HA/AN).

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:		AVEC PNT			SANS PNT			TRADITIONNEL AMELIORE			TRADITIONNEL	
BENEFICE BRUT ANNUEL (FCFA/Ha):												
Mil grains		57600			28800		16400	16800	15600	16400	16800	15600
Arachide graines	34100		18700	29150		14300						
Fane d'arachide	7440		4080	6360		3120						
Benefice brut	41540	57600	22780	35510	28800	17420	16400	16800	15600	16400	16800	15600
Gain de main d'oeuvre (1)	-3869	4621	-917	-2381	5941	306	5952	6602	6112			
Gain de main d'oeuvre (2)	-7995	-1738	-5710	-6787	-579	-4717						
Benefice brut total (1)	37671	62221	21863	33129	34741	17726	22352	23402	21712	16400	16800	15600
Benefice brut total (2)	33541	55862	17070	28723	28221	12703	16400	16600	15600			
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):												
Moyenne sur 3 ans (1)		24318			12265			6222				
Moyenne sur 3 ans (2)		35491			23215							
COUTS VARIABLES ANNUELS (FCFA/HA):												
Semences	9600	828	9600	9600	828	9600	550	550	550	550	550	550
Traitement des semences	610	76	610	610	76	610	76	76	76	76	76	76
Trait. Actellic des stocks	799	0	533	799	0	266	0	0	0	0	0	0
Total	11009	904	10743	11009	904	10477	626	626	626	626	626	626
CHARGES ANNUELLES (FCFA/HA/AN):												
Materiel agricole	3217	3217	3217	3217	3217	3217	3217	3217	3217			
Attelage	4557	4557	4557	4557	4557	4557	4557	4557	4557			
Fertilisation au PNT	4372	4372	4372	0	0	0	0	0	0			
Total	12146	12146	12146	7774	7774	7774	7774	7774	7774			
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Annuel	23155	13050	22889	18784	8679	18251	8401	8401	8401	626	626	626
Moyenne sur 3 ans		19698			15238			8401			626	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Moyenne sur 3 ans (1)		19052			14591			7754				
Moyenne sur 3 ans (2)		12087			7626							
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):												
Annuelle	279	1273	-2	274	649	-17	242	290	248	298	330	306
BENEFICE NET (FCFA/HA) (1):												
Annuel	14516	49171	-1026	14345	26063	-525	13952	15001	13311	15774	16174	14974
Moyenne sur 3 ans		20887			13294			14088			15640	
BENEFICE NET (FCFA/HA) (2):												
Annuel	10385	42812	-5819	9939	19542	-5548	7999	8399	7199			
Moyenne sur 3 ans		15793			7978			7866				
AUGMENTATION DU BENEFICE NET (FCFA/HA):												
Moyenne sur 3 ans (1)		5267			-2326			-1532				
Moyenne sur 3 ans (2)		7137			-678							

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle ameliorée (equipee).

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ANNEXE H.

TABLEAU H.4: BUDGETS ECONOMIQUES DE LA ROTATION ARACHIDE-MIL-ARACHIDE POUR LE SENO SUD (FCFA/HA/AN).

TYPE DE ROTATION:	ARACHIDE	MIL	ARACHIDE	ARACHIDE	MIL	ARACHIDE	MIL	MIL	MIL	MIL	MIL	MIL
STADE TECHNOLOGIQUE:		AVEC PNT			SANS PNT		TRADITIONNEL		AMELIORE		TRADITIONNEL	
BENEFICE BRUT ANNUEL (FCFA/Ha):												
Mil grains		43000			35000		21600	15900	4800	21600	15900	4800
Arachide graines	28500		11500	21500		13000						
Fane d'arachide	5472		2208	4128		2496						
Benefice brut	33972	43000	13708	25628	35000	15496	21600	15900	4800	21600	15900	4800
Gain de main d'oeuvre (1)	-3822	4597	-282	-764	5210	-282	7645	6129	1877			
Gain de main d'oeuvre (2)	-11815	-1347	2775	-8664	-808	2775						
Benefice brut total (1)	30150	47597	13426	24864	40210	15214	29245	22029	6677	21600	15900	4800
Benefice brut total (2)	22157	41653	16483	16964	34192	18271	21600	15900	4800			
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):												
Moyenne sur 3 ans (1)		14124			10496			3051				
Moyenne sur 3 ans (2)		26764			23142							
COUTS VARIABLES ANNUELS (FCFA/HA):												
Semences	9600	828	9600	9600	828	9600	500	500	500	500	500	500
Traitement des semences	610	76	610	610	76	610	76	76	76	76	76	76
Trait. Actellic des stocks	799	0	266	533	0	266	0	0	0	0	0	0
Total	11009	904	10477	10743	904	10477	576	576	576	576	576	576
CHARGES ANNUELLES (FCFA/HA/AN):												
Materiel agricole	3594	3594	3594	3594	3594	3594	3594	3594	3594			
Attelage	3645	3645	3645	3645	3645	3645	3645	3645	3645			
Fertilisation au PNT	4372	4372	4372	0	0	0	0	0	0			
Total	11611	11611	11611	7240	7240	7240	7240	7240	7240			
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Annuel	22621	12516	22088	17983	8144	17716	7816	7816	7816	576	576	576
Moyenne sur 3 ans		19075			14614			7816			576	
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):												
Moyenne sur 3 ans (1)		18428			13968			7170				
Moyenne sur 3 ans (2)		11863			7003							
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):												
Annuelle	175	871	-175	134	814	-46	394	269	-121	382	306	94
BENEFICE NET (FCFA/HA) (1):												
Annuel	7529	35082	-8662	6881	32066	-2502	21429	14214	-1139	21024	15324	4224
Moyenne sur 3 ans		11316			12148			11501			13524	
BENEFICE NET (FCFA/HA) (2):												
Annuel	-464	29137	-5605	-1019	26048	554	13784	8084	-3016			
Moyenne sur 3 ans		7649			8528			6284				
AUGMENTATION DU BENEFICE NET (FCFA/HA):												
Moyenne sur 3 ans (1)		-4304			-3472			-4119				
Moyenne sur 3 ans (2)		-966			-128							

(1) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la rotation triennale mil-mil-mil avec la technologie traditionnelle amelioree (equipee).

ANNEXE H.

TABLEAU H.5: BUDGETS ECONOMIQUES DE LA CULTURE DE SESAME COMPARES A LA 2eme CULTURE DE LA ROTATION MIL-MIL-MIL SELON LES ZONES ECOCLIMATIQUES (FCFA/HA/AN).

ZONE:	SUD			CENTRE/PLATEAU			NORD		
STADE TECHNOLOGIQUE:	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL	SESAME AMELIORE	MIL(2eme annee) TRAD.AM.	MIL(2eme annee) TRADITIONNEL
BENEFICE BRUT (FCFA/Ha):									
Mil		15900	15900		16800	16800		15000	15000
Sesame	60329			48479			30164		
Benefice brut	60329	15900	15900	48479	16800	16800	30164	15000	15000
Gain de main d'oeuvre (1)	306	6129		1980	6602		2243	6213	
Gain de main d'oeuvre (2)	-5359			-4055			-3651		
Benefice brut total (1)	60635	22029	15900	50459	23402	16800	32408	21213	15000
Benefice brut total (2)	54970	15900		44424	16800		26513	15000	
AUGMENTATION DU BENEFICE BRUT (FCFA/Ha):									
(1)	44735	6129		33659	6602		17408	6213	
(2)	39070			27624			11513		
COUTS VARIABLES ANNUELS (FCFA/HA):									
Semences: Mil		500	500		550	550		600	600
Sesame	1800			1800			1800		
Traitement semences de mil	0	76	76	0	76	76	0	76	76
Fertilisation	5509	0	0	5509	0	0	2755	0	0
Couts variables totaux	7309	576	576	7309	626	626	4555	676	676
CHARGES ANNUELLES (FCFA/HA/AN):									
Materiel agricole	3217	3217	0	3217	3217	0	3217	3217	0
Attelage	3645	3645	0	4557	4557	0	3645	3645	0
Charges annuelles totales	6863	6863	0	7774	7774	0	6863	6863	0
COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
	14172	7439	576	15083	8401	626	11417	7539	676
AUGMENTATION DES COUTS VARIABLES ET CHARGES ANNUELLES (FCFA/HA/AN):									
(1)	13596	6863		14457	7774		10741	6863	
(2)	6733			6683			3878		
REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
	942	282	306	777	290	330	536	317	345
AUGMENTATION DE LA REMUNERATION DE LA JOURNEE DE MAIN D'OEUVRE (FCFA/HOMME JOUR):									
(1)	636	-24		447	-40		190	-28	
(2)	660			487			218		
BENEFICE NET (FCFA/HA):									
(1)	46463	14590	15324	35376	15001	16174	20990	13674	14324
(2)	40798	8461		29340	8399		15096	7461	
AUGMENTATION DU BENEFICE NET (FCFA/HA):									
(1)	31140	-733		19202	-1173		6667	-650	
(2)	32337			20941			7635		

(1) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle.
(2) Vis-a-vis de la deuxieme culture de mil de la rotation mil-mil-mil avec la technologie traditionnelle amelioree (equipee).

ANNEXE I: ANALYSE DE SENSIBILITE DES PAQUETS TECHNOLOGIQUES.

TABLEAU I.1: ANALYSE DE SENSIBILITE DU TAUX MARGINAL DE RENTABILITE DES PAQUETS TECHNOLOGIQUES EN VARIANT LES PRIX OU LES RENDEMENTS ET EN VARIANT LES COUTS DES INTRANTS POUR LA ZONE NORD.

	PRIX OU RENDEMENT						
PAQUET TECHNOLOGIQUE (1)	-50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-N amelioree	Domine	Domine	11	26	41	56	101
Assolement M-N ameliore	17	99	121	142	163	184	248
Association M-N trad. amelioree	Domine	40	52	63	74	83	108
Association M-N traditionnelle							
B) EXPLOITATION EQUIPEE:							
Association M-N amelioree	Domine	Domine	1	14	26	39	76
Assolement M-N ameliore	36	94	113	133	152	172	230
Association M-N trad. amelioree							

	COUTS						
PAQUET TECHNOLOGIQUE (1)	-50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-N amelioree	150	57	40	26	15	6	Domine
Assolement M-N ameliore	382	202	169	142	120	102	62
Association M-N trad. amelioree	235	106	82	63	48	35	6
Association M-N traditionnelle							
B) EXPLOITATION EQUIPEE:							
Association M-N amelioree	105	37	24	14	6	Domine	Domine
Assolement M-N ameliore	349	187	157	133	113	97	61
Association M-N trad. amelioree							

(1) M-N: Mil-Niebe

TABLEAU I.2: ANALYSE DE SENSIBILITE DU TAUX MARGINAL DE RENTABILITE DES PAQUETS TECHNOLOGIQUES EN VARIANT LES PRIX OU LES RENDEMENTS ET EN VARIANT LES COUTS DES INTRANTS POUR LES ZONES CENTRE ET PLATEAU.

PAQUET TECHNOLOGIQUE (1)	PRIX OU RENDEMENT -50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-M amelioree	Domine	18	37	56	74	93	148
Assolement M-M ameliore	6	50	65	80	96	111	157
Association M-M trad. amelioree	11	56	69	80	90	100	125
Association M-M traditionnelle							
Rotation A-M-A amelioree avec PNT	Domine	24	37	49	250	282	377
Rotation M-M-M traditionnelle							
Rotation A-M-A amelioree sans PNT	Domine	Domine	Domine	Domine	5	12	31
Rotation M-M-M trad. amelioree	Domine	Domine	Domine	Domine	Domine	Domine	Domine
Culture amelioree du sesame	Domine	23	41	53	149	171	238
2e annee rot. M-M-M trad.amelioree					0	5	19
2e annee rotation M-M-M trad.	Domine	Domine	Domine	Domine			
B) EXPLOITATION EQUIPEE:							
Association M-M amelioree	Domine	12	29	45	62	79	129
Assolement M-M ameliore	2	39	52	64	76	89	126
Association M-M trad. amelioree							
Rotation A-M-A amelioree avec PNT	16	161	191	221	252	282	373
Rotation A-M-A amelioree sans PNT	Domine	3	10	18	25	32	55
Rotation M-M-M trad. amelioree							
Culture amelioree du sesame	35	92	111	130	149	168	224
2e annee rot. M-M-M trad.amelioree							

PAQUET TECHNOLOGIQUE (1)	COUTS -50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-M amelioree	210	94	73	56	41	30	4
Assolement M-M ameliore	259	125	100	80	64	51	21
Association M-M trad. amelioree	266	127	101	80	63	49	18
Association M-M traditionnelle							
Rotation A-M-A amelioree avec PNT	535	298	254	49	36	24	Domine
Rotation M-M-M traditionnelle							
Rotation A-M-A amelioree sans PNT	114	35	9	Domine	Domine	Domine	Domine
Rotation M-M-M trad. amelioree	82	12	Domine	Domine	Domine	Domine	Domine
Culture amelioree du sesame	350	183	152	53	39	27	2
2e annee rot. M-M-M trad.ameliore	93	19	6	Domine	Domine	Domine	Domine
2e annee rotation M-M-M trad.							
B) EXPLOITATION EQUIPEE:							
Association M-M amelioree	176	78	60	45	34	24	2
Assolement M-M ameliore	204	99	80	64	51	41	17
Association M-M trad. amelioree							
Rotation A-M-A amelioree avec PNT	514	294	254	221	195	173	124
Rotation A-M-A amelioree sans PNT	63	29	23	18	13	10	2
Rotation M-M-M trad. amelioree							
Culture amelioree du sesame	292	171	148	130	115	103	76
2e annee rot. M-M-M trad.amelioree							

(1) M-M: Mil-Niebe — A-M-A: Rotation arachide-mil-arachide
M-M-M: Rotation mil-mil-mil — PNT: Phosphate Naturel de Tilemsi

ANNEXE I.

TABLEAU I.3: ANALYSE DE SENSIBILITE DU TAUX MARGINAL DE RENTABILITE DES PAQUETS TECHNOLOGIQUES EN VARIANT LES PRIX OU LES RENDEMENTS ET EN VARIANT LES COUTS DES INTRANTS POUR LA ZONE SUD

PAQUET TECHNOLOGIQUE (1)	PRIX OU RENDEMENT -50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-N amelioree	Domine	1	14	26	39	51	89
Assolement M-N ameliore	Domine	35	46	57	68	73	104
Association M-N trad. amelioree	3	48	61	72	83	93	119
Association M-N traditionnelle							
Culture amelioree du sesame	27	90	109	269	306	343	209
2e annee rot. M-M-M trad.ameliore	Domine	Domine	Domine	0	6	12	27
2e annee rotation M-M-M trad.							
B) EXPLOITATION EQUIPEE:							
Association M-N amelioree	Domine	Domine	8	19	30	41	74
Assolement M-N ameliore	Domine	35	46	57	68	78	104
Association M-N trad. amelioree							
Culture amelioree du sesame	109	205	237	269	301	333	429
2e annee rot. M-M-M trad.amelioree							

PAQUET TECHNOLOGIQUE (1)	COUTS -50%	-20%	-10%	0%	+10%	+20%	+50%
A) EXPLOITATION NON EQUIPEE:							
Association M-N amelioree	151	57	40	26	15	5	Domine
Assolement M-N ameliore	214	97	75	57	43	31	5
Association M-N trad. amelioree	251	117	92	72	56	42	13
Association M-N traditionnelle							
Culture amelioree du sesame	635	361	310	269	107	89	52
2e annee rot. M-M-M trad.ameliore	104	26	12	0	Domine	Domine	Domine
2e annee rotation M-M-M trad.							
B) EXPLOITATION EQUIPEE:							
Association M-N amelioree	126	46	31	19	9	1	Domine
Assolement M-N ameliore	214	97	75	57	43	31	5
Association M-N trad. amelioree							
Culture amelioree du sesame	562	342	302	269	243	221	172
2e annee rot. M-M-M trad.amelioree							

(1) M-N: Mil-Niebe
M-M-M: Rotation Mil-Mil-Mil

ANNEXE I.

TABLEAU I.4: Rentabilite moyenne du travail et rentabilite marginale de la journee de travail avec un cout d'opportunite du capital de 50%.

Paquet Technologique(1)	Benefice Brut (FCFA) (2)	Cout Total (FCFA) (3)	Rentabilite du Travail (FCFA)	Intrant Travail (jour)	Journee Supplementaire (jour)	Rentabilite Moy. du Travail (4) (FCFA/jour)	Rentabilite Marginale du Travail(FCFA)	Rentabilite Marginale par Journee (5) (FCFA/jour)
A) ZONE NORD:								
Tecn. trad. sur l'association M-N	20500	1805	18696	48.5	12.5	385	501	40
Association M-N amelioree	46000	27806	18195	36.0	5.0	505	623	125
Assolement M-N amelioree	36775	19203	17572	31.0	3.5	567	6417	1833
Tech. trans. sur l'association M-N	22150	10995	11155	27.5		406		
2e annee de tecn. trad. sur M-M-M	15000	994.5	14006	41.5	6.5	337	7859	1209
Culture amelioree de sesame	21000	14853	6147	35.0	11.5	176	1332	116
2e annee de tech. trans. sur M-M-M	15000	10185	4815	23.5		205		
B) ZONES CENTRALE ET DU PLATEAU:								
Association M-N amelioree	62600	36488	26113	47.5	4.4	550	752	171
Tecn. trad. sur l'association M-N	27000	1640	25361	57.5	14.4	441	Domine (6)	
Assolement M-N amelioree	49500	25752	23748	43.1	9.1	551	6885	757
Tech. trans. sur l'association M-N	28950	12587	16363	34.0		496		
Technique trad. sur rotation M-M-M	16267	969	15298	50.3	3.6	304	104	29
Rotation amelioree A-M-A avec PNT	40640	25446	15194	51.0	4.3	298	Domine (6)	
Rotation amelioree A-M-A sans PNT	27243	19769	7475	46.7	16.4	160	2624	160
Technique trans. sur rotation M-M-M	16267	11417	4851	30.3		160		
2e annee de tecn. trad. sur M-M-M	16800	920	15881	49.0	6.0	324	1653	276
Culture amelioree de sesame	33750	19523	14228	43.0	14.0	331	8795	628
2e annee de tech. trans. sur M-M-M	16800	11367	5433	29.0		187		
C) ZONE SUD:								
Tecn. trad. sur l'association M-N	23400	1520	21881	64.0	6.5	342	6157	947
Assolement M-N amelioree	52000	36276	15724	57.5	18.5	273	173	9
Association M-N amelioree	68300	52749	15551	39.0	0.0	399		
Tech. trans. sur l'association M-N	25200	10710	14490	39.0		372	Domine (6)	
Technique trad. sur rotation M-M-M	14100	945	13155	50.0	4.0	263	6141	1535
Rotation amelioree A-M-A sans PNT	25375	18401	6975	46.0	16.0	152	3010	188
Rotation amelioree A-M-A avec PNT	30227	24080	6148	49.3	19.3	125	Domine (6)	
Technique trans. sur rotation M-M-M	14100	10136	3965	30.0		132		
Culture amelioree de sesame	42000	18266	23735	49.0	19.0	484	17870	941
2e annee de tech. trad. sur M-M-M	15900	845	15056	50.0	20.0	301	Domine (6)	
2e annee de tech. trans. sur M-M-M	15900	10035	5865	30.0		196		

(1) M-N: Mil-Niebe — M-M-M: Rotation Mil-Mil-Mil
A-M-A: Rotation Arachide-Mil-Arachide — PNT: Phosphate Naturel de Tilemsi
Technique de transition: Technique mecanisee sans intrant exterieur.
Technique traditionnelle: Technique non-mecanisee sans intrant exterieur.
(2) Gain de travail exclu.
(3) Cout de travail exclu, mais incluant un cout d'opportunite du capital de 50% pour la saison agricole.
(4) Rentabilite du travail divise par le nombre total de journees de travail.
(5) Rentabilite marginale du travail divise par le nombre de journees supplementaires.
(6) Un paquet technologique est domine s'il encourre plus de travail sans benefice additionnel.
Source: A partir des tableaux F.1. a F.5. de l'annexe F et les tableaux G.1. a G.5. de l'annexe G.

ANNEXE J: ANALYSE ECONOMIQUE DES PAQUETS TECHNOLOGIQUES.

TABLEAU J.1: SUPERFICIE, POPULATION ET TAUX D'EQUIPEMENT PAR SYSTEME DE PRODUCTION DU SENO ET DU PLATEAU.

ZONE	SUPERFICIE EMBLAVEE(HA) (2)	POPULATION (3)	SYSTEME PRODUC(%) AGRO-PASTEUR	ELEVEUR (4)	EQUIPEMENT(%) AGRO-PASTEUR	ELEVEUR (5)
NORD	31250	67823	79	21	20	8
CENTRE	37250	119861	95	5	46	-
PLATEAU	10100	42867	90	10	32	-
SUD	50550	145120	72	28	20	4
TOTAL	129150	375671				
Sous region (1)		655372				
Pourcentage(%)		57				

(1) Cercle de Bandiagara, Bankass, Koro et Douentza et les arrondissements de Boni, Mondoro, Hombori et Douentza Central du cercle de Douentza.

Sources: (2) Selon le Rapport Mensuel de l'OMM, Janvier-Fevrier 1987.

(3) Selon "Recensement General de la Population et de l'Habitat (du 1er au 14 avril)." Ministere de l'Administration Territorial et du Developpement a la Base. Republique du Mali. Juillet 1987.

(4) Kassambara, Bara, 1980 et Enquete Informelle, Projet IER-USAID-MS Decembre 1987.

(5) Enquete Informelle. Projet IER-USAID-MSU. Decembre 1987.

ANNEXE J.

TABLEAU J.2: CARACTERISTIQUES DES GROUPES CIBLES (STRATE) RETENUS POUR LE SENO ET LE PLATEAU.

STRATE No	GROUPES CIBLES	Pop./UP (2)	Actif/UP (2)	Superf. emblavee Ha	%	Population (3) #	%
1	Agropast.Nord non equipe	14	10	19750	16	42864	12
2	Agropasteur Nord equipe	20	13	4938	4	10716	3
3	(Agropast.Cent.non equipe	8	6	19109	15	61489	17
	(Agropast.Plat.non equipe	12	8	6181	5	26235	7
4	(Agropast.Cent.equipe	14	9	16278	13	52379	14
	(Agropast.Plat.equipe	11	8	2909	2	12346	3
5	Agropast. Sud non equipe	8	6	29117	23	83589	23
6	Agropast. Sud equipe	21	12	7279	6	20897	6
7	Eleveur Nord non equipe	15	10	6038	5	13103	4
8	Eleveur Nord equipe	18	11	525	0	1139	0
9	Eleveur Sud	14	9	14154	11	40634	11
Total				126278	100	365391	100
Sous region (1)						655372	
Pourcentage(%)						56	

(1) Cercle de Bandiagara, Bankass, Koro et Douentza et les arrondissements de Boni, Mondoro, Hombori et Douentza Central du cercle de Douentza.

Sources: (2) Selon les resultats de l'enquete formelle. Projet IER-USAID-MSU. Decembre 1987 - Mars 1988. Les valeurs statistiques ne sont pas significativement differentes entre-elles.

(3) Selon le tableau J.1, Annexe J.

ANNEXE J.

TABLEAU J.3: ANALYSE ECONOMIQUE DE L'ASSOCIATION MIL-NIEBE PAR STRATE ET AN.

COMPOSANTES PAR STRATE	VALEUR PAR HECTARE	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9	AN 10
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.8	1.6
Superfice (Ha):	19750	0	0	0	0	0	20	40	79	158	316
Augmentation benefice brut(Milliers FCFA):	30	0	0	0	0	0	609	1219	2407	4814	9629
Augmentation des couts (Milliers FCFA):	20	0	0	0	0	0	407	815	1609	3218	6436
Augmentation benefice net (Milliers FCFA):	10	0	0	0	0	0	202	404	798	1596	3192
STRATE 2											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.9	1.9	3.9
Superfice (Ha):	4938	0	0	0	0	0	10	21	44	91	192
Augmentation benefice brut(Milliers FCFA):	20	0	0	0	0	0	195	410	858	1775	3744
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	135	284	594	1229	2593
Augmentation benefice net (Milliers FCFA):	6	0	0	0	0	0	60	126	264	546	1151
STRATE 3											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.9	1.9
Superfice (Ha):	25290	0	0	0	0	0	25	53	112	234	492
Augmentation benefice brut(Milliers FCFA):	40	0	0	0	0	0	1003	2125	4452	9314	19731
Augmentation des couts (Milliers FCFA):	27	0	0	0	0	0	669	1419	2995	6266	13175
Augmentation benefice net (Milliers FCFA):	13	0	0	0	0	0	333	706	1492	3118	6556
STRATE 4											
Coefficient d'adoption ajuste:	2.20										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.7	1.6	3.5
Superfice (Ha):	15187	0	0	0	0	0	29	63	139	306	674
Augmentation benefice brut(Milliers FCFA):	26	0	0	0	0	0	745	1618	3570	7854	17309
Augmentation des couts (Milliers FCFA):	19	0	0	0	0	0	551	1197	2641	5815	12808
Augmentation benefice net (Milliers FCFA):	7	0	0	0	0	0	194	421	928	2043	4501
STRATE 5											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	1.3
Superfice (Ha):	29117	0	0	0	0	0	29	55	105	200	379
Augmentation benefice brut(Milliers FCFA):	51	0	0	0	0	0	1485	2816	5375	10239	19402
Augmentation des couts (Milliers FCFA):	41	0	0	0	0	0	1178	2234	4264	8123	15392
Augmentation benefice net (Milliers FCFA):	11	0	0	0	0	0	307	582	1111	2116	4010
STRATE 6											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.8	1.6	3.2
Superfice (Ha):	7279	0	0	0	0	0	15	29	58	116	233
Augmentation benefice brut(Milliers FCFA):	40	0	0	0	0	0	600	1160	2320	4639	9318
Augmentation des couts (Milliers FCFA):	34	0	0	0	0	0	506	979	1958	3915	7864
Augmentation benefice net (Milliers FCFA):	6	0	0	0	0	0	94	181	362	724	1455
STRATE 7											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5
Superfice (Ha):	6038	0	0	0	0	0	3	5	10	18	32
Augmentation benefice brut(Milliers FCFA):	30	0	0	0	0	0	91	152	305	548	975
Augmentation des couts (Milliers FCFA):	20	0	0	0	0	0	61	102	204	367	652
Augmentation benefice net (Milliers FCFA):	10	0	0	0	0	0	30	51	101	182	323
STRATE 8											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.7	1.4	2.6
Superfice (Ha):	525	0	0	0	0	0	1	2	4	7	14
Augmentation benefice brut(Milliers FCFA):	20	0	0	0	0	0	20	39	78	137	273
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	14	27	54	95	189
Augmentation benefice net (Milliers FCFA):	6	0	0	0	0	0	6	12	24	42	84
STRATE 9											
Coefficient d'adoption ajuste:	1.70										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.8
Superfice (Ha):	14154	0	0	0	0	0	14	24	41	70	118
Augmentation benefice brut(Milliers FCFA):	51	0	0	0	0	0	717	1229	2099	3583	6041
Augmentation des couts (Milliers FCFA):	41	0	0	0	0	0	569	975	1665	2843	4792
Augmentation benefice net (Milliers FCFA):	11	0	0	0	0	0	148	254	434	741	1248
STRATE 1 A 9:											
Superfice (Ha):	126278	0	0	0	0	0	146	292	592	1200	2450
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.5	1.0	1.9
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	5464	10767	21503	42978	86422
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	4090	8031	15989	31870	63901
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	1374	2736	5514	11108	22520
Aug.benefice brut(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	18	36	72	143	288
Augmentation cout(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	14	27	53	106	213
Aug.benefice net (Milliers $ US):	300 = 1 $ US	0	0	0	0	0	5	9	18	37	75

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ANNEXE J.

TABLEAU J.3 (SUITE): ANALYSE ECONOMIQUE DE L'ASSOCIATION MIL-NIEBE PAR STRATE ET AN.

COMPOSANTES PAR STRATE

		AN 11	AN 12	AN 13	AN 14	AN 15	AN 16	AN 17	AN 18	AN 19	AN 20
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		3.2	6.4	12.8	16.0	17.6	18.4	18.8	19.0	19.1	19.2
Superfice (Ha):	19758	632	1264	2528	3160	3476	3634	3713	3753	3772	3782
Augmentation benefice brut(Milliers FCFA):		19257	38514	77028	96285	105914	110728	113135	114354	114933	115238
Augmentation des couts (Milliers FCFA):		12873	25745	51491	64363	70795	74018	75627	76441	76828	77032
Augmentation benefice net (Milliers FCFA):		6384	12769	25538	31922	35114	36710	37509	37913	38105	38206
STRATE 2											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		8.2	17.2	21.4	23.5	24.4	24.9	25.1	25.2	25.3	25.3
Superfice (Ha):	4938	403	847	1058	1159	1207	1230	1240	1246	1248	1249
Augmentation benefice brut(Milliers FCFA):		7859	16517	20632	22601	23538	23986	24181	24294	24337	24357
Augmentation des couts (Milliers FCFA):		5443	11439	14288	15652	16301	16611	16746	16827	16856	16868
Augmentation benefice net (Milliers FCFA):		2416	5078	6343	6949	7237	7375	7435	7471	7483	7489
STRATE 3											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		4.1	8.6	18.0	22.5	24.6	25.7	26.1	26.4	26.5	26.5
Superfice (Ha):	25290	1033	2169	4555	5691	6232	6490	6613	6671	6699	6712
Augmentation benefice brut(Milliers FCFA):		41427	86984	182670	228228	249923	260270	265203	267529	268652	269173
Augmentation des couts (Milliers FCFA):		27661	58080	121972	152391	166877	173786	177080	178633	179383	179731
Augmentation benefice net (Milliers FCFA):		13765	28904	60699	75837	83046	86484	88123	88896	89269	89442
STRATE 4											
Coefficient d'adoption ajuste:	2.20										
Taux d'adoption cumulatif(%Ha):		7.7	17.0	37.4	46.7	50.9	52.8	53.7	54.1	54.3	54.4
Superfice (Ha):	19187	1483	3263	7179	8959	9768	10136	10303	10379	10413	10429
Augmentation benefice brut(Milliers FCFA):		38085	83798	184366	230078	250854	260305	264594	266546	267419	267830
Augmentation des couts (Milliers FCFA):		28182	62008	136424	170250	185624	192617	195790	197235	197881	198185
Augmentation benefice net (Milliers FCFA):		9903	21790	47941	59828	65231	67688	68804	69311	69538	69645
STRATE 5											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		2.5	4.7	8.9	11.2	12.3	13.0	13.3	13.5	13.5	13.6
Superfice (Ha):	29117	721	1370	2603	3252	3593	3773	3867	3917	3943	3957
Augmentation benefice brut(Milliers FCFA):		30910	70138	159254	166478	183935	193150	197962	200521	201852	202569
Augmentation des couts (Milliers FCFA):		29282	55640	105716	132074	145923	153234	157051	159082	160138	160707
Augmentation benefice net (Milliers FCFA):		7628	14494	27538	34404	38012	39916	40910	41439	41714	41863
STRATE 6											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		6.4	12.8	16.0	17.6	18.4	18.8	19.0	19.1	19.2	19.2
Superfice (Ha):	7279	466	932	1165	1281	1339	1368	1383	1390	1394	1396
Augmentation benefice brut(Milliers FCFA):		18637	37273	46592	51231	53551	54710	55310	55590	55750	55830
Augmentation des couts (Milliers FCFA):		15728	31455	39319	43236	45192	46170	46677	46913	47048	47115
Augmentation benefice net (Milliers FCFA):		2909	5818	7273	7997	8359	8540	8634	8677	8702	8715
STRATE 7											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		0.9	1.7	3.1	5.5	6.9	7.6	8.0	8.3	8.4	8.5
Superfice (Ha):	6038	57	103	185	333	415	460	486	500	508	512
Augmentation benefice brut(Milliers FCFA):		1737	3138	5637	10147	12645	14016	14808	15235	15479	15601
Augmentation des couts (Milliers FCFA):		1161	2098	3768	6783	8453	9369	9899	10184	10347	10428
Augmentation benefice net (Milliers FCFA):		576	1041	1869	3364	4192	4647	4910	5051	5132	5172
STRATE 8											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		5.0	9.4	17.9	22.3	24.7	25.9	26.6	26.9	27.1	27.2
Superfice (Ha):	525	26	49	94	117	130	136	139	141	142	143
Augmentation benefice brut(Milliers FCFA):		507	956	1833	2282	2535	2652	2711	2750	2769	2789
Augmentation des couts (Milliers FCFA):		351	662	1269	1580	1756	1837	1877	1904	1918	1931
Augmentation benefice net (Milliers FCFA):		156	294	564	701	779	815	833	845	851	857
STRATE 9											
Coefficient d'adoption ajuste:	1.70										
Taux d'adoption cumulatif(%Ha):		1.4	2.4	4.1	7.0	8.7	9.7	10.2	10.6	10.8	10.9
Superfice (Ha):	14154	201	342	581	987	1226	1367	1450	1499	1527	1544
Augmentation benefice brut(Milliers FCFA):		10290	17508	29743	50527	62762	69980	74229	76738	78171	79041
Augmentation des couts (Milliers FCFA):		8163	13890	23596	40085	49792	55518	58889	60879	62016	62707
Augmentation benefice net (Milliers FCFA):		2126	3618	6147	10442	12970	14462	15340	15858	16155	16335
STRATE 1 A 9:											
Superfice (Ha):	126278	5022	10339	19948	24939	27386	28594	29194	29496	29646	29724
Taux d'adoption cumulatif(%Ha):		4.0	8.2	15.8	19.7	21.7	22.6	23.1	23.4	23.5	23.5
Augmentation benefice brut(Milliers FCFA):		174708	356822	681755	857857	945657	989798	1012133	1023561	1029362	1032427
Augmentation des couts (Milliers FCFA):		128843	261017	497844	626613	690717	723160	739636	748099	752413	754704
Augmentation benefice net (Milliers FCFA):		45865	93805	183911	231444	254941	266638	272497	275462	276949	277723
Aug.benefice brut(Milliers $ US):	300	582	1183	2273	2860	3152	3299	3374	3412	3431	3441
Augmentation cout(Milliers $ US):	300	429	870	1659	2088	2302	2411	2465	2494	2508	2516
Aug.benefice net (Milliers $ US):	300	153	313	613	771	850	889	908	918	923	926

ANNEXE J.

TABLEAU J.6: ANALYSE ECONOMIQUE DE L'ASSOLEMENT MIL-NIEBE PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE	VALEUR PAR HECTARE	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9	AN 10
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	1.70										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.4
Superfice (Ha):	19750	0	0	0	0	0	10	17	29	49	82
Augmentation benefice brut(Milliers FCFA):	23	0	0	0	0	0	232	395	674	1138	1905
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	138	234	400	676	1131
Augmentation benefice net (Milliers FCFA):	9	0	0	0	0	0	94	160	274	463	774
STRATE 2											
Coefficient d'adoption ajuste:	1.40										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.9	1.6
Superfice (Ha):	4938	0	0	0	0	0	7	13	24	43	78
Augmentation benefice brut(Milliers FCFA):	13	0	0	0	0	0	90	167	308	552	1001
Augmentation des couts (Milliers FCFA):	7	0	0	0	0	0	49	90	166	298	541
Augmentation benefice net (Milliers FCFA):	6	0	0	0	0	0	41	77	142	254	461
STRATE 3											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	1.3
Superfice (Ha):	25290	0	0	0	0	0	25	48	91	173	330
Augmentation benefice brut(Milliers FCFA):	29	0	0	0	0	0	724	1391	2637	5012	9561
Augmentation des couts (Milliers FCFA):	19	0	0	0	0	0	475	912	1728	3286	6268
Augmentation benefice net (Milliers FCFA):	10	0	0	0	0	0	249	479	908	1726	3293
STRATE 4											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.8	1.6	3.2
Superfice (Ha):	19187	0	0	0	0	0	38	77	153	307	614
Augmentation benefice brut(Milliers FCFA):	15	0	0	0	0	0	576	1168	2320	4655	9311
Augmentation des couts (Milliers FCFA):	11	0	0	0	0	0	426	864	1717	3444	6889
Augmentation benefice net (Milliers FCFA):	4	0	0	0	0	0	150	304	603	1211	2422
STRATE 5											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.6	1.0
Superfice (Ha):	29117	0	0	0	0	0	29	52	94	170	306
Augmentation benefice brut(Milliers FCFA):	37	0	0	0	0	0	1083	1942	3510	6348	11426
Augmentation des couts (Milliers FCFA):	27	0	0	0	0	0	783	1403	2537	4588	8258
Augmentation benefice net (Milliers FCFA):	10	0	0	0	0	0	300	538	973	1760	3168
STRATE 6											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	1.0	2.0
Superfice (Ha):	7279	0	0	0	0	0	11	21	39	75	142
Augmentation benefice brut(Milliers FCFA):	27	0	0	0	0	0	295	563	1045	2010	3806
Augmentation des couts (Milliers FCFA):	20	0	0	0	0	0	221	423	785	1509	2858
Augmentation benefice net (Milliers FCFA):	7	0	0	0	0	0	73	140	260	501	948
STRATE 7											
Coefficient d'adoption ajuste:	1.60										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5
Superfice (Ha):	6038	0	0	0	0	0	5	8	12	20	32
Augmentation benefice brut(Milliers FCFA):	23	0	0	0	0	0	116	186	279	465	743
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	69	110	166	276	441
Augmentation benefice net (Milliers FCFA):	9	0	0	0	0	0	47	76	113	189	302
STRATE 8											
Coefficient d'adoption ajuste:	1.70										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	1.0	1.7
Superfice (Ha):	525	0	0	0	0	0	1	2	3	5	9
Augmentation benefice brut(Milliers FCFA):	13	0	0	0	0	0	13	26	39	64	116
Augmentation des couts (Milliers FCFA):	7	0	0	0	0	0	7	14	21	35	62
Augmentation benefice net (Milliers FCFA):	6	0	0	0	0	0	6	12	18	30	53
STRATE 9											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.9	1.6
Superfice (Ha):	14154	0	0	0	0	0	21	38	69	124	223
Augmentation benefice brut(Milliers FCFA):	37	0	0	0	0	0	784	1419	2576	4630	8327
Augmentation des couts (Milliers FCFA):	27	0	0	0	0	0	567	1026	1862	3346	6018
Augmentation benefice net (Milliers FCFA):	10	0	0	0	0	0	217	393	714	1284	2309
STRATE 1 A 9:											
Superfice (Ha):	126278	0	0	0	0	0	147	276	514	966	1816
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.8	1.4
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	3914	7255	13387	24875	46195
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	2734	5076	9381	17458	32466
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	1179	2179	4006	7416	13729
Aug.benefice brut(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	13	24	45	83	154
Augmentation cost(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	9	17	31	58	108
Aug.benefice net (Milliers $ US):	300 = 1 $ US	0	0	0	0	0	4	7	13	25	46

ANNEXE J.

TABLEAU J.4 (SUITE): ANALYSE ECONOMIQUE DE L'ASSOLEMENT MIL-NIEBE PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE

	AN 11	AN 12	AN 13	AN 14	AN 15	AN 16	AN 17	AN 18	AN 19	AN 20
Coefficient d'adoption de base: 2.00										
STRATE 1										
Coefficient d'adoption ajuste: 1.70										
Taux d'adoption cumulatif(%Ha):	0.7	1.2	2.1	3.5	5.9	10.1	12.5	14.0	14.8	15.3
Superfice (Ha): 19750	140	238	405	689	1171	1991	2473	2757	2923	3022
Augmentation benefice brut(Milliers FCFA):	3253	5529	9409	16008	27206	46257	57455	64053	67910	70210
Augmentation des couts (Milliers FCFA):	1931	3283	5586	9504	16152	27462	34111	38028	40317	41683
Augmentation benefice net (Milliers FCFA):	1322	2247	3823	6504	11054	18795	23345	26026	27593	28527
STRATE 2										
Coefficient d'adoption ajuste: 1.80										
Taux d'adoption cumulatif(%Ha):	2.8	5.1	9.2	16.5	20.6	22.9	24.1	24.8	25.2	25.4
Superfice (Ha): 4938	140	252	453	816	1018	1130	1192	1226	1246	1256
Augmentation benefice brut(Milliers FCFA):	1797	3234	5814	10473	13065	14503	15298	15735	15991	16120
Augmentation des couts (Milliers FCFA):	970	1746	3139	5655	7055	7831	8261	8497	8635	8704
Augmentation benefice net (Milliers FCFA):	827	1488	2674	4818	6010	6671	7037	7238	7356	7415
STRATE 3										
Coefficient d'adoption ajuste: 1.90										
Taux d'adoption cumulatif(%Ha):	2.5	4.7	8.9	17.0	21.2	23.4	24.6	25.2	25.6	25.7
Superfice (Ha): 25290	626	1190	2261	4295	5366	5930	6226	6382	6465	6501
Augmentation benefice brut(Milliers FCFA):	18137	34478	65509	124441	155471	171812	180389	184908	187313	188559
Augmentation des couts (Milliers FCFA):	11890	22603	42945	81578	101921	112633	118256	121259	122795	123612
Augmentation benefice net (Milliers FCFA):	6247	11876	22564	42862	53551	59179	62133	63690	64518	64947
STRATE 4										
Coefficient d'adoption ajuste: 2.00										
Taux d'adoption cumulatif(%Ha):	6.4	12.8	25.6	32.0	35.2	36.8	37.6	38.0	38.2	38.3
Superfice (Ha): 19187	1228	2456	4912	6140	6754	7061	7214	7291	7329	7349
Augmentation benefice brut(Milliers FCFA):	18621	37242	74484	93105	102416	107071	109391	110559	111135	111438
Augmentation des couts (Milliers FCFA):	13778	27555	55110	68888	75777	79221	80938	81802	82228	82453
Augmentation benefice net (Milliers FCFA):	4843	9687	19374	24217	26639	27850	28453	28757	28907	28986
STRATE 5										
Coefficient d'adoption ajuste: 1.80										
Taux d'adoption cumulatif(%Ha):	1.9	3.4	6.1	11.0	13.7	15.3	16.1	16.6	16.8	17.0
Superfice (Ha): 29117	550	990	1783	3209	4001	4441	4686	4821	4897	4939
Augmentation benefice brut(Milliers FCFA):	20537	36966	66577	119823	149396	165826	174974	180015	182853	184421
Augmentation des couts (Milliers FCFA):	14843	26718	48119	86603	107977	119851	126463	130106	132158	133291
Augmentation benefice net (Milliers FCFA):	5694	10249	18458	33220	41419	45975	48511	49908	50695	51130
STRATE 6										
Coefficient d'adoption ajuste: 1.90										
Taux d'adoption cumulatif(%Ha):	3.7	7.1	13.4	25.5	31.8	35.2	36.9	37.9	38.3	38.6
Superfice (Ha): 7279	270	514	976	1856	2317	2560	2688	2756	2791	2810
Augmentation benefice brut(Milliers FCFA):	7236	13775	26157	49687	62096	68608	72038	73861	74799	75308
Augmentation des couts (Milliers FCFA):	5434	10344	19642	37311	46629	51519	54095	55463	56168	56550
Augmentation benefice net (Milliers FCFA):	1802	3431	6515	12376	15467	17089	17944	18398	18631	18758
STRATE 7										
Coefficient d'adoption ajuste: 1.60										
Taux d'adoption cumulatif(%Ha):	0.8	1.3	2.1	3.4	5.5	8.8	10.9	12.1	13.0	13.5
Superfice (Ha): 6038	51	81	130	207	332	531	656	733	782	812
Augmentation benefice brut(Milliers FCFA):	1185	1882	3020	4809	7713	12337	15241	17030	18168	18865
Augmentation des couts (Milliers FCFA):	703	1117	1793	2855	4579	7324	9048	10110	10786	11200
Augmentation benefice net (Milliers FCFA):	481	765	1227	1954	3134	5013	6193	6919	7382	7665
STRATE 8										
Coefficient d'adoption ajuste: 1.70										
Taux d'adoption cumulatif(%Ha):	2.8	4.8	8.2	14.0	17.3	19.3	20.5	21.2	21.6	21.8
Superfice (Ha): 525	15	25	43	73	91	101	108	111	113	115
Augmentation benefice brut(Milliers FCFA):	193	321	552	937	1168	1296	1386	1425	1450	1476
Augmentation des couts (Milliers FCFA):	104	173	298	506	631	700	748	769	783	797
Augmentation benefice net (Milliers FCFA):	89	148	254	431	537	596	638	655	667	679
STRATE 9										
Coefficient d'adoption ajuste: 1.80										
Taux d'adoption cumulatif(%Ha):	2.8	5.1	9.2	16.5	20.6	22.9	24.1	24.8	25.2	25.4
Superfice (Ha): 14156	401	722	1300	2340	2917	3238	3417	3516	3571	3601
Augmentation benefice brut(Milliers FCFA):	14973	26959	48542	87375	108920	120906	127590	131287	133340	134460
Augmentation des couts (Milliers FCFA):	10822	19485	35084	63151	78722	87385	92216	94888	96372	97182
Augmentation benefice net (Milliers FCFA):	4151	7474	13458	24224	30198	33521	35374	36399	36968	37279
STRATE 1 A 9:										
Superfice (Ha): 126278	3421	6468	12263	19623	23967	26983	28660	29593	30117	30412
Taux d'adoption cumulatif(%Ha):	2.7	5.1	9.7	15.5	19.0	21.4	22.7	23.4	23.8	24.1
Augmentation benefice brut(Milliers FCFA):	85931	160388	300064	506658	627651	708616	753762	778872	792960	800158
Augmentation des couts (Milliers FCFA):	60475	113024	211716	356051	439442	493928	524136	540882	550243	555472
Augmentation benefice net (Milliers FCFA):	25456	47364	88348	150607	188009	214688	229627	237990	242717	245386
Aug.benefice brut(Milliers $ US): 300	286	535	1000	1689	2092	2362	2513	2596	2643	2670
Augmentation cout(Milliers $ US): 300	202	377	706	1187	1465	1646	1747	1803	1834	1852
Aug.benefice net (Milliers $ US): 300	85	158	294	502	627	716	765	793	809	818

ANNEXE J.

TABLEAU J.5: ANALYSE ECONOMIQUE DE LA ROTATION ARACHIDE-MIL-ARACHIDE PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE	VALEUR PAR HECTARE	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9	AN 10
Coefficient d'adoption de base: 2.00											
STRATE 1											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 988		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 2											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 247		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 3											
Coefficient d'adoption ajuste: 2.10											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.1	4.4	9.3
Superfice (Ha): 1265		0	0	0	0	0	0	13	27	56	117
Augmentation benefice brut(Milliers FCFA):	24	0	0	0	0	0	0	316	657	1362	2845
Augmentation des couts (Milliers FCFA):	19	0	0	0	0	0	0	248	514	1067	2229
Augmentation benefice net (Milliers FCFA):	5	0	0	0	0	0	0	68	142	295	616
STRATE 4											
Coefficient d'adoption ajuste: 2.20											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.2	4.8	10.6
Superfice (Ha): 959		0	0	0	0	0	0	10	21	46	102
Augmentation benefice brut(Milliers FCFA):	35	0	0	0	0	0	0	355	745	1633	3620
Augmentation des couts (Milliers FCFA):	12	0	0	0	0	0	0	121	254	556	1233
Augmentation benefice net (Milliers FCFA):	7	0	0	0	0	0	0	71	150	328	728
STRATE 5											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 1456		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 6											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 364		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 7											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 302		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 8											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 26		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 9											
Coefficient d'adoption ajuste: 0.00											
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha): 708		0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 1 A 9:											
Superfice (Ha): 6314		0	0	0	0	0	0	23	48	102	219
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8	1.6	3.5
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	671	1402	2994	6465
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	369	768	1623	3462
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	140	292	633	1344
Aug.benefice brut(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	2	5	10	22
Augmentation cout(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	1	3	5	12
Aug.benefice net (Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	0	1	2	4

ANNEXE J.

TABLEAU J.5 (SUITE): ANALYSE ECONOMIQUE DE LA ROTATION ARACHIDE-MIL-ARACHIDE PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE

		AN 11	AN 12	AN 13	AN 14	AN 15	AN 16	AN 17	AN 18	AN 19	AN 20
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	988	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 2											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	247	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 3											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		19.4	40.8	85.8	180.1	225.0	246.4	256.6	261.5	263.8	264.9
Superfice (Ha):	1265	246	516	1085	2278	2846	3116	3245	3306	3335	3349
Augmentation benefice brut(Milliers FCFA):		5982	12548	26385	55397	69210	75776	78913	80397	81102	81442
Augmentation des couts (Milliers FCFA):		4687	9831	20671	43400	54221	59365	61823	62985	63538	63805
Augmentation benefice net (Milliers FCFA):		1296	2718	5714	11997	14989	16411	17090	17411	17564	17638
STRATE 4											
Coefficient d'adoption ajuste:	2.20										
Taux d'adoption cumulatif(%Ha):		23.4	51.5	113.4	249.4	311.3	339.4	352.2	358.0	360.6	361.8
Superfice (Ha):	959	225	494	1088	2393	2986	3256	3379	3434	3460	3471
Augmentation benefice brut(Milliers FCFA):		7985	17533	38614	84930	105976	115559	119924	121876	122799	123189
Augmentation des couts (Milliers FCFA):		2720	5971	13150	28924	36091	39355	40841	41506	41820	41953
Augmentation benefice net (Milliers FCFA):		1606	3526	7766	17080	21312	23240	24118	24510	24696	24774
STRATE 5											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	1456	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 6											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	364	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 7											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	302	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 8											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	26	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 9											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	708	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 1 A 9:											
Superfice (Ha):	6314	471	1010	2173	4671	5832	6372	6624	6740	6795	6820
Taux d'adoption cumulatif(%Ha):		7.5	16.0	34.4	74.0	92.4	100.9	104.9	106.7	107.6	108.0
Augmentation benefice brut(Milliers FCFA):		13968	30081	65000	140327	175186	191335	198837	202273	203901	204631
Augmentation des couts (Milliers FCFA):		7406	15802	33822	72324	90313	98720	102664	104491	105358	105758
Augmentation benefice net (Milliers FCFA):		6562	14243	31180	29077	36303	39650	41208	41921	42260	42412
Aug.benefice brut(Milliers $ US):	300	47	100	217	468	584	638	663	674	680	682
Augmentation cout(Milliers $ US):	300	25	53	113	241	301	329	342	348	351	353
Aug.benefice net (Milliers $ US):	300	18	21	45	97	121	132	137	140	141	141

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ANNEXE J.

TABLEAU J.6: ANALYSE ECONOMIQUE DE LA CULTURE DE SESAME PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE	VALEUR PAR HECTARE	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9	AN 10
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	1975	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 2											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	494	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 3											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.9	1.6	2.9
Superfice (Ha):	2529	0	0	0	0	0	0	13	23	41	74
Augmentation benefice brut(Milliers FCFA):	34	0	0	0	0	0	0	438	776	1380	2491
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	0	188	333	593	1070
Augmentation benefice net (Milliers FCFA):	19	0	0	0	0	0	0	250	442	787	1421
STRATE 4											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.2	2.4	4.8
Superfice (Ha):	1919	0	0	0	0	0	0	12	23	46	92
Augmentation benefice brut(Milliers FCFA):	28	0	0	0	0	0	0	331	635	1271	2541
Augmentation des couts (Milliers FCFA):	7	0	0	0	0	0	0	80	154	307	615
Augmentation benefice net (Milliers FCFA):	21	0	0	0	0	0	0	251	482	963	1927
STRATE 5											
Coefficient d'adoption ajuste:	1.50										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.1	2.2	4.1
Superfice (Ha):	2912	0	0	0	0	0	0	17	33	63	120
Augmentation benefice brut(Milliers FCFA):	45	0	0	0	0	0	0	760	1476	2818	5368
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	0	231	449	857	1631
Augmentation benefice net (Milliers FCFA):	31	0	0	0	0	0	0	529	1028	1962	3737
STRATE 6											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.9	4.0	8.3
Superfice (Ha):	728	0	0	0	0	0	0	7	14	29	61
Augmentation benefice brut(Milliers FCFA):	39	0	0	0	0	0	0	273	547	1133	2383
Augmentation des couts (Milliers FCFA):	7	0	0	0	0	0	0	47	94	195	411
Augmentation benefice net (Milliers FCFA):	32	0	0	0	0	0	0	226	453	938	1973
STRATE 7											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	604	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 8											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	53	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):	0	0	0	0	0	0	0	0	0	0	0
STRATE 9											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.6	3.2	6.4
Superfice (Ha):	1415	0	0	0	0	0	0	11	23	45	91
Augmentation benefice brut(Milliers FCFA):	45	0	0	0	0	0	0	492	1029	2013	4071
Augmentation des couts (Milliers FCFA):	14	0	0	0	0	0	0	150	313	612	1237
Augmentation benefice net (Milliers FCFA):	31	0	0	0	0	0	0	343	716	1401	2834
STRATE 1 A 9:											
Superfice (Ha).	12628	0	0	0	0	0	0	60	116	224	438
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.9	1.8	3.5
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	2295	4462	8615	16855
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	696	1342	2564	4964
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	1599	3120	6051	11891
Aug.benefice brut(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	8	15	29	56
Augmentation cout(Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	2	4	9	17
Aug.benefice net (Milliers $ US):	300 = 1 $ US	0	0	0	0	0	0	5	10	20	40

ANNEXE J.

TABLEAU J.6 (SUITE): ANALYSE ECONOMIQUE DE LA CULTURE DE SESAME PAR STRATE ET PAR AN.

COMPOSANTES PAR STRATE

		AN 11	AN 12	AN 13	AN 14	AN 15	AN 16	AN 17	AN 18	AN 19	AN 20
Coefficient d'adoption de base:	2.00										
STRATE 1											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	1975	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 2											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	494	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 3											
Coefficient d'adoption ajuste:	1.80										
Taux d'adoption cumulatif(%Ha):		5.2	9.4	17.0	30.6	55.1	68.7	76.3	80.5	82.8	84.1
Superfice (Ha):	2529	133	239	430	774	1393	1738	1929	2035	2094	2127
Augmentation benefice brut(Milliers FCFA):		4477	8044	14473	26052	46887	58499	64928	68496	70482	71593
Augmentation des couts (Milliers FCFA):		1923	3455	6217	11190	20139	25126	27888	29420	30273	30750
Augmentation benefice net (Milliers FCFA):		2554	4589	8257	14862	26748	33373	37040	39076	40209	40842
STRATE 4											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		9.6	19.2	38.4	76.8	96.0	105.6	110.4	112.8	114.0	114.6
Superfice (Ha):	1919	184	368	737	1474	1842	2026	2118	2164	2187	2199
Augmentation benefice brut(Milliers FCFA):		5083	10165	20359	40717	50883	55965	58507	59777	60413	60744
Augmentation des couts (Milliers FCFA):		1230	2459	4925	9851	12310	13539	14154	14462	14615	14696
Augmentation benefice net (Milliers FCFA):		3853	7706	15433	30867	38573	42426	44353	45316	45797	46049
STRATE 5											
Coefficient d'adoption ajuste:	1.90										
Taux d'adoption cumulatif(%Ha):		7.8	14.9	28.2	53.6	101.9	127.3	140.7	147.7	151.4	153.4
Superfice (Ha):	2912	228	433	822	1562	2967	3707	4096	4301	4409	4466
Augmentation benefice brut(Milliers FCFA):		10300	19370	36772	69876	132730	165834	183236	192405	197238	199788
Augmentation des couts (Milliers FCFA):		3130	5887	11176	21237	40339	50400	55688	58475	59944	60719
Augmentation benefice net (Milliers FCFA):		7160	13483	25597	48640	92391	115434	127547	133931	137294	139069
STRATE 6											
Coefficient d'adoption ajuste:	2.10										
Taux d'adoption cumulatif(%Ha):		17.5	36.8	77.2	162.1	202.5	221.8	231.0	235.3	237.4	238.4
Superfice (Ha):	728	127	268	562	1180	1474	1614	1681	1713	1728	1735
Augmentation benefice brut(Milliers FCFA):		4962	10471	21958	46103	57590	63059	65677	66927	67513	67787
Augmentation des couts (Milliers FCFA):		855	1804	3784	7945	9924	10867	11318	11533	11634	11682
Augmentation benefice net (Milliers FCFA):		4107	8666	18174	38158	47665	52193	54359	55394	55879	56105
STRATE 7											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	604	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 8											
Coefficient d'adoption ajuste:	0.00										
Taux d'adoption cumulatif(%Ha):		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Superfice (Ha):	53	0	0	0	0	0	0	0	0	0	0
Augmentation benefice brut(Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation des couts (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
Augmentation benefice net (Milliers FCFA):		0	0	0	0	0	0	0	0	0	0
STRATE 9											
Coefficient d'adoption ajuste:	2.00										
Taux d'adoption cumulatif(%Ha):		12.8	25.6	51.2	102.4	128.0	140.8	147.2	150.4	152.0	152.8
Superfice (Ha):	1415	181	362	725	1449	1812	1993	2083	2129	2151	2163
Augmentation benefice brut(Milliers FCFA):		8097	16194	32433	64821	81060	89157	93184	95241	96226	96762
Augmentation des couts (Milliers FCFA):		2461	4922	9857	19700	24636	27096	28320	28945	29245	29408
Augmentation benefice net (Milliers FCFA):		5636	11273	22576	45121	56425	62061	64864	66296	66981	67355
STRATE 1 A 9:											
Superfice (Ha):	12628	853	1670	3276	6439	9488	11078	11907	12342	12569	12690
Taux d'adoption cumulatif(%Ha):		6.8	13.2	25.9	51.0	75.1	87.7	94.3	97.7	99.5	100.5
Augmentation benefice brut(Milliers FCFA):		32818	64245	125955	247570	369149	432515	465531	482849	491872	496674
Augmentation des couts (Milliers FCFA):		9568	18528	35958	69922	107347	127029	137368	142836	145711	147254
Augmentation benefice net (Milliers FCFA):		23250	45718	90037	177648	261802	305486	328163	340012	346160	349420
Aug.benefice brut(Milliers $ US):	300	109	214	420	825	1230	1442	1552	1609	1640	1656
Augmentation cout(Milliers $ US):	300	32	62	120	233	358	423	458	476	486	491
Aug.benefice net (Milliers $ US):	300	77	152	300	592	873	1018	1094	1133	1154	1165

ANNEXE K: VALEUR ECONOMIQUE DU PROJET ET ANALYSE DE SENSIBILITE.

TABLEAU K.1: VALEUR ECONOMIQUE DU PROJET (Milliers de $ US) (1)

RUBRIQUE		AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 7	AN 8	AN 9	AN 10
ENTREES											
Aug. de benefice brut, association mil-niebe		0	0	0	0	0	18	36	72	143	288
Aug. de benefice brut, assolement mil-niebe		0	0	0	0	0	13	24	45	83	154
Aug. de benefice brut, rot.arachide-mil-arachide		0	0	0	0	0	0	2	5	10	22
Aug. de benefice brut, culture de sesame		0	0	0	0	0	0	8	15	29	56
TOTAL ENTREES		0	0	0	0	0	31	70	136	265	520
SORTIES											
COUTS DE PRODUCTION SUR L'EXPLOITATION											
Augmentation de cout, association mil-niebe		0	0	0	0	0	14	27	53	106	213
Augmentation de cout, assolement mil-niebe		0	0	0	0	0	9	17	31	58	108
Augmentation de cout, rot. arachide-mil-arachide		0	0	0	0	0	0	1	3	5	12
Augmentation de cout, culture de sesame		0	0	0	0	0	0	2	4	9	17
COUTS TOTAUX SUR L'EXPLOITATION		0	0	0	0	0	23	47	92	178	349
COUTS DU PROJET											
Couts du capital (financement AID):											
Assistance technique		0	340	325	310	305	5	5			
Formation court-terme		0	35	28	28	28	0	0			
Vehicules		0	60	0	0	60	0	0			
Equipement de recherche		0	24	2	14	27	12	14			
Equipement de bureau		0	20	0	0	20	0	0			
Meubles		0	175	25	0	0	0	0			
Construction		306	348	76	0	0	0	0			-365
Imprevus	0.10	31	100	46	35	44	2	2			
Sous total		336	1102	501	387	483	18	21	0	0	-365
Couts recurrents (financement AID):											
Salaires											
Staff professionnel		0	15	15	15	15	15	15	15	15	
Staff d'appui		0	20	20	20	9	20	20	20	20	
Entretien des vehicules		0	14	15	15	11	11	11	11	11	
Fournitures de bureau		0	10	10	10	7	7	7	7	7	
Location, Eaux & Electricite, Entretien		0	17	17	17	12	12	12	12	12	
Fournitures de recherche		0	12	12	12	8	8	8	8	8	
Activites cooperatives de recherche		0	31	31	31	31	31	31	31	31	
Evaluations		200	0	0	40	0	0	80	0	0	
Imprevus	0.10	20	12	12	16	9	10	18	10	10	
Sous total		220	129	130	174	101	113	201	113	113	0
Couts recurrents (financement gouv. du Mali)											
Salaires											
Staff professionnel		0	37	37	37	37	37	37	37	37	
Staff d'appui		0	4	4	4	15	4	4	4	4	
Entretien des vehicules		0	0	0	0	4	4	4	4	4	
Fournitures de bureau		0	0	0	0	3	3	3	3	3	
Location, Eaux & Electricite, Entretien		0	0	0	0	5	5	5	5	5	
Fournitures de recherche		0	0	0	0	4	4	4	4	4	
Activites cooperatives de recherche		0	0	0	0	0	0	0	0	0	
Imprevus	0.10	0	4	4	4	7	6	6	6	6	
Sous total		0	45	45	45	75	62	62	62	62	0
COUTS TOTAUX DU PROJET		556	1277	676	606	659	194	285	176	176	-365
TOTAL SORTIES		556	1277	676	606	659	217	332	267	354	-16
AVANTAGES SUPPLEMENTAIRES NETS (net cash flow)		-556	-1277	-676	-606	-659	-185	-262	-131	-89	535

VALEUR NETTE ACTUALISEE A 12% DU COUT D'OPPORTUNITE DU CAPITAL (Milliers $US)= 648
TAUX DE RENTABILITE ECONOMIQUE (%) = 13.72
RATIO AVANTAGES NETS-INVESTISSEMENTS A 12% DU COUT D'OPPORTUNITE DU CAPITAL = 1.21

(1) Effets directs uniquement.

ANNEXE K: VALEUR ECONOMIQUE DU PROJET ET ANALYSE DE SENSIBILITE.

TABLEAU K.I (SUITE): VALEUR ECONOMIQUE DU PROJET (Milliers de $ US)

RUBRIQUE		AN 11	AN 12	AN 13	AN 14	AN 15	AN 16	AN 17	AN 18	AN 19	AN 20
ENTREES											
Aug. de benefice brut, association mil-niebe		582	1183	2273	2860	3152	3299	3374	3412	3431	3441
Aug. de benefice brut, assolement mil-niebe		286	535	1000	1689	2092	2362	2513	2596	2643	2670
Aug. de benefice brut, rot.arachide-mil-arachide		47	100	217	466	534	638	663	674	680	682
Aug. de benefice brut, culture de sesame		109	214	420	825	1230	1442	1552	1609	1640	1656
TOTAL ENTREES		1025	2032	3909	5841	7058	7741	8101	8292	8394	8449
SORTIES											
COUTS DE PRODUCTION SUR L'EXPLOITATION											
Augmentation de cout, association mil-niebe		429	870	1659	2086	2302	2411	2465	2494	2508	2516
Augmentation de cout, assolement mil-niebe		202	377	706	1137	1465	1646	1747	1803	1834	1852
Augmentation de cout, rot. arachide-mil-arachide		25	53	113	241	301	329	342	348	351	353
Augmentation de cout, culture de sesame		32	62	120	233	358	423	458	476	486	491
COUTS TOTAUX SUR L'EXPLOITATION		688	1361	2598	3749	4426	4809	5013	5121	5179	5211
COUTS DU PROJET											
Couts du capital (financement AID):											
Assistance technique											
Formation court-terme											
Vehicules											
Equipement de recherche											
Equipement de bureau											
Meubles											
Construction											
Imprevus	0.10										
Sous total											
Couts recurrents (financement AID):											
Salaires											
Staff professionnel											
Staff d'appui											
Entretien des vehicules											
Fournitures de bureau											
Location, Eaux & Electricite, Entretien											
Fournitures de recherche											
Activites cooperatives de recherche											
Evaluations											
Imprevus	0.10										
Sous total											
Couts recurrents (financement gouv. du Mali)											
Salaires											
Staff professionnel											
Staff d'appui											
Entretien des vehicules											
Fournitures de bureau											
Location, Eaux & Electricite, Entretien											
Fournitures de recherche											
Activites cooperatives de recherche											
Imprevus	0.10										
Sous total											
COUTS TOTAUX DU PROJET											
TOTAL SORTIES		688	1361	2598	3749	4426	4809	5013	5121	5179	5211
AVANTAGES SUPPLEMENTAIRES NETS (net cash flow)		337	671	1312	2092	2632	2931	3088	3171	3215	3238

ANNEXE K.

TABLEAU K.2: ANALYSE DE SENSIBILITE DE LA VALEUR ECONOMIQUE DU PROJET (1).

VARIABLES TESTEES	VALEUR NETTE ACTUALISEE Milliers $US -50%	-20%	-10%	0%	(2) +10%	+20%	+50%
1. Augmentation du benefice brut sur l'exploitation	-4918	-1338	-345	648	1642	2635	5615
2. Passage des themes a la vulgarisation	-1434	-322	-100	648	1322	1500	4090
3. Augmentation des couts sur l'exploitation	1781	1306	1277	648	20	-609	-1493
4. Coefficient d'adoption	-1476	-572	92	648	1142	1736	2959
5. Vie de l'innovation	-2312	-473	313	648	948	1466	2180
6. Succes de la recherche systeme	-1175	-61	284	648	1013	1378	2471
7. Plafond d'adoption	-742	57	353	648	944	1240	2127
8. Cout du projet	2147	1248	948	648	349	49	-851

(1) Cette analyse de sensibilite est faite en observant la variation de la valeur nette actualisee du projet a un taux d'actualisation de 12%.
(2) Pour la variable "taux d'adoption", la valeur nette actualisee a 0% de variation est estimee en utilisant les coefficients d'adoption donnes par une regression calculee sur le flux des benefices nets additionnels obtenus par les exploitations. C'est pourquoi la valeur nette actualisee utilisee pour le test de sensibilite sur cette variable est legerement differente de la valeur utilisee pour le test sur les autres variables.

TABLEAU K.3: ANALYSE DE SENSIBILITE RELATIVE DE LA VALEUR ECONOMIQUE DU PROJET (1).

VARIABLES TESTEES	CHANGEMENT RELATIF DE LA VALEUR NETTE ACTUALISEE % -50%	-20%	-10%	0%	+10%	+20%	+50%
1. Augmentation du benefice brut sur l'exploitation	-766	-306	-153	0	153	307	767
2. Passage des themes a la vulgarisation	-321	-227	-120	0	135	286	532
3. Augmentation des couts sur l'exploitation	485	194	97	0	-97	-194	-485
4. Coefficient d'adoption	-456	-182	-87	0	73	149	325
5. Vie de l'innovation	-456	-173	-52	0	46	125	236
6. Succes de la recherche systeme	-231	-113	-56	0	56	113	281
7. Plafond d'adoption	-215	-91	-46	0	46	91	228
8. Cout du projet	231	93	46	0	-46	-92	-231

(1) Cette analyse de sensibilite est faite en observant la variation de la valeur nette actualisee du projet a un taux d'actualisation de 12%.

ANNEXE K.

TABLEAU K.4: CLASSEMENT DES VARIABLES TESTEES DANS L'ANALYSE DE SENSIBILITE DU PROJET.

VARIABLES TESTEES	CLASSEMENT 1) -50%	-20%	-10%	+10%	+20%	+50%	CLASSEMENT MOYEN 2)	ORDRE 3)
1. Augmentation du benefice brut sur l'exploitation	1	1	1	1	1	1	1.00	1
2. Passage des themes a la vulgarisation	5	2	2	2	2	2	2.50	2
3. Augmentation des cours sur l'exploitation	2	3	3	3	3	3	3.00	3
4. Coefficient d'adoption	3	4	4	4	4	4	3.83	4
5. Vie de l'innovation	3	5	6	7	5	6	5.33	5
6. Succes de la recherche systeme	6	6	5	5	6	5	5.50	6
7. Plafond d'adoption	7	7	7	6	7	7	6.83	7
8. Cout du projet	8	7	8	7	8	8	7.67	8

1) Classement decroissant des variables selon la variation relative de la valeur nette actualisee (voir tableau K.3 de l'annexe K).
2) Moyenne des classements etablis en (1).
3) Classement decroissant des variables selon leur influence relative sur la valeur nette actualisee du projet.