PN-ABM-705
80200

Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Mali:

A Study of the Mechanization of Cotton Production

November 1992

AGRICULTURAL MARKETING IMPROVEMENT STRATEGIES PROJECT

Sponsored by the

U.S. Agency for International Development

Prime Contractor: Abt Associates, Inc.
Subcontractors: Postharvest Institute for Perishables, University of Idaho
Deloitte & Touche, Inc.

AID Contract No. DHR-5447-Z-00-7074

AID Project No. 936-5477

AGRIBUSINESS AND PUBLIC SECTOR COLLABORATION IN AGRICULTURAL TECHNOLOGY DEVEVLOPMENT AND USE IN MALI: A STUDY OF THE MECHANIZATION OF COTTON PRODUCTION

Submitted to
USAID/AFR/ARTS/FARA

Agricultural Marketing Improvement Strategies Project (AMIS)

Abt Associates Inc.
4800 Montgomery Lane
Suite 600
Bethesda, MD 20814

Prepared by:

Phil Serafini
and
Boubacar Sada Sy

November 1992

TABLE OF CONTENTS

GLOSSARY i

ACKNOWLEDGEMENTS iv

EXECUTIVE SUMMARY v

INTRODUCTION 1

PART I: SITUATIONAL ANALYSIS

1. OVERVIEW OF COTTON PRODUCTION 5
   1.1 Nature of Cotton Production 6
   1.2 World Demand 11
   1.3 Input Distribution Networks and Extension 11
      1.3.1 Distribution 15
      1.3.2 Financing 15
      1.3.3 Extension 16
   1.4 Market Channels 16
   1.5 Infrastructure 17
   1.6 Research 18

2. DEMAND FOR MECHANICAL TECHNOLOGY 19
   2.1 Type of Technology 19
      2.1.1 Input Delivery and Post-Harvest Transportation 19
      2.1.2 Tillage 19
      2.1.3 Crop Management 21
      2.1.4 Primary Processing 27
      2.1.5 Secondary Processing 27
   2.2 Competing/Complementary Inputs 27
   2.3 Rate of Adoption 29

3. IMPACTS OF MECHANICAL TECHNOLOGY AND ITS INPUTS 30
   3.1 Types of Technology 30
      3.1.1 Agrichemical Technology 30
      3.1.2 Animal Traction 33
      3.1.3 Tractors 33
   3.2 Yield Impacts 33
   3.3 Mechanization of Coarse Grain Production 34
   3.4 Labor Impacts 34
   3.5 Local Fabrication Revenues 40
   3.6 Transportation Efficiencies 40
   3.7 Primary Processing 43
   3.8 Economic Impacts 43
   3.9 Environmental Impacts 44

4. RESEARCH SUPPORT FOR MECHANICAL TECHNOLOGIES 45
4.1 Mechanical Technologies 45
4.2 Mechanical Technology Products in Current Use and Their Sources 45
4.3 The Research and Development Process 46
4.3.1 Public Institutions 46
4.3.2 Private Organizations 47
4.3.3 Types of Research 47
4.3.4 Joint Conduct and Financing of Research 48
4.3.5 Governmental Research 49

5. ECONOMIC, BUSINESS, AND REGULATORY ENVIRONMENT 50
5.1 The Pertinent Legal Areas 50
5.2 The Structural Adjustment Program and the Regulatory System 52
5.3 Commercial Code 52
5.4 General Tax Code 53
5.4.1 Direct Taxes 53
5.4.2 Excise Taxes 54
5.4.3 Fees 55
5.5 The Customs Code 55
5.6 Investment Code 55
5.7 Labor and Social Security Code 58
5.7.1 The Labor Law 58
5.7.2 The Social Security Code (Code de Prevoyance Sociale) 59
5.8 Rules Relating to Foreign Currency 60
5.9 Intellectual Property Rights 60
5.10 Conclusion 60

PART II: ISSUES AND IMPLICATIONS

6. GENERAL IMPLICATIONS OF THE MALI CASE STUDY 61

PART III: CONCLUSIONS AND RECOMMENDATIONS

7. CONCLUSIONS 62

8. RECOMMENDATIONS 64

BIBLIOGRAPHY 65

LIST OF EXHIBITS

EXHIBIT 1: The Evolution of Seed-Cotton Production in Mali, 1961-1989 7
EXHIBIT 2: Farm Mechanization and Production Characteristics of Mali's Cotton Growers, 1989 8
EXHIBIT 3: Evolution of the Price of Cotton and Net Revenues per Unit Area of Cotton, 1977-1986 12
EXHIBIT 4: World Cotton Price, Actual vs. Simulated Values, 1966-1988 13
EXHIBIT 5: World Cotton Consumption, Actual vs. Simulated Values, 1966-1986 . . 14
EXHIBIT 6: Evolution of Animal Traction Equipment Numbers in Southern Mali, 1964-1986 20
EXHIBIT 7: Work Time Before and After the Introduction of Animal Traction 22
EXHIBIT 8: Animal Traction Work Times and Area 23
EXHIBIT 9: Animal Traction vs. Small Tractors - Production Parameters, A Comparison Over Two Villages, 1990 24
EXHIBIT 10: Cotton Input and Production Factors, 1984-1988 Cropping Seasons 28
EXHIBIT 11: Fertilizer and Insecticide Sales, CMDT, 1961-1988 31
EXHIBIT 12: The Use of 14% N, 22% P_2O_5, & 12 K, and Urea by 4 Farmers in Southern Mali, 1978-1987 32
EXHIBIT 13: Farm Mechanization and Coarse Cereal Production Characteristics of Mali's Cotton Growers,1989 35
EXHIBIT 14: Area Cultivated per Farm Worker 36
EXHIBIT 15: Cotton Harvested per Farm Worker 37
EXHIBIT 16: Annual Work Pattern Shifts as Mechanization is Increased 38
EXHIBIT 17: Proportion of Farms Practicing New Activities Following the Introduction of AT 39
EXHIBIT 18: The Evolution of Agricultural Equipment Ownership 41
EXHIBIT 19: CMDT Supported Blacksmith's Annual Income, 1988 42

GLOSSARY

AMGI	Multilateral Agency for Investment Guarantees
AT	Animal Traction
AV	Association Villageoise
BAD	African Development Bank
BADEA	Banque Arabe pour le Developpement Economique en Afrique
BNDA	Banque Nationale pour le Developpement Agricole
CCCE	Caisse Centrale de Cooperation Economique
CEEMAT	Centre d'Etudes et d'Experimentation du Machinism Agricole Tropical (FR)
CFDT	Compagnie Francaise pour le Developpement des Fibres Textiles
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (FR)
CIRDI	Centre de International pur le Règlement de Différends Relatifs aux Investissements entre Etats et Resortissants d'autre Etats
CMDT	Compagne Malienne pour le Developpement des Textiles
COPACO	Compagnie Cotonniere Domiciliee a Paris (FR)
DMA	Agricultural Machinery Division
FAC	Fonds d'Aide et du Cooperation
FED	European Development Fund
GRM	Government of the Republic of Mali
HUICOMA	Malian Edible Oil Company
ICI	Imperial Chemical Industries (UK)

IDA	International Development Association
IER	Institut d'Économie Rurale
IMF	International Monetary Fund
INPS	Institut National de Prévoyance Social
IRCT	Institut de Recherches sur le Coton et les Textiles (FR)
ISRA	Senegalese Agricultural Research Institute
K	Potassium
KIT	Royal Tropical Institute (Dutch)
N	Nitrogen
NIAE	National Institute for Agricultural Engineering (UK)
PRC	Peoples Republic of China
RFA	Federal Republic of Germany
SA	La Société Anonyme
SARL	La Société à Responsabilité Limitee - Company with limited responsibility
SGS	Société de Surveillance
SMECMA	Société Malienne pour l'Éxperimentation et le Construction des Machines Agricoles
SRCFJ	Section de Recherche sur le Coton et les Fibres Jutieres (IER)
SRCVO	Section de Recherche sur les Cultures Vivrieres et Oleagineuses (IER)
TM	Tropicale Malienne (plow)
TPS	Tax on the Provision of Services
TVA	Value added taxes
ULV	Ultra-Low Volume

USAID	United States Agency for International Development
WB	World Bank

ACKNOWLEDGEMENTS

This study of the agribusiness and public sector roles in the mechanization of cotton production in Mali was a collaborative field effort between Dr. Phil Serafini and Dr. Boubacar Sada Sy. Dr. Serafini's authorship of the case study is indebted to Dr. Sy's considerable input and his contribution of the economic and regulatory chapter. The authors would like to express deep appreciation for the significant editorial contributions by Christine Erbacher of the AMIS project.

Further thanks are offered for the assistance provided by USAID/Bamako in the conduct of this study.

EXECUTIVE SUMMARY

Background

Most African governments have chosen to play key roles in supporting agricultural development and making crop production inputs available. In many cases they have dominated the process from research and product procurement to credit and input delivery to the farmer. Private sector participation has often been discouraged or prohibited. This pattern has begun to change.

While research continues to be the domain of national agricultural research programs, the emphasis is clearly on verification and adaptation of technologies from elsewhere. The donor community has chosen to support local governmental attempts to provide the inputs and information necessary to increase agricultural productivity, while largely ignoring the private sector's ability to provide these goods and services. This situation is changing to one in which governments provide a regulatory, legal, and policy environment that is conducive to private sector agribusiness concerns delivering crop production inputs and other associated services to farmers.

It is felt that in a privatized marketplace direct governmental involvement would be limited to verification research and product licensing/registration. National research organizations and private industry would collaborate in this process. Once licensed, products would be promoted by private industry. Private industry and dealer-based distribution systems would have a direct economic stake in high-quality product stewardship. Product registration and licensing, product and technology dissemination to the user, or *stewardship*, privatization of product delivery and financing, and fostering an environment conducive to business have been identified as areas of public-private sector collaboration that would be supportive of a larger private sector role in technology development and delivery.

A number of case studies of technology development and delivery as they relate to agriculture in Africa were initiated to test and refine these hypotheses in light of the existing system. The mechanization of the cotton production system in Mali was chosen as one of the examples.

Overview of Cotton Production

Cotton production in Mali is a highly vertically-integrated industry with all aspects--research, input supply, credit, production, processing, and export--coordinated through the Compagnie Malienne pour le Développement des Textiles (CMDT). CMDT is the final purchaser of all Malian cotton, announcing prices at the start of the season. Cotton is purchased by Operation Haute Vallée (OHV) in the Koulikoro regions of Mali for resale to CMDT, which has a monopoly on cotton marketing. A good deal of technical and marketing support is provided through the Compagnie Francaise pour le Développement des Fibres Textiles (CFDT).

In contrast with cotton production in many of the Anglophone countries, cotton production in Mali is characterized by relatively high input and yield levels. In their study of francophone African cotton production, Uma Lele et al. notes problems with the CFDT-induced approach, including high costs, monopolization, and excessive focus on cotton, but notes that cotton production in Francophone Africa has grown enormously (740 percent between 1960 and 1985), while the collective production in the rest of Sub-Saharan Africa grew very little in that period (only 60 percent). Lele et al ascribe CFDT's success to its provision of credit to farmers, timely payment of producers, and excellent research and input delivery system (Lele et al. 1989, 5). Cotton farmers in Mali's CMDT zone are an example of this success in that they have experienced remarkable growth in commercial cotton production due to important increases both in yields per unit area and the area under cotton production within the CMDT zone.

CMDT is viewed by its management as an input supplier, extension, and credit agency serving cotton growers. Extension services, both direct and indirect, include farmer level trials and demonstrations as well as other services. Relationships with the primary input suppliers are handled by, or have been developed by, the CMDT. The extension effort has been funded from cotton revenues and by direct and indirect support from the multinational input producers and donor community, both on a bilateral basis and through the World Bank (WB). In the past, credit has been supplied directly by the CMDT, although, since 1974, the Banque Nationale pour le Développement Agricole (BNDA) has played an increasingly important role in financing both annual inputs and longer-term capital investments for farmers and their suppliers.

Technical and financial support from the CMDT to small businesses has improved their earning power. Revenues of small businesses, notably local blacksmiths, are much higher if they are servicing cotton farmers. The shift from centralized manufacture to fabrication by local blacksmiths has resulted in increased availability and a generally more competitive environment for the procurement and repair of animal traction equipment. The sale and custom application of pest and weed control products could enjoy a similar evolution.

Cotton production directly provides three products that are both used locally and exported: cotton fiber that is woven into cloth in two major factories (3 percent of the fiber produced by the CMDT), cooking oil that is extracted from the seed and consumed locally, and cotton seedcake that is used locally as livestock feed and exported to neighboring countries. Primary processing has been improved through greater ginning capacity, increased storage, and provision of oil extraction facilities. These improvements have resulted in increases in direct economic returns domestically as well as secondary returns in the livestock industry and reduced food oil imports. The production of cloth from domestic cotton has provided employment and locally-produced cloth.

Mali's cotton production is highly dependent on the international marketplace for inputs in the areas of fertility maintenance, pest control, and mechanization. Fertilizer application rates in Mali are high for Africa and in 1989, insecticide sales to CMDT farmers totaled $6.25 million. Essentially all cotton areas receive fertilizer and pesticide applications. More mechanized farms tend to use higher levels of other crop inputs including insecticides and

fertilizers. Due to the tendered-bidding procurement procedures used by the CMDT, externally manufactured inputs are not available in sufficient quantities to be considered competitive with those available through the CMDT. The CMDT's de facto monopoly on farm credit reinforces their quasi monopoly on externally-procured inputs.

Cotton production largely depends on the international marketplace for equipment and marketing. CMDT controls directly or indirectly the machinery used for the ginning, oil extraction, and other treatment of cotton fibers and byproducts. This equipment is primarily of U.S. origin and purchased through CFDT. Other imported equipment comes from Europe. Almost all Malian cotton passes through French marketing channels, at a final sale price based on a combination of prearranged levels and the world market price. An effective effort has been made to provide stable prices. Payments to farmers are made at the pickup points and production and capital loan reimbursements are collected in the process.

Mechanization of Agriculture

Mechanization of agriculture includes animal traction, tractors and planting and harvesting equipment, application of agrichemicals with sprayers and other applicators, and use of processing equipment such as cotton gins. This study discusses the use of animal traction, agrichemicals, and other inputs, as these are necessary for application of various mechanical technologies.

Animal traction (AT) is practiced by more than 80 percent of the cotton growers in the CMDT zone. Ninety-eight percent of the cotton area receives some form of preplant tillage with AT. Weeding and harvesting are the principal labor constraints and result in substantial seasonal shifts in both the cost and availability of hired labor.

Yields per unit area and per farm worker of both cotton and coarse cereals (maize, millet, and sorghum) increase dramatically as cotton production is intensified and mechanized. The development of animal traction-based mechanization closely parallels the increased use of other inputs. Farms move from being subsistence or deficit cereal producers to being substantial exporters as they mechanize and intensify their cotton production practices. In the absence of cotton production, higher yields of grains are not clearly associated with increased animal-traction mechanization. Mechanization increases the area cultivated per farm. There has been more than a ten-fold increase in the value of pesticide, fertilizer, and other inputs delivered since the inception of CMDT in 1974.

These efficiencies and improvements in productivity shift labor use away from the most arduous tasks. The manual labor that is saved is often reabsorbed in harvesting and processing the crop that results from the improved yields so that the total labor requirements per unit area are similar or increased. The total labor time per worker, both male and female, on and off farm, increases as cotton production is intensified and mechanized.

Research in Mechanical and Other Technologies Applied to Agriculture

Three principal types of research have occurred in the mechanization of cotton production in Mali: public sector/international, private sector/international, and national research. Production research has been carried out internationally, while technology testing and adaptation have taken place at the national level. Two local research organizations, Le Division de Mechanisme Agricole (DMA) and Institut d'Économie Rurale (IER)/Section de Recherche sur le Coton et les Fibres Jutières (SRCFJ), have played the principal roles in mechanical technology development. A third contributing agency is the Section de Recherche sur les Cultures Vivrières et Oleagineuses (SRCVO). With support from the French, Dutch, and Canadian development agencies, DMA has tested and adapted animal traction equipment. At the national level, adaptive research and product testing is supported in part, directly and indirectly, through the CMDT/CFDT by the multinational input suppliers. The CFDT, bilateral donors, and WB frequently subsidize these activities.

CMDT directly supports research on cotton and the other major cereal and legume crops. Through their relationships with French and national research organizations, the CMDT has benefitted from a whole range of research activities focused on the cotton production system including cotton and maize varietal improvement, the development of customized fertilizer materials, the development of animal traction farming equipment, the development of the ultra low volume (ULV) pesticide application technology, the formulation of special insecticide and seed treatment products for the cotton and cereal crops, the development of intermediate motorized farming equipment, and a range of other technologies. Major input suppliers such as the three chemical companies Imperial Chemical Industries (ICI), Ciba-Geigy and Rhone-Poulenc, and large European fertilizer suppliers have participated in these developments. In the case of the ULV technology there were important investments made by the multinational pesticide producers who needed this technology to get their products to limited-resource cotton producers. Technical contributions came from the National Institute of Agricultural Engineering (NIAE) in England, Centre d'Études et d'Expérimentation de Mechanisme Agricole Tropicale (CEEMAT) in France, ICI, Ciba-Geigy, Rhone-Poulenc, CFDT, CMDT, and others. This type of collaborative and focused relationship is increasing throughout the region where CFDT is active, and is frequently subsidized by the French or other governments/donor agencies.

Research organizations, such as NIAE, CEEMAT, Wageningen - Tillage Laboratory in Holland, Senegalese Agricultural Research Institute (ISRA)-Bombey, and DMA, as well as private companies such as Rumptstad in Holland, Muzon in France, and several parastatal animal traction manufacturing concerns in West Africa have contributed to the development and improvement of the AT equipment used in the cotton producing areas. These organizations have also worked to apply mechanized technologies to seeding, weeding, and pest control; currently, all pesticide application on cotton is mechanized. In the last ten years, these research organizations have made a major effort to introduce motorized tillage equipment to the larger cotton producers with mixed results. Yields of both cotton and cereals were similar for AT and motorized farms. Moreover, in terms of revenue, revenue on motorized farms was lower both

on a per hectare and per person basis than on animal traction farms, but total revenue was substantially higher for the farms with tractors.

Ecological Impact of Mechanization

There have been two principal and paradoxical ecological impacts of the intensification of cotton production that are directly related to the widespread adoption of animal traction-based crop production technologies. Overall, the basic fertility and stability of the production system has improved. However, the increased revenues and the improved mechanical efficiencies have permitted and motivated farmers to move into more marginal areas. The CMDT and their associated research and extension agencies have placed a major emphasis on preventing soil erosion. A number of technologies to reduce soil erosion have been developed and extended.

Policy and Regulatory Environment

Mali has been involved in a "structural adjustment program" since 1982. A collaborative effort with the WB and the IMF, this adjustment program is aimed at reforming the size, structure, and involvement of government. The structural reform is dealing with all areas of socioeconomic activity: the macro-economic imbalance, the legal structure, publicly-owned enterprises, agriculture, and education. As a result of this process, the legislation defining the operating environment has created a business climate that is conducive to enterprises enlarging their scope and level of activity, as well as clarifying their relationships with the State. Further, Malian regulations are now favorable to business, and the ongoing liberalization strategies, combined with the structural adjustment programs, will reinforce this.

Conclusions

The Mali case study teaches several general lessons regarding public and private collaboration in the success of agricultural enterprises and their mechanization.

- Successful agricultural enterprises are often highly vertically integrated.

- The State can take action to encourage the environment for private sector growth. Sustainable investments by the State in infrastructure allow private investments to be profitable. Also, macro-level reforms, like those in Mali, can encourage investment in technology adoption and mechanization.

- Technology adoption that involves investment or reallocation of farmers' resources must generate enough returns to support and reward this investment or reallocation. Mechanical technologies were adopted in Mali because they worked with other crop production inputs and intensification practices. Farm workers responded to the opportunity to increase farm earnings by working more both on and off the farm.

- Small enterprises respond to extension and financial support effectively if market conditions are conducive to success and assure reasonable returns on investment. Donor initiated support might concentrate on these small enterprises. Farms, as small enterprises, will increase their production and investments if there is a reasonable return on these. Although both land and labor usage increased, returns to land were greater than returns to labor in Mali.

- International, national and business research capacity can be mobilized to effectively provide appropriate technology when there are clear cut crop and market objectives, as well as reasonable potential returns on that investment. If these conditions are met, collaborative research is likely to grow.

Recommendations

Based on these conclusions, the report makes seven recommendations with regard to improving mechanization of cotton production and public and private collaboration in this area.

1) Efforts to increase farm productivity should focus on crop situations where there is a clear and adequate cash market potential for the products.

2) Technical and financial support to private agribusiness sector participants should focus on farmers and those who directly provide them with products and services (blacksmiths, pesticide suppliers, ULV applicator services and distributors, village cooperatives and associations, etc.).

3) In many situations a high degree of vertical integration will be desirable.

4) Technology delivery should be based upon high quality product stewardship at the farm level by both private and public sector extension and sales operatives.

5) Provision of adequate input and crop processing/storage/transport infrastructure will be a characteristic of successful production programs.

6) Technologies should be grouped in technological packages to exploit possible positive interactions among them.

7) Macro-policy issues should be identified and resolved early in efforts to increase farm productivity and revenue in order to provide the proper incentives for success.

INTRODUCTION

Issues in Public-Private Sector Collaboration in Technology Development

In the years since independence, most African governments have chosen to play key roles in supporting agricultural development and providing crop production inputs. In many cases they have dominated all aspects of the process from research and product procurement from primary suppliers to providing credit and delivering inputs to the farmer. Private sector participation has often been discouraged or prohibited, but recently, this pattern has begun to change.

In many cases, and for a range of reasons that were often confounded with inefficient national research organizations and disincentive policies, governmental control of the delivery and financing of agricultural inputs came to be viewed as a factor inhibiting agricultural development. With pressure from the International Monetary Fund (IMF), the World Bank (WB), donors and development agencies, as well as private sector agribusiness concerns, many African governments have begun to remove themselves from the process. "Privatization" is the clarion call and governments are selling parastatal agribusiness concerns and otherwise getting out of buying and delivering crop production inputs. While research continues to be the domain of the national agricultural research programs, the emphasis is clearly on verification and adaptation of technologies emanating from elsewhere. The most important question now is how to provide information and supplies to farmers in this new context.

Up to the present, the donor community has chosen to support local governmental attempts to provide the inputs and information necessary to increase agricultural productivity, while largely ignoring the private sector's ability to provide these goods and services. The current situation dictates that this approach change to one in which governments provide a regulatory, legal, and policy environment that is conducive to private sector agribusiness concerns delivering crop production inputs and other associated services to farmers. To support this shift, the donor community must develop new approaches to supporting local governments and private sector concerns, both large and small, indigenous and off-shore.

To find the best avenues to promote the privatization of agricultural input delivery in Africa, the commercial activities of Pioneer HiBred International and Ciba-Geigy, two of the more successful international agribusiness companies operating in Sub-Saharan Africa, were reviewed. Both companies have substantial operations and financial involvement in Africa. Their activities are a logical consequence of their perceptions of the actual and potential market conditions on the continent. Both companies have product development strategies based on ecology-specific research to adapt their technologies, crop protection chemicals and improved genetic-potential seeds to local conditions. A review of their current and anticipated product development and marketing strategies suggested that these companies face certain limitations within the existing parastatal-driven, technology delivery system in areas of potentially beneficial collaboration between public sector institutions and private agribusiness concerns.

Currently, parastatal monopolies procure crop production inputs from the international marketplace through centralized, tendered bids. Suppliers are competing for essentially one buyer. Purchases are financed by export sales or multilateral (World Bank) and bilateral donor support. Inputs that can be produced locally are often manufactured in centralized facilities or produced on a limited number of farms/research facilities operated by, or in association with, the parastatal. Farmers interface with a technology training and delivery system that is monopolized by the parastatal. The extension agents who actually work with the farmer have no direc ke in the successful use of the technologies, are often not well trained in use of the products, re young in rural societies where respect often comes with age, and frequently have come from an urban environment and education.

In this marketplace:

- Competition either does not exist or is based on prices in the international marketplace;
- Economic incentives for high-quality technology delivery at the farm level are limited;
- The product's producer or their agents do not practice product stewardship;
- Products are not adapted for local conditions by the product's producer; and,
- Opportunities for corruption are varied.

As a result, products are often not adapted to farmers' needs, the environment or its inhabitants are not considered, monies are frequently misused, real market infrastructure is not developed, and farmers are not involved. In a privatized marketplace direct governmental involvement would be limited to verification research and product licensing/registration. Industry and the national research organization would collaborate in this process. Once licensed, products would be promoted by industry. Distribution and sales would take place through local affiliates or other representatives. Industry and dealer-based distribution systems would have a direct economic stake in high-quality product stewardship for the following reasons:

- Compensation is based on the sale and performance of the product;
- Effective training and successful experience leads to increased sales and profits;
- Successful product performance encourages all the participants to continue;
- Local participation and stable relationships are encouraged because they support sales; and,
- Farmers are empowered as consumers.

Areas of Public-Private Sector Collaboration

Four areas of public-private sector collaboration that would be supportive of a larger private sector role in technology delivery have been identified:

I. Product registration and licensing define the conditions of market access for individual products.

- It is in the best interests of input suppliers and farmers that product registration be handled openly and consistently.

- The national agricultural research organizations often carry out the necessary testing.

- It is critical that this process be competent, expeditious, effective, and honest.

II. Product stewardship is the process by which the technology or technology components are delivered to the farmer or other user.

- Technology delivery at the farm level is everyone's concern. The farm enterprise is where equity, ecological and sustainability issues are perceived.

- The opportunity and transaction costs of information about the safety, effectiveness, and procurement of improved crop-production technologies are among the most important constraints to their use.

- Dealer networks and the like have been important in creating a capacity to deliver products and information. The effectiveness of those who sell, deliver, and provide council to farmers on input use will determine the quality of product stewardship. They will also be rewarded based on their effectiveness, which in turn will provide the motivation to be effective.

III. Privatization of product delivery and financing of inputs involve the supply and management of product delivery and the financing thereof by private sector concerns.

- New methods of capitalizing the purchase and delivery of crop production supplies will have to be found.

- Farmers are poor credit risks.

- It is the institutions who must manage the delivery of the product that have the greatest need for capital.

- Public sector support to small entrepreneurs could well govern their ability to provide a private sector technology delivery system.

IV. Business environment, which is the legal, policy, and financial environment in which businesses operate.

- The existence of a marketplace that functions with a reasonably obvious set of rules, where contractual reciprocity is expected and enforced without hidden overhead from government and company officials and redress of grievances is served by a judicial system, is supportive of the development of an effective private sector.

- An effective business environment is especially important as it relates to agricultural endeavors where the input and product delivery systems are, by their nature, diverse in time, space, and product -- a situation that is often best served by smaller rather than larger business entities.

A number of case studies of technology development and delivery relative to agriculture in Africa were initiated to test and refine these hypotheses in light of the existing system. They were to describe the system as it currently functions--the participants, their roles, and constraints. The mechanization of the cotton production system in Mali was chosen for one of these studies.

PART I: SITUATIONAL ANALYSIS

1. OVERVIEW OF COTTON PRODUCTION

Cotton production in Mali is a highly vertically-integrated industry with all aspects--research, input supply, production, processing, and export--coordinated through the Compagnie Malienne pour le Développement des Textiles (CMDT). A good deal of technical and marketing support is provided through the Compagnie Francaise pour le Développement des Fibres Textiles (CFDT). This section will describe the cotton subsector in Mali and highlight lessons learned.

In contrast with cotton production in many other Sub-Saharan African countries, cotton production in Mali is characterized by relatively high input and yield levels. Yield levels in Mali are three to four times higher than yields in many Anglophone African countries. Discussing the general cotton production situation in Francophone Africa, Uma Lele et al. note that "despite its (CFDT's) success in increasing production and yields per hectare in Francophone countries, the CFDT-induced approach has come under heavy criticism for its high costs, monopoly approach, and excessive focus on cotton." Nevertheless, they recognize that cotton production in the Francophone countries in Africa grew 740 percent between 1960 and 1985, while the collective production in the rest of Sub-Saharan Africa grew only 60 percent. They conclude that:

> . . .while differences in macroeconomic and sectoral pricing policies appear to have been critical, institutional factors have been fundamental in explaining the sustained growth of cotton production in Francophone countries. The CFDT approach has led to the development and extension of technology and assured the availability of inputs, marketing, and processing facilities. In particular, it has ensured adequate financing of the cotton sector, making possible, among other things, timely payments to farmers.... Although the impact of price incentives on cotton production is important for determining short-run shifts between food and export crops or for allocating labor between cotton and other crops (including off-farm wage employment)... a variety of other incentives have been important, including CFDT's own incentive to make profits, [and are] related directly to the volume of exports; and second, that process must not be considered in isolation from a range of nonprice factors....

They identify the essential elements of the CFDT approach as:

- Credit to farmers
- The timely payment of producer prices
- An excellent research and input delivery system closely tied to the nature of the internal or external market, and based on a thorough understanding of the location-specific circumstances affecting cotton producers (Lele et al. 1989, p.5).

The CFDT has a 40 percent equity position in the CMDT and earns a 6 percent commission on the value of cotton exports from Mali.

1.1 Nature of Cotton Production

Efforts to expand and intensify cotton production in Mali began in the early 1950s. The Fonds d'Aide et du Coopération (FAC) and European Development Fund (FED) supported this effort through the CFDT from 1950 through 1974. In 1974 the "Projet Mali Sud" created the CMDT. Support was provided by the International Development Association (IDA), Caisse Centrale de Coopération Économique (CCCE), FAC, African Development Bank (BAD), and Banque Arabe pour le Développement Économique en Afrique (BADEA). The second phase of Mali Sud began in 1981 with support from all the original funding agencies in addition to Germany (RFA) and Belgium. The relative success of this and other CFDT led cotton production schemes in Africa are well known and have been described and contrasted with the lack of success in the neighboring Anglophone countries (Lele et al. 1989, p.5).

Mali is currently a leading cotton producer in Africa, ranking 4th in total production with average yields per ha of 1,300 kg/ha, the highest yields for rainfed cotton in the world. Exhibit 1 summarizes the evolution of average yields, area cultivated, and total production from 1961 to 1989. It chronicles the very remarkable growth in commercial production (greater than eight-fold) that has been due to both very important increases in yields per unit area (more than three-fold) and the area in cotton production (more than two and one-half-fold) within the CMDT zone. Mali produces approximately 7 percent of the African and 0.5 percent of the world crop.

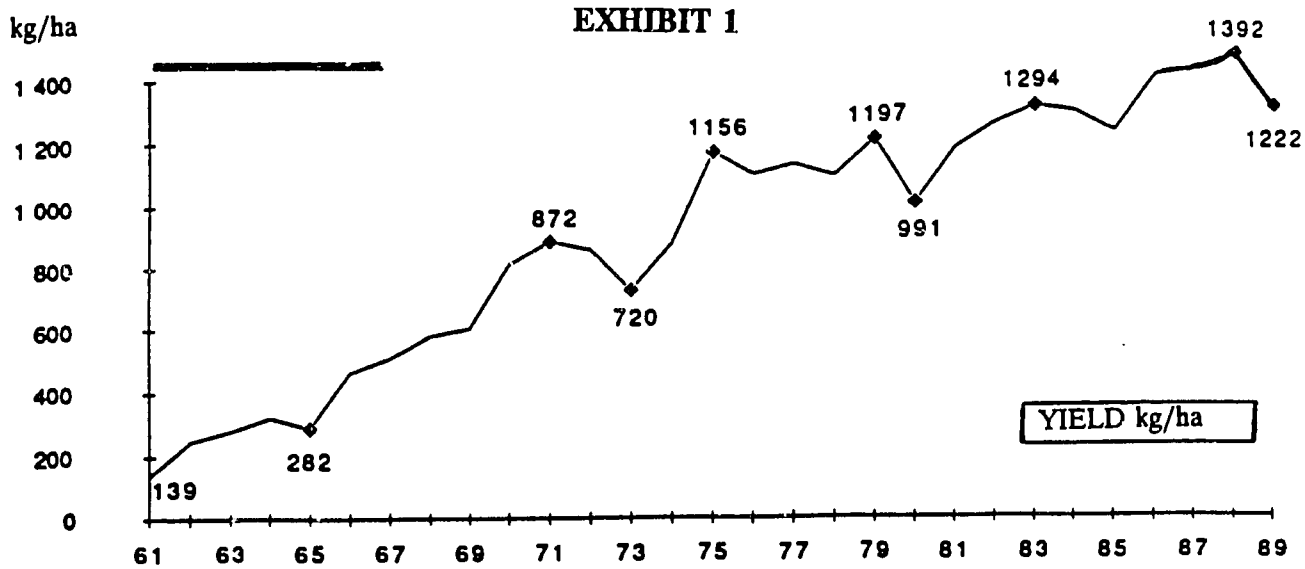
Cotton accounts for 7 percent of Mali's GDP, 50 percent of the country's exports, and 59 percent of the agricultural exports. Mali is the third largest cotton exporter in Sub-Saharan Africa, accounting for 12 percent of the region's exports. Mali's exports are equal to about 6 percent of United States exports. The indirect effects of the export-generated revenues from cotton are probably very substantial and can be evidenced by a generally higher standard of living in rural areas where cotton is grown. For the 1990 cropping season, the CMDT reports average gross revenues of $460/ha[1] and net (gross-purchased inputs) revenues of $240/ha from cotton for their production zone. Revenues, gross and net, for the 25 percent of farms with average yields above 1,400 kg/ha (averaging 1600 kg/ha) were $575/ha and $355/ha, respectively. These farmers cultivate about one-third of the cotton-producing area and account for over 50 percent of the production and revenue from cotton (see Exhibit 2). The 30 percent of the farmers who have yields less than 1,000 kg/ha cultivate almost 40 percent of the cotton-producing area and account for 24 percent of the production. Their average net revenues are less than $50/ha (Naing, 1992, p.5).

Cotton is always centrally processed where it is grown for commercial purposes. In Mali, the cotton production and marketing system is vertically integrated with the CMDT

[1] Fcfa converted to U.S. $ at 275 Fcfa/U.S. $

The Evolution of Seed-Cotton Production in Mali, 1961-1989

EXHIBIT 1



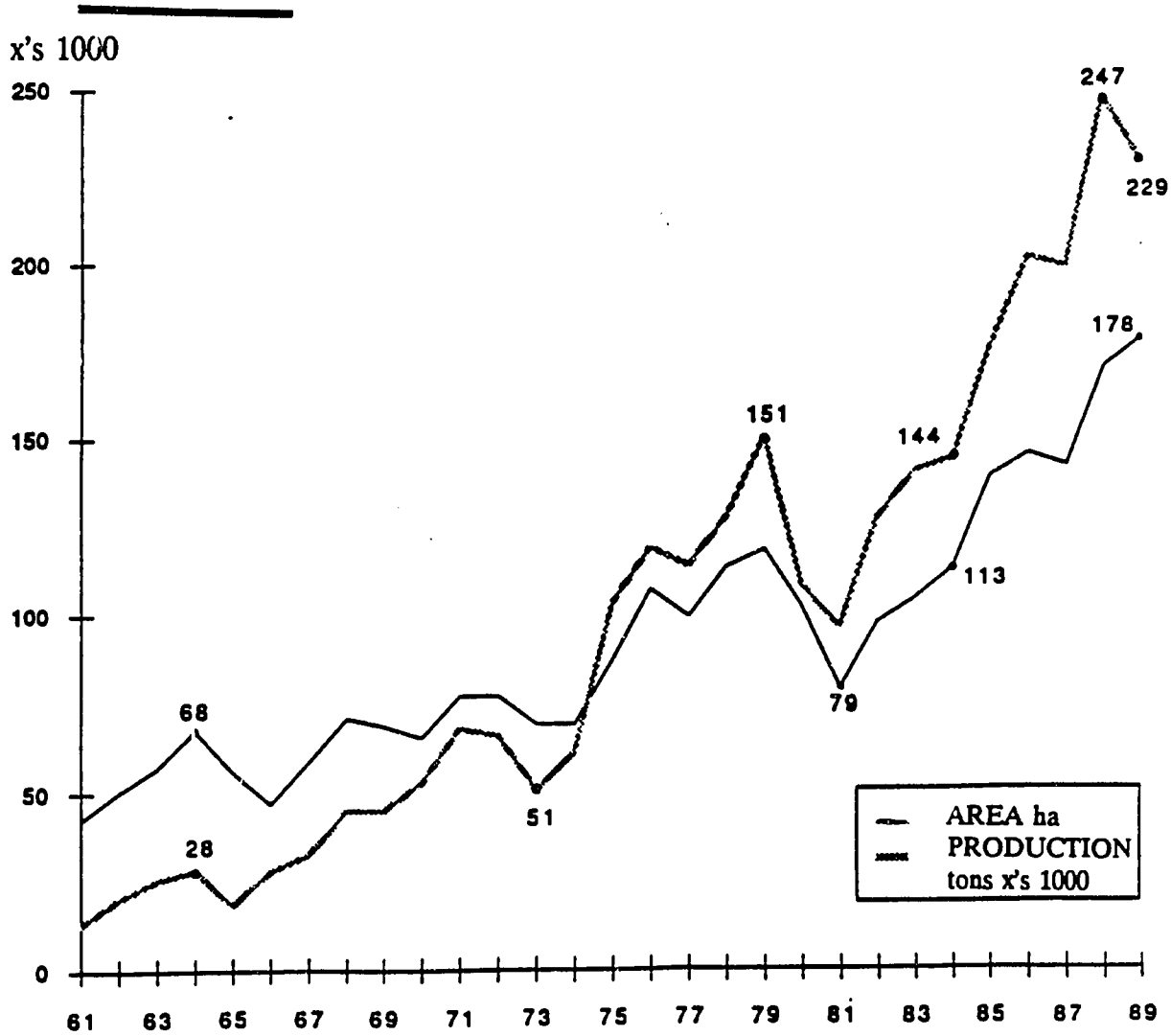


EXHIBIT 2

FARM MECHANIZATION AND PRODUCTION CHARACTERISTICS OF MALI'S COTTON GROWERS, 1989

Level of Equipment	# of Farms	% of Farms	Population	Pop. /Farm	Annual Crop Area (ha)	Area /Farm ha	Cattle	Cattle /Farm	Traction Animals	Traction Animals /Farm
Hand Tillage	25,000	18%	177,900	7.12	79,290	3.17	3,700	0.15	-	-
AT - Partial	23,600	17%	186,600	7.91	108,558	4.60	21,700	0.92	9,200	0.39
AT - 1 unit	56,300	40%	660,800	11.74	388,450	6.90	338,100	6.01	118,200	2.10
AT - 2 units	26,100	19%	521,100	19.97	316,177	12.11	401,300	15.38	105,300	4.03
AT - 3 units	5,400	4%	144,300	26.72	97,493	18.05	162,200	30.04	33,700	6.24
AT - 4 units	1,800	1%	70,600	39.22	38,349	21.31	89,000	49.44	14,900	8.28
AT - 5 units	900	1%	45,000	50.00	21,711	24.12	36,500	40.56	10,000	11.11
Motorized	300	<1%	14,400	48.00	8,759	29.20	11,500	38.33	1,600	5.33
Total/Average	139,400		1,820,700		1,058,787		1,064,000		292,900	
Total Best Equipped 25%	34,500		795,400		482,489		700,500		165,500	
Total AT Equipped	90,800		1,456,200		870,939		1,038,600		283,700	
% of Total Best 25%	25%		44%		46%		66%		57%	
% of Total AT Equipped	65%		80%		82%		98%		97%	

Level of Equipment	Area in Cotton	Area in Cotton ha/Farm	% of Farm Area	Input Use				Cotton Yields kg/ha	Cotton Production tons	Area in Millet ha	Area in Millet ha/Farm	% of Farm Area	Millet Yields kg/ha	Millet Production tons
				14/22/12* kg/ha	Urea** kg/ha	Fungicide kg/ha	Insecticide Litres/ha							
Hand Tillage	1,760	0.07	2%	110	48	0.185	10.5	660	1,162	22,000	0.88	28%	544	11,968
AT - Partial	13,200	0.56	12%	110	49	0.185	10.75	965	12,738	31,400	1.33	29%	681	21,383
AT - 1 unit	66,200	1.18	17%	118	50	0.185	11.12	1,190	78,778	106,200	1.89	27%	928	98,554
AT - 2 units	65,000	2.49	21%	120	50	0.185	11.75	1,254	81,510	74,000	2.84	23%	911	67,414
AT - 3 units	24,400	4.52	25%	128	50	0.185	11.95	1,290	31,476	20,000	3.70	21%	1,243	24,860
AT - 4 units	10,500	5.83	27%	135	50	0.185	12.00	1,325	13,913	6,470	3.59	17%	1,310	8,476
AT - 5 units	5,130	5.70	24%	148	50	0.185	14.00	1,640	8,413	4,120	4.58	19%	1,414	5,826
Motorized	4,210	14.03	48%	150	50	0.185	13.00	1,560	6,568	1,080	3.60	12%	1,150	1,242
Total/Average	190,400			127	50	0.185	11.88	1,232	234,557	265,270			904	239,722
Total Best Equipped 25%	109,240								141,879	105,670				107,817
Total AT Equipped	175,440								220,657	211,870				206,371
% of Total Best 25%	57%								60%	40%				45%
% of Total AT Equipped	92%								94%	80%				86%

* 14% Nitrogen (N), 22% Phosphorus (P205), 12% Potassium (K)

** 46% Nitrogen (N)

FARM MECHANIZATION AND PRODUCTION CHARACTERISTICS OF MALI'S COTTON GROWERS, 1989 (Continued)

Level of Equipment	Area in Sorghum ha	Area in Sorghum ha/Farm	% of Farm Area	Sorghum Yields kg/ha	Sorghum Production tons	Area in Maize ha	Area in Maize ha/Farm	% of Farm Area	Maize Yields kg/ha	Maize Production tons	Area in Rice ha	Area in Rice ha/Farm	% of Farm Area	Rice Yields kg/ha	Rice Production tons
Hand Tillage	22,453	0.90	28%	775	17,401	5,603	0.23	7%	1,342	7,788	2,383	0.10	3%	716	1,706
AT - Partial	36,041	1.53	33%	713	25,697	8,074	0.34	7%	936	7,557	3,674	0.16	3%	1,225	4,501
AT - 1 unit	107,823	1.92	28%	877	94,561	37,250	0.66	10%	1,380	51,405	8,581	0.15	2%	903	7,749
AT - 2 units	88,892	3.41	28%	940	83,558	36,000	1.38	11%	1,447	52,092	12,040	0.46	4%	873	10,511
AT - 3 units	30,613	5.67	31%	1,155	35,358	8,688	1.61	9%	1,601	13,909	2,722	0.50	3%	877	2,387
AT - 4 units	12,908	7.17	34%	1,119	14,444	3,541	1.97	9%	1,579	5,591	1,847	1.03	5%	800	1,478
AT - 5 units	5,908	6.56	27%	1,134	6,700	3,751	4.17	17%	1,714	6,429	989	1.10	5%	1,759	1,740
Motorized	1,092	3.64	12%	1,155	1,261	1,458	4.86	17%	1,485	2,165	-	-	-	-	-
Total/Average	305,730			913	278,981	104,565			1,405	146,937	32,236			933	30,071
Total Best Equipped 25%	139,413				141,321	53,438				80,187	17,598				16,115
Total AT Equipped	247,236				235,882	90,688				131,592	26,179				23,864
% of Total Best 25%	46%				51%	51%				55%	55%				54%
% of Total AT Equipped	81%				85%	87%				90%	81%				79%

Level of Equipment	Area in Fonio ha	Area in Fonio ha/Farm	% of Farm Area	Fonio Yields kg/ha	Fonio Production tons	Area in Maize/ Millet (ha)	Area in Maize/Millet ha/Farm	% of Farm Area	Area in Maize/ Sorghum (ha)	Area in Maize/Sorghum ha/Farm	% of Farm Area
Hand Tillage	3,430	0.14	4%	435	1,492	7,048	0.28	9%	2,291	0.09	3%
AT - Partial	735	0.03	1%	295	217	952	0.04	1%	1,058	0.04	1%
AT - 1 unit	7 760	0.14	2%	517	4,012	5,174	0.09	1%	3,461	0.06	1%
AT - 2 units	2,390	0.09	1%	353	844	5,731	0.22	2%	1,759	0.07	1%
AT - 3 units	185	0.03	<1%	-	-	2,236	0.41	2%	565	0.10	1%
AT - 4 units	23	0.01	<1%	-	-	1,261	0.70	3%	36	0.02	<1%
AT - 5 units	178	0.20	1%	-	-	-	-	-	-	-	-
Motorized	-	-	-	-	-	-	-	-	-	-	-
Total/Average	14,701			447	6,564	22,402			9,170		
Total Best Equipped 25%	2,776				844	9,228			2,360		
Total AT Equipped	10,536				4,856	14,402			5,821		
% of Total Best 25%	19%				13%	41%			26%		
% of Total AT Equipped	72%				74%	64%			63%		

FARM MECHANIZATION AND PRODUCTION CHARACTERISTICS OF MALI'S COTTON GROWERS, 1989 (Continued)

Level of Equipment	Area in Peanuts ha	Area in Peanuts ha/Farm	% of Farm Area	Peanut Yields kg/ha	Peanut Production tons	Area in Cowpeas ha	Area in Cowpeas ha/Farm	% of Farm Area	Area in Other Crops (ha)	Area in Other ha/Farm	% of Farm Area
Hand Tillage	9,281	0.37	12%	790	7,332	14	-	-	2,827	0.11	4%
AT - Partial	7,369	0.31	7%	768	5,659	714	0.03	1%	5,341	0.23	5%
AT - 1 unit	29,789	0.53	8%	664	19,780	2,212	0.04	1%	14,000	0.25	4%
AT - 2 units	23,066	0.68	7%	722	16,654	2,207	0.08	1%	5,092	0.20	2%
AT - 3 units	5,825	1.08	6%	460	2,680	1,145	0.21	1%	1,114	0.21	1%
AT - 4 units	1,237	0.69	3%	904	1,118	360	0.20	1%	166	0.09	<1%
AT - 5 units	1,518	1.69	7%	641	973	34	0.04	<1%	83	0.09	<1%
Motorized	431	1.44	5%	-	-	473	1.58	5%	15	0.05	<1%
Total/Average	78,516			690	54,196	7,159			28,638		
Total Best Equipped 25%	32,077				21,424	4,219			6,470		
Total AT Equipped	61,868				41,204	6,431			20,470		
% of Total Best 25%	4[illegible]%				40%	59%			23%		
% of Total AT Equipped	79%				76%	90%			71%		

Adapted from: 1. Niang, M., "Resultats de l'Enquete Agricole Permanent: Analyse du Comportement des Exploitations: Generalities, Campagne 1989/90"
2. Niang, M., Personal Communication

supplying the production inputs, delivering the production credit, processing the grain cotton, and exporting the cotton fiber. They are also the largest shareholder and control the management of Mali's principal oil producing facilities, the Malian Edible Oil Company (HUICOMA). HUICOMA produces about 23,000 mt of oil from cotton seed at its two plants in Koulikoro and Koutiala.

Cotton production directly provides three products that are used locally and exported. The most important economically is the cotton fiber that is woven into cloth in two major factories in the country and exported. About three percent of the fiber produced by the CMDT is consumed locally (CMDT 1989, p.131). Oil is extracted from the seed and is consumed locally and occasionally exported. Cottonseed cake is also used locally as a supplemental livestock feed and exported principally to neighboring countries. Improvements in the quality and quantity of beef and milk products in Mali in the last 15 years are due, at least in part, to the value and increased availability of cottonseed cake as a livestock feed.

1.2 World Demand

Cotton production in Mali is highly dependent on the international marketplace for both inputs and marketing of a substantial portion of the cotton products. Fertility maintenance, pest control, and mechanization are heavily dependent on imported inputs. In 1989, annual inputs for the cotton industry were valued at approximately $21,000,000.

In 1989, 250,000 mt of cotton was ginned, 97,000 mt of fiber was produced, and the average sale price was $1.59 resulting in a gross revenue from cotton fiber sales of about $153,000,000 (CMDT 1989, pp.130-131). This is equivalent to about $ 0.61/kg for seed-cotton. About 145,000 mt of seed were produced, of which about 10,000 mt were kept for seed. The remaining 135,000 mt yielded 23,000,000 liters of oil and 74,000 mt of cottonseed cake (HUICOMA 1992, p.3).

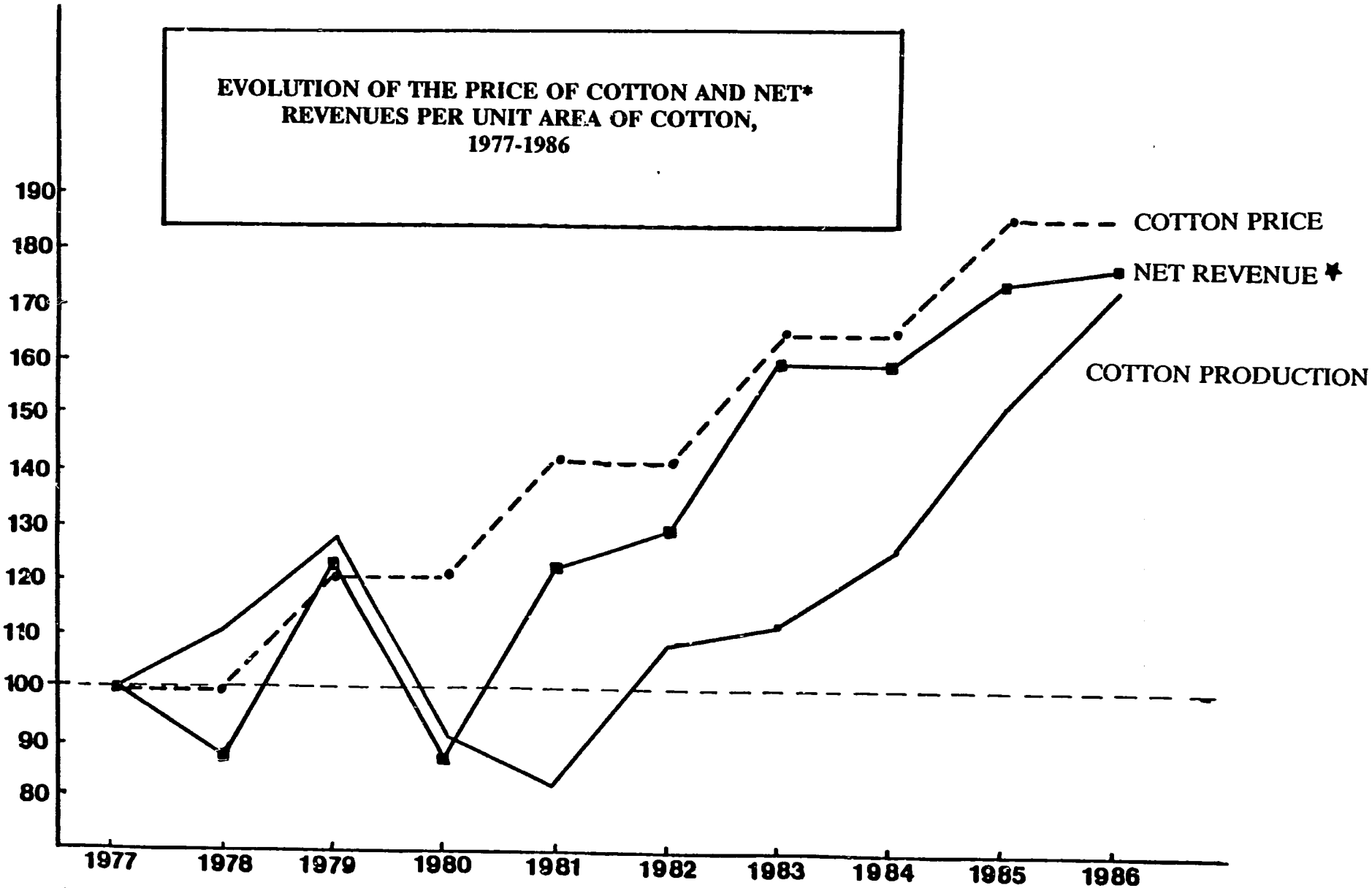
From 1977 to 1986 cotton prices paid to producers were generally favorable. However, production dropped when input prices were raised and returns to the farmer were reduced (Exhibit 3) (Kleene et al. 1989, p.44). This took place in the context of increasing demand for cotton worldwide despite a volatile (cv equals 42%; Lele et al. 1989, p.7) international cotton market (Exhibits 4 and 5) (Coleman and Thigpen 1991, pp.90-91).

1.3 Input Distribution Networks and Extension

Inputs are supplied through a mix of public and private channels. CMDT is viewed by its management as first and foremost an input supplier and extension agency. This is reflected in their staffing patterns, where most staff positions relate to input supply and extension activities. The CMDT directly supplies and generally provides credit for all inputs. Funding for the credit comes either from village associations or the National Agricultural Development Bank (BNDA). The delivery of mechanized inputs from spraying equipment to tractors is also

ADAPTED FROM: Kleeene, Paul, Bakary Sanogo, Gerben Vierstra, "A Partir de Fonsebougou...Presentation, objectifs et methodologie du 'Volet Fonesbougou' (1977-1987), Systemes de Production Rurale au Mali: Volume 1."

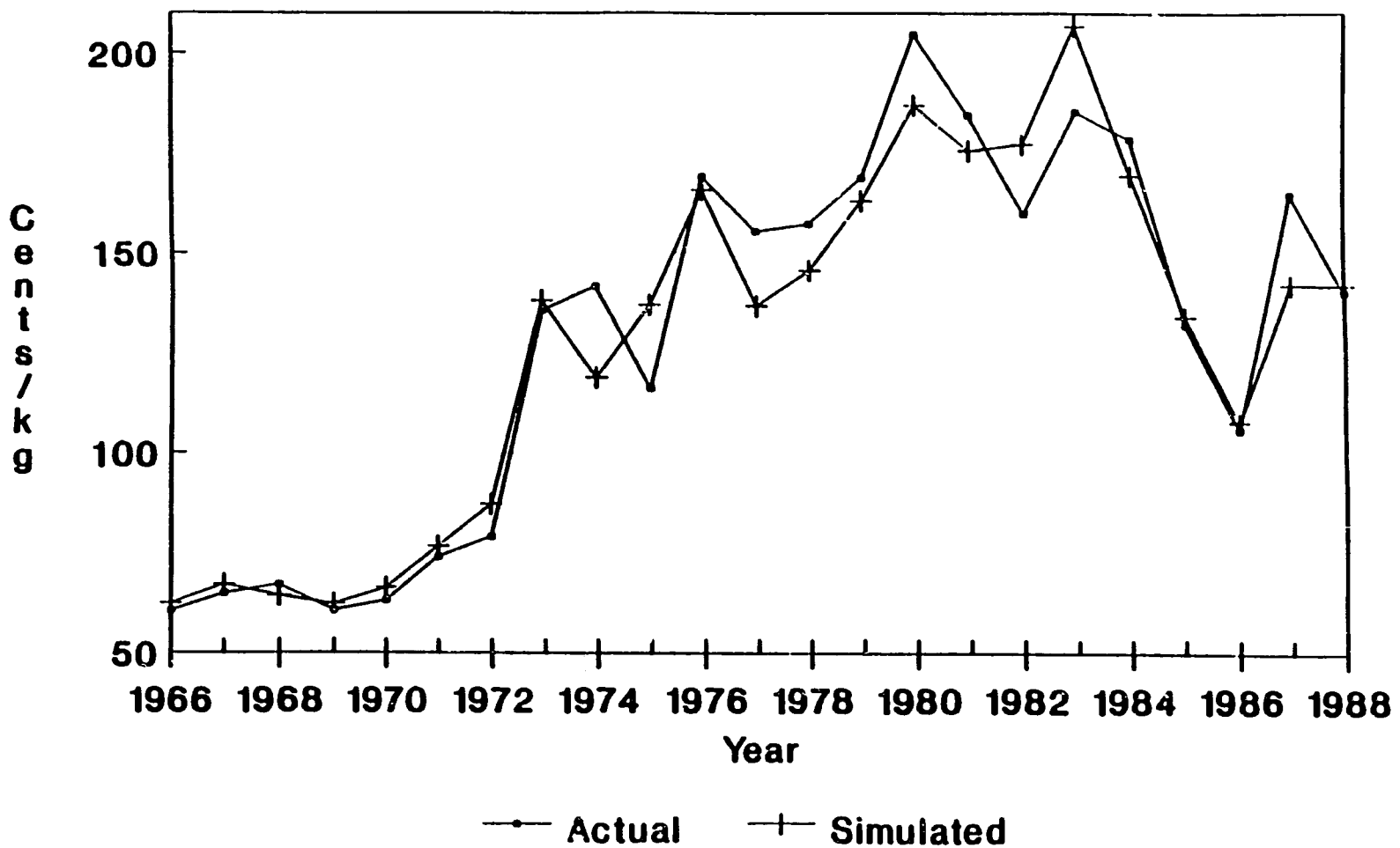
EXHIBIT 3



* Net revenue is defined as: Cotton revenues (priced fixed by the CMDT multiplied by the production) minus the variable input costs (the amount due to the CMDT for fertilizer, insecticides, herbicides, etc. but not including equipment loans).

EXHIBIT 4

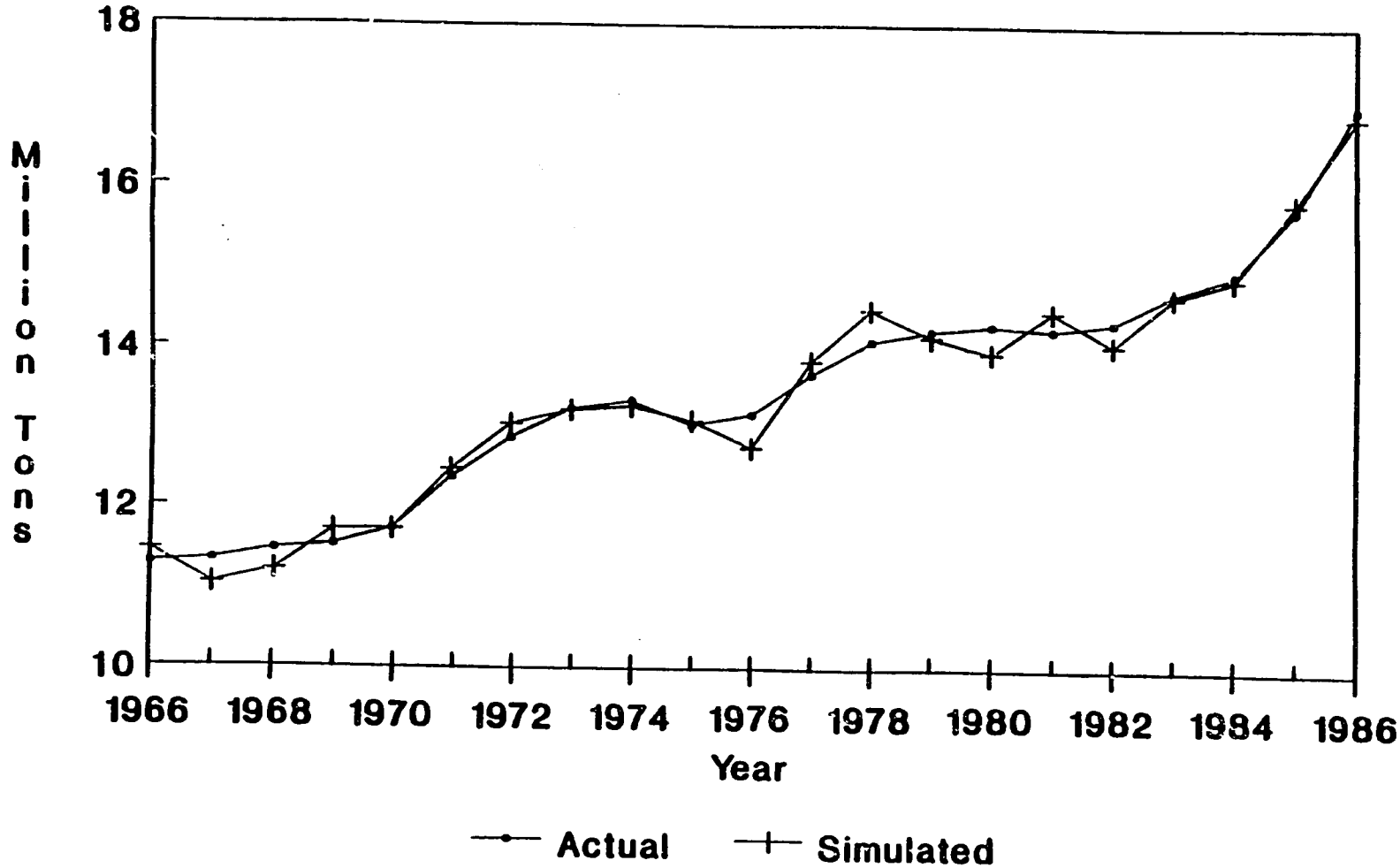
World Cotton Price, Actual vs. Simulated Values, 1966-1988



ADAPTED FROM: Coleman, Jonathan, M. Elton Thigpen, "An Econometric Model of the World Cotton and Non-Cellulosic Fibers Markets."

EXHIBIT 5

World Cotton Consumption, Actual vs. Simulated Values, 1966-1986



ADAPTED FROM: Coleman, Jonathan, M. Elton Thigpen, "An Econometric Model of the World Cotton and Non-Cellulosic Fibers Markets."

initiated through the CMDT system. The products, credit, training, and follow-on support are provided through official channels.

1.3.1 Distribution

Inputs are distributed and delivered through the CMDT extension agents. Production contracts are issued and inputs supplied based on an anticipated yield. This is similar to the system used by contractors in the United States for centrally-processed products such as poultry, tomatoes, grapes, and the like. In some cases in the United States, money is advanced against the contract (either by the bank or the processor) for the farmer to purchase inputs, and in other cases inputs are supplied by the processor.

1.3.2 Financing

Credit has traditionally been supplied directly by the CMDT; however, since 1974 the Banque Nationale pour le Développement Agricole (BNDA) has played an increasingly important role in financing both annual inputs and longer-term capital investments for farmers and their suppliers, including many blacksmiths. The total value of loans, both long and short term, during 1988 was $28 million. Of this, 75 percent financed annual inputs through the CMDT and the rest directly from the BNDA and/or AV. Longer-term credits for AT equipment, spraying equipment, carts, tractors, village-level processing equipment, blacksmith's equipment and the like through the CMDT (not including those through the BNDA) were $1.1 million. The input credit-to-crop value ratio was 29 percent. Recovery rates for annual credit were 97 percent and 91 percent for equipment loans (CMDT 1989, p.58-63).

Village associations (Association villageoise - AV) often manage the credit program in a relatively autonomous fashion, with the CMDT offering technical support depending on each particular situation. Credit payments are made from the cotton income at harvest and passed to the village association or BNDA. This system effectively supplies new technologies to farmers and increases productivity on both a per unit area and aggregate basis. Nevertheless, there has been a movement to transfer these supply functions to small fabricators and retailers and the credit function to the village associations within the production areas.

For example, the program "Action Forgerone" (Blacksmith Action Program), provides local blacksmiths with training, equipment, and operating capital to upgrade their capacity to a level where they can produce all of the basic animal-drawn farming equipment and carts. Farmers can obtain credit through the CMDT for purchases from their local blacksmiths. The relatively large revenues of both "encadre" and "non-encadre" blacksmiths within the CMDT zone are indicative of the impact and success of this strategy with these small entrepreneurs. Pesticide dealers and custom applicators are beginning to be seen in the project zone without any direct support from the CMDT.

Inputs are also sold and limited credit given for secondary crops, especially maize. From 1982-84 the CMDT made a large number of loans for maize production and purchased

the output at prices that were set prior to the season. More maize was produced than the CMDT could profitably market and they were obliged to abandon the scheme. Farmers have nevertheless continued to grow and market significant quantities of maize, which is viewed by many as a secondary cash crop.

1.3.3 Extension

The majority of CMDT's personnel is involved in the extension of the agency's production themes to farmers. These agents also handle the input supply, credit applications, and sale of cotton for the CMDT with the farmers. As a result, they have a good deal of leverage in bringing extension messages to individual farmers. Farmers are encouraged to adopt the whole package of recommended technologies, including plowing, planting in lines, the use of fertilizer, and pesticide application.

CMDT has a long tradition of successfully communicating crop management and other extension/development themes to farmers. They are currently involved in a number of purely development-oriented activities, including literacy training and support to both women's and men's village-level development/training associations. Characteristically, new technologies are first introduced/tested with farmer/leaders (Paysan Pilot) who verify the technology's effectiveness/appropriateness, and then help their neighbors to incorporate it into their farming practice. Performance characteristics are established before farmers are considered creditworthy for a new technical innovation. For example, intermediate tractor farmers must have at least 20 hectares under cultivation and average cotton yields of above 1.2 mt/ha to be considered for a tractor loan. The agency has developed a great deal of legitimacy over the years and their recommendations are taken seriously. The agency has over a 95 percent recovery rate on its loans.

1.4 Market Channels

CMDT is the only purchaser of cotton. Prices are announced in advance of the season so farmers do have the opportunity to choose if they want to grow cotton or not. In years such as 1980/81 significant numbers of farmers chose not to grow cotton and aggregate production suffered as a result. Overall, however, CMDT has been successful in stimulating the production of cotton through a package of incentives that includes an attractive price for the crop, as well as the inputs and technical information to successfully grow and deliver the crop. In 1989, with the price of cotton at $0.31, for a farm with average cotton yields (1,359 kg/ha), 31 percent of the farm's cotton revenue went to imported inputs, and 20 percent to domestic inputs (Naing 1992, p.5). The evolution of the relationship between the price of cotton (total revenue minus pesticides and fertilizer) and production from 1977 to 1986 is presented in Exhibit 3.

Payments to farmers are made at the pickup points, and production and capital loan reimbursements are collected in the process. Prices are fixed in advance of the season so that the farmer essentially contracts his entire crop to the CMDT prior to planting as a part of

receiving his production inputs (credit) from the CMDT. This is similar to the way many centrally-processed agricultural crops are marketed in the United States.

Cotton is marketed through the CMDT. All primary processing is handled in CMDT-owned and managed facilities. CMDT collects the cotton in company-owned trucks from bulking points that are located on major roadways. Processed cotton is sold through the Compagnie Cotonniere Domiciliée à Paris (COPACO - CFDT 40 percent owner) that acts as CMDT's marketing agent. Almost all Malian cotton passes through French marketing channels. The final sale price is based on a combination of pre-arranged levels and the world market price. An effective effort has been made by the CMDT/CFDT to provide stable prices both to the producers and the CMDT. Oil and cottonseed cake are sold principally on the local market.

CMDT's management views the support they provide to farmers as their principal "raison d'être." This support, both direct and indirect, includes farmer-level trials and demonstrations, as well as extension services for 85,000 farmers. CMDT provides the inputs and associated credit for the cotton crop. The purchase and evacuation of the cotton from bulking points is assured through the CMDT. It handles and develops relationships with the primary suppliers of the inputs for the cotton crop.

1.5 Infrastructure

Historically CMDT and the Government of the Republic of Mali (GRM) have essentially provided all the infrastructure supporting cotton production and primary processing in Mali. The road system was at least in part planned and improved to move the cotton crop to market. Credit was provided through the CMDT. The government and CMDT supported the fabrication and distribution of animal traction and other improved farming equipment through Société Malienne pour l'Expérimentation et le Construction des Machines Agricoles (SMECMA) and other fabricators in Africa and France. The development and extension of the ULV sprayer technology was supported and subsidized by the French and British governments as well as the CMDT. Until recently all the trucks transporting cotton to the gin were owned and operated by the CMDT. Most cotton is still transported in CMDT trucks. The gins, other conditioning equipment, oil extraction facilities (subsidiary HUILCOMA), and storage areas are CMDT property. Inputs were delivered at least to the bulking points, where cotton is received after harvest, and often directly to the farmer.

In recent years the CMDT has begun to place critical support functions in the hands of private entrepreneurs. The "Action Forgerone" has resulted in much of the fabrication and repair of animal traction equipment being handled by local blacksmiths. SMECMA is bankrupt, thus all AT equipment is currently fabricated by local blacksmiths. Credit is increasingly handled by the local banks. The provision of pesticides and herbicides by local suppliers is tolerated, if not encouraged. CMDT has also begun to use private truckers as well as lease arrangements to provide transportation of a small portion of the crop. Processed lint is moved to the mills and port cities by private truckers or other organizations including the Rege Chemin

du Fer du Mali. However, crop storage and processing of seed, oil (through HUILCOMA), and fiber remains the exclusive domain of the CMDT.

1.6 Research

CMDT directly supports research at the N'Tarla research station on cotton and the other major cereal and legume crops grown by cotton farmers in Mali. Through their relationship with the Institut de Recherches sur le Coton et les Textiles (IRCT), Centre de Coopération Internationale en Recherche Agromonique pour le Développement (CIRAD), and Institut d'Économie Rurale (IER)/Section de Recherche sur le Coton et les Fibres Jutieres (SRCFJ), the CMDT has benefitted from a whole range of research activities focused on cotton production in Francophone West Africa. This research includes cotton and maize varietal improvement, the development of customized fertilizer materials, the development of a whole range of animal traction farming equipment, the development of the ULV pesticide application technology, the formulation of special insecticide and seed treatment products for the cotton and cereal crops in the cotton growing areas, the development of intermediate motorized farming equipment, and a range of other technologies. Major input suppliers such as Imperial Chemical Industries (ICI), Ciba-Geigy, Rone-Poulenc, and large European fertilizer suppliers have participated in these developments. This collaborative and focused relationship is being maintained throughout the West African region where CFDT is active.

2. DEMAND FOR MECHANICAL TECHNOLOGY

2.1 Type of Technology

The mechanical technologies currently used in cotton production in Mali can be conveniently divided into several areas including input delivery and post-harvest transportation, tillage, crop management, primary processing, and secondary processing. These areas will be discussed in turn.

2.1.1 Input Delivery and Post-Harvest Transportation

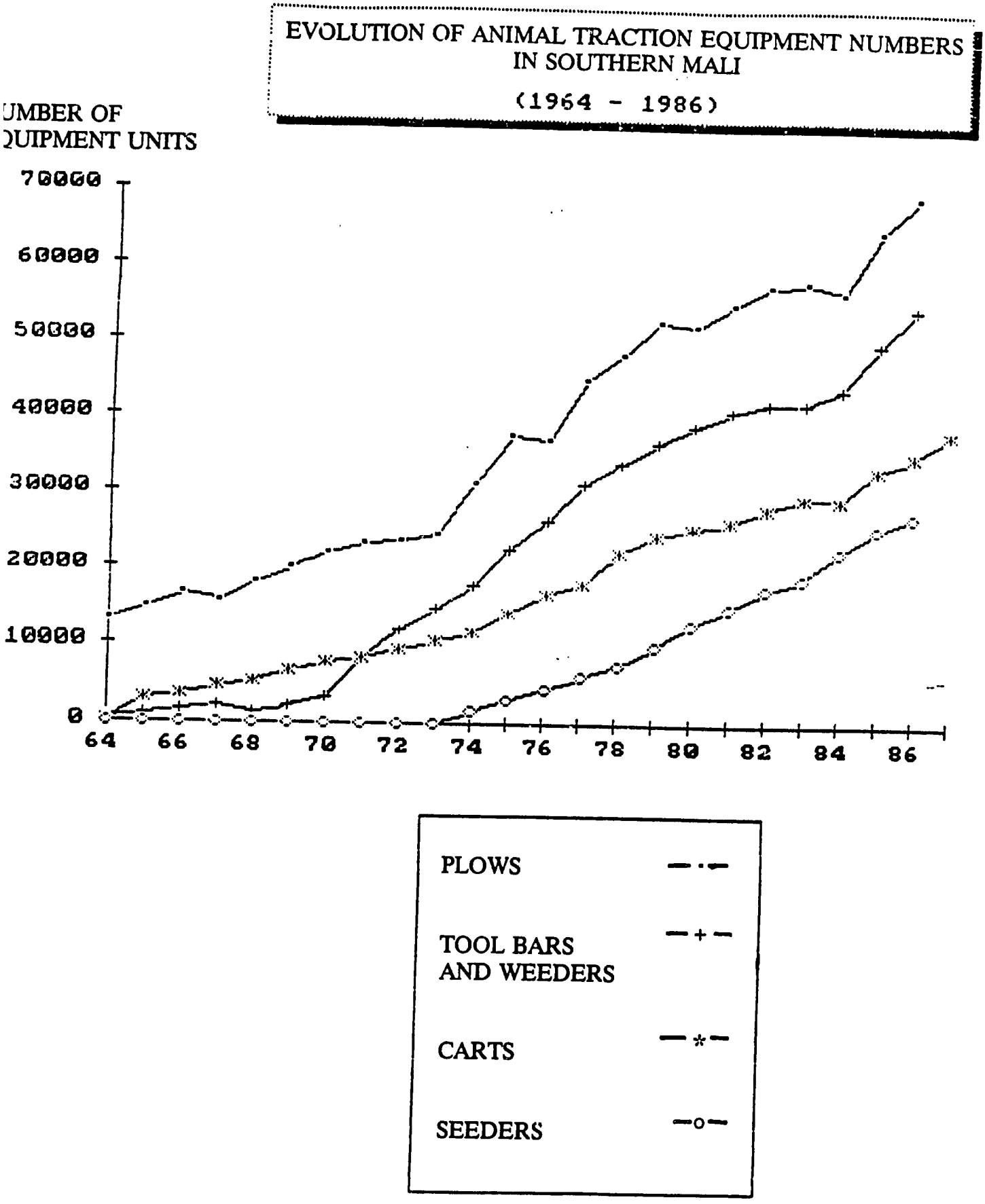
Input delivery and post-harvest transportation involves movement of crop inputs, seed cotton, and processed cotton commodities on trucks, railways and carts. Truck and rail transportation naturally dominates the large volume, long-haul portions of these activities. Specially-built or modified wagons are used for portions of both the rail and truck transportation that is provided. Seed-cotton wagons (built in France) are similar to those used in the US.

There is probably no technology that has had greater impact on the work capacity and movement of limited resource farmers in West Africa than the rubber-tired, wheel-ball-bearing, animal-traction-drawn cart. Well into this century, human power was the only, or major, means of transportation. In the areas where rainfed cotton is currently grown, goods were carried exclusively by people, principally on their heads. Both the distances travelled and quantities moved were extremely limited. In Francophone West Africa, the successful extension of carts with rubber pneumatic tires and wheel ball bearings was linked to the intensification of cotton production. While this technology has become relatively widespread throughout the region, it was in the cotton production zones where the technology initially was extended and took hold. Cotton sales financed the purchase of this tool. It would be impossible for the cotton industry in Mali to function at its current level of production and investment without the essentially ubiquitous availability of this innovation. Today AT carts move the inputs to the farm and the crop to market. They also carry the farmer and his family (Exhibit 6).

2.1.2 Tillage

There is a range of soil-tillage equipment that has been developed or modified specifically for cotton farmers in West Africa. The "Tropical Mali" (TM) plow is one of the most successful of these pieces of equipment. Research organizations in England (National Institute of Agricultural Engineering - NIAE), France (Centre d'Études et d'Experimentation du Machinism Agricole Tropical - CEEMAT), Holland (Wageningen - Tillage Laboratory), and West Africa (Senegalese Agricultural Research Institute (ISRA)-Bombey, Agricultural Machinery Division (DMA)-Mali, etc.); and private companies such as Rumptstad in Holland and Muzon in France, as well as several parastatal AT-manufacturing concerns in West Africa have contributed to the development and improvement of the AT equipment so widely used in the cotton-producing areas throughout the region. More than 80 percent of the farmers (in 90 percent of the area cultivated) in the cotton growing areas in Mali have this piece of machinery

EXHIBIT 6



ADAPTED FROM: Bigot, Y. (IRAT), "Mechanisation Agricole et Dynamique des Systemes Agraires en Zone Soudanienne Senoufu: Quelques Aspects Generaux."

which was developed and first extended to the farmers in the region in the late 1950s and early 1960s. Fifty percent of the farm units that do not have AT equipment cultivate less than 4 ha while those lacking AT equipment with more than 7 ha represent only 17 percent of the nonequipped farms (Naing 1991, p.8). The introduction of AT decreases the work time per unit area at least 35 percent (Exhibit 7). The area worked per day with the principal pieces of AT equipment is presented in Exhibit 8.

In the last 10 years a major effort has been made to introduce motorized tillage equipment (specially-designed tractors and implements) to the larger cotton producers. The "Boyer" tractor (26 hp) was developed (with research contributions by NIAE in the UK; Centre des Experimentation et Études in Mechanism Agricole Tropicale (CEEMAT) in France; the CFDT, and the French parastatal company Broyer) specifically for limited-resource farmers in Africa. Originally built in France, 50 tractors are currently being assembled each year in Koutiala, Mali. This simple "platform tractor" has been made available to more than 141 farmers in Mali. The French government underwrote the tractor's initial development and, along with CFDT and CMDT, is subsidizing its manufacture and delivery.

In a study of a relatively limited sample of farmers (32) in two villages, farmers with tractors cultivated 63 percent more area than farmers who were well-equipped with AT (39.5 ha for the farms with tractors and 24.9 ha for the farms with AT). The mechanized farms also had more people directly dependent on the enterprise, 42 persons/farm versus 27 persons/farm. The area per person and the area per active participant in the farm enterprise were not different on the mechanized farms. The percentage of the area in cotton relative to cereals is slightly increased on mechanized farms (39.4 percent cotton and 57.2 percent cereals for farmers with AT and 44.6 percent cotton and 51.5 percent cereals for farmers with tractors). Yields of both cotton and cereals were similar for AT and motorized farmers. Revenue (total earnings minus inputs and tractor operating costs) for motorized farmers was lower both on a per hectare and per person basis due to the operating costs for the tractor ($136/person - AT versus $122/person - tractor and $147/ha -AT versus $128/ha -tractor; the tractor's amortization was not included in the calculation). Total revenue less input charges, including the tractor's operating cost, was substantially higher for the farms with the tractors ($5,062 for the farms with tractors versus $3,659 for the AT farms - see Exhibit 9).

2.1.3 Crop Management

Mechanical technologies are also applied to seeding, weeding, and pest control in the cotton production system as it is currently practiced in Mali. While animal traction and mechanized seeding and weeding equipment have been developed specifically for cotton producers in the region, their use is less widespread than the primary tillage equipment. This occurrence is consistent with similar developments in Asia and elsewhere where high precision, lower labor operations tend to be mechanized later in the technology adoption process. In 1988, 68 percent of the area in cotton was planted with AT seeders and 90 percent of the area was weeded mechanically (CMDT 1989, p.41).

EXHIBIT 7

Work Time Before and After the Introduction of Animal Traction

Agricultural Labor Activity		Average Number of Workers			Hand Labor days /ha	Mechanized Animal Traction days/ha	Change in Work Time days/ha	Change in Work Time in %
		Men	Women	Total				
Cleaning Fields	Hand	4	0	4	16			
	AT	4	1	5		16	0	0%
Hoeing (hand)		4	2	6	21		-21	-100%
Scarafication		3	1	4		4	4	100%
Deep Scarafication		3	1	4		3	3	100%
Plowing		3	1	4	19	12	-7	-37%
Mechanical Ridging		3	1	4		4	4	100%
Hand Ridging		6	0	6	40		-40	-100%
Chemical Weeding		1	0	1		5	5	100%
Seeding		3	2	5	16	14	-2	-13%
Weeding x's 3	Hand	3	1	4	33			
	AT	4	1	5		30	-3	-9%
2nd Ridging	Hand	3	1	4	26			0%
	AT	3	1	4		8	-18	-225%
Manure Hauling	Hand	4	2	6	11			
	AT	2	1	3		4	-7	-64%
Manure Application	Hand	3	1	4	3			
	AT	5	4	9		3	0	0%
Chemical Fertilizer	Hand	4	0	4	1			
	AT	3	1	4		4	3	300%
Insecticide Treatment		1	0	1	3	4	1	33%
Harvest	Hand	5	3	8	16			
	AT	6	4	10		29	13	81%
Post Harvest	Hand	3	2	5	12			
	AT	6	8	14		2	-10	-83%
Total					217	142	-75	-35%

Adapted From: Niang, M., "Impact de l'Equipement sur l'Organisation du Travail au Sein de l'Exploitation

EXHIBIT 8

Animal Traction Work Times and Area

Equipment	Workers			Average	Time	Area/
	Men	Women	Total	Area (ha)	(Days)	Day (ha)
Plow	2	1	3	6	15	0.4
Tool Bar	2	0	2	7	16	0.4
Weeder (Bullock)	3	1	4	7	12	0.6
Weeder (Donkey)	2	0	2	4	20	0.2
Seeder	2	1	3	8	12	0.7
ULV	1	0	1	4	6	0.7
Cart*	2	1	3	7	20	0.4
Tractor	4	0	4	32	16	2.0

* Area of Manure Application

Adapted From: Niang, M., "Impact de l'Equipement sur l'Organisation du Travail au Sien de l'Exploitation"

EXHIBIT 9

Animal Traction VS Small Tractors - Production Parameters
A Comparison Over Two Villages, 1990

Population, Livestock, Equipment and Land-Use Characteristics

Farm Unit Profile	Animal Traction	Tractor Since 1981	Tractor Since 1985
Sample Size - Farm Units	10	10	12
Demographics			
Population	27.0	48.8	36.1
Men	5.9	10.4	7.3
Women	6.9	13.0	10.1
Children	14.2	25.5	18.7
Rural Exodus	2.7	4.3	5.1
Farm Workers	10.0	17.1	14.3
Men	4.4	8.2	6.3
Women	3.0	5.0	3.8
Children	2.7	3.9	4.2
Wage Earners	0.9	1.1	0.2
Herders	1.9	3.3	2.0
Cattle	38.4	55.5	49.7
Farm Equipment			
Animal Traction			
Traction Animals	8.4	7.2	8.0
Plow	2.5	2.4	2.5
Tool Bar	2.4	2.4	1.9
Seeder	1.3	1.6	1.6
Harrow	0.3	0.2	0.2
Donkey Cart	1.6	1.6	1.5
Bullock Cart	0.0	0.0	0.1
Pesticide Sprayer	2.2	3.0	2.7

Adapted From: C.M.D.T., personal communication.

Animal Traction VS Small Tractors - Production Parameters
A Comparison Over Two Villages, 1990 (Continued)

Population, Livestock, Equipment and Land-Use Characteristics

Farm Unit Profile	Animal Traction	Tractor Since 1981	Tractor Since 1985
Tractor Equipped			
Tractor		1.0	1.0
Plow		1.0	1.0
Tool Bar		1.0	1.0
Cart		1.0	1.0
Seeder		0.5	
Thresher		0.1	0.1
Grain Mil		0.5	
Land Use (ha)			
Area Cultivated	24.9	39.5	39.4
Area/Person	0.9	0.9	1.1
Area/Farm Worker	2.5	2.3	2.8
Cotton	9.7	16.7	17.6
Maize	1.0	4.3	2.5
Maize/Millet	0.5	0.9	1.9
Maize/Sorghum	0.7		0.5
Other Maize Intercrop			0.3
Total Maize	2.2	5.2	5.1
Sorghum	4.3	4.8	10.1
Sorghum/Cowpea	2.1	3.8	0.4
Sorghum/Peanut	0.1		0.1
Millet	2.1	3.0	3.1
Millet/Cowpea	0.8	2.0	
Millet/Peanut	0.8	0.3	0.1
Rice/Lowland	1.5	1.1	0.4
Rice/Upland	0.3	0.5	0.4
Peanut	0.3	0.9	1.0
Peanut/Intercrops		0.0	
Sesame		0.1	0.1
Forage Cowpea	0.5	0.4	0.7
Other	0.1	0.6	0.2

Animal Traction VS Small Tractors - Production Parameters
A Comparison Over Two Villages, 1990 (Continued)

Cash Crop Production/Revenue Profile

Production/Revenue Characteristics ($U.S. @ 275 Fcfa/$)	Animal Traction	Tractor Since 1981	Tractor Since 1985
Cotton			
Cotton Yield (kg/ha)	1,317	1,404	1,245
Seed (kg/ha)	40	40	40
Urea (kg/ha)	39	41	38
14-N/22-P/12-K (kg/ha)	106	101	102
Telemsi Rock Phosphate (kg/ha)	47	44	111
Herbicide (l/ha)	0.9	0.8	0.8
Insecticide (l/ha)	8.6	10.5	9.0
Crop Value/ha @ $ 0.31/kg	$407	$434	$385
Input Charges	$124	$129	$129
Crop Value/ha - Input Charges	$283	$305	$256
Value - Charges/Farm	$2,751	$5,087	$4,502
Maize			
Maize Yield (kg/ha)	2,533	2,491	2,094
Urea (kg/ha)	40	39	59
14-N/22-P/12-K (kg/ha)	54	67	81
Telemsi Rock Phosphate (kg/ha)		40	
Herbicide (l/ha)	0.4	1.1	0.7
Crop Value/ha @ $ 0.18/kg	$460	$453	$381
Input Costs	$47	$59	$76
Crop Value/ha - Input Charges	$413	$394	$304
Value - Charges/Farm	$907	$2,051	$1,562
Tractor Expenses			
Diesel		$766	$556
Oil & Filters		$199	$129
Spares		$1,003	$381
Other		$11	$25
Total		$1,989	$1,090
Income Characteristics			
Cotton & Maize, Income - Inputs	$3,659	$5,149	$4,975
Income - Inputs/Capata	$136	$106	$138
Income - Inputs/Worker	$368	$301	$349
Income - Inputs/ha	$147	$130	$126

All pesticide application on cotton is mechanized. Initially "backpack" sprayers were used but these have been largely replaced by ultra low volume (ULV) sprayers with special pesticide formulations for use with this equipment. The ULV technology and pesticide formulations were developed with inputs from CEEMAT, NIAE, Ciba-Geigy, Rone-Poulenc, ICI, CFDT, CMDT, and others in the research and development, petrochemical, and cotton production industries. The technology was developed specifically for, and has been applied almost exclusively by, limited-resource cotton farmers in Africa. In 1988, at least four ULV pesticide applications were made to 151,978 ha (84 percent of the cotton crop) and a total of 1,756,128 l of insecticide products were used. The insecticide was sold to farmers for $3.64/l for a total farm level investment of $6.25 million (Exhibit 10) (CMDT 1989, pp.41, 46).

2.1.4 Primary Processing

The machinery used for the ginning, oil extraction, and other treatment of cotton fibers and byproducts is controlled directly or indirectly by the CMDT. This equipment is principally of U.S. origin and was purchased through the CFDT. The ginning facility was purchased as an entire factory and was installed by French technicians. The technologies used for processing cotton and its byproducts have been developed elsewhere and are similar throughout the industry worldwide. It is noteworthy that the use of intermediate technology solutions, including animal traction and pesticide application equipment designed specifically for limited-resource farmers, has resulted in the need for high volume, state-of-the-art processing equipment.

2.1.5 Secondary Processing

There are two weaving mills in Mali and a number in Côte d'Ivoire. The larger mill in Mali uses Chinese equipment and is managed as a part of the Peoples Republic of China (PRC) bilateral assistance program. This installation is currently in the process of being privatized and will probably continue to be managed by the Chinese on a contractual basis. The smaller mill uses European (German, French, Italian, and Dutch) machinery. Neither enterprise is profitable because of relatively high labor and operating costs as well as competition with cloth imported from Côte d'Ivoire, Asia, Europe, and elsewhere in Africa. It is interesting that cloth purchases are rather high on a per capita basis because Malians are willing to spend a relatively high proportion of their limited disposable income on cloth that is custom tailored locally.

2.2 Competing/Complementary Inputs

Due to the tendered-bidding procurement procedures used by the CMDT for their input supply, externally manufactured inputs are not available in sufficient quantities to be considered competitive with those available through the CMDT. This also applies to the truck/trailers, rail wagons, and primary and secondary processing equipment. The CMDT's de facto monopoly on farm credit reinforces their quasi monopoly on externally procured inputs.

EXHIBIT 10

Cotton Input and Production Factors, 1984-1988 Cropping Seasons

Input and Production Factors	Cropping Season 1984	1985	1986	1987	1988
Farms with extension support	63,291	69,627	73,118	77,259	84,797
Area seeded in cotton (ha)	113,198	139,218	145,747	142,222	180,136
Primary tillage					
Area plowed (ha)	100,242	123,348	132,029	127,390	164,256
% plowed	89%	89%	91%	90%	91%
Area ridged (ha)	9,699	11,986	11,046	11,120	13,316
% ridged	9%	9%	8%	8%	7%
Area hand tilled (ha)	3,257	3,884	2,672	3,712	2,555
% hand tilled	3%	3%	2%	3%	1%
Area seeded mechanically (ha)	69,515	88,736	98,160	94,526	121,647
% of total area	61%	64%	67%	66%	68%
Fertilizer					
Area with organic fertilizer (ha)	37,897	33,200	35,687	43,008	56,799
% of total area	33%	24%	24%	30%	32%
Area with 14%-N, 22%-P, 12%-K (ha)	103,321	127,729	121,288	124,985	158,112
% of total area	91%	92%	83%	88%	88%
Area receiving urea (46% N) (ha)	90,813	118,016	104,770	116,943	150,300
% of area receiving NPK	88%	92%	86%	94%	95%
% of total area	80%	85%	72%	82%	83%
Insecticide Treatment					
Area with 4 ULV treatments (ha)	76,763	102,842	111,138	116,019	151,978
% of total	68%	74%	76%	82%	84%
Area with 5 ULV treatments (ha)	26,641	37,811	43,158	52,767	78,602
% of total	24%	27%	30%	37%	44%
Litres used	1,285,409	1,645,765	1,700,127	1,737,840	1,756,128
Litres/ha	11.4	11.8	11.7	12.2	9.7
Secondary Tillage					
Area weeded mechanically (ha)	99,167	120,344	128,820	127,803	162,746
% of total	88%	86%	88%	90%	90%
Area ridged mechanically (ha)	78,991	102,257	114,756	112,498	148,897
% of total	70%	73%	79%	79%	83%
Production					
Cotton produced CMDT zone (tons)	139,067	169,557	194,763	189,596	239,151
Cotton produced Mali (tons)	144,261	175,092	201,653	198,887	249,056
Yields					
Cotton yield CMDT zone, kg/ha	1,229	1,218	1,336	1,333	1,328

Adapted From: "Rapport Annuel, Campagne Agricole 1988-89 en Zone Cotonniere, C.M.D.T."

In the area of AT equipment, the shift from centralized manufacture to fabrication by local blacksmiths has resulted in increased availability and a generally more competitive environment for the procurement and repair of this equipment. Village and town-level manufacture and repair have also broadened the impact of these income-generating activities by spreading them across the entire region.

Pharmaceutical and veterinary services are undergoing a similar transformation because of changes in the legal and policy environment enabling individuals to begin to directly market these goods and services in the rural areas. Just a few years ago, only traditional medicinal products were available in the private marketplace. Today there is a proliferation of small pharmacies even in remote village situations. A similar process is being observed in the provision of veterinary services/pharmaceutical supplies.

It would seem logical that the sale and custom application of pest and weed control products could undergo a similar evolution. This would be consistent with the industry's development in the US, Europe, Japan, Taiwan, Korea, India, Bangladesh, and other areas where the private sector has had the opportunity to deliver these goods and services. Given the experience elsewhere it is reasonable to assume that the availability of these inputs as well as the safety and efficiency of their use would improve. Progress in this direction would permit the CMDT to focus on product testing (licensing), and perhaps taxing the use of these products. Taxes applied to imported inputs are likely to improve the efficiency of their use, limit their misuse, and provide a source of revenue for agricultural research focused on the cotton farmer.

2.3 Rate of Adoption

Adoption of mechanical technologies has been rapid and widespread in the cotton production zone, as evidenced by the increased yields and production discussed earlier. On-farm adoption has a dramatic effect on per unit production and results in important increases in the area cultivated in cotton as well as other field crops. This takes place over the first few years of adopting the cotton production technological package. In the aggregate, the successful extension and adoption of mechanical and other cotton production technologies has resulted in an exponential growth in the number of producers, production, and input use since the CMDT's inception.

3. IMPACTS OF MECHANICAL TECHNOLOGY AND ITS INPUTS

Cotton prices to the farmers, while the lowest in francophone West Africa, have been favorable enough to increase and intensify cotton production for most of the last 15 years. With long term, gradual increases in price, the available information shows reasonably high returns on investment and labor from growing cotton. Returns from both labor and capital are higher with increased intensification. The growth of the cotton crop has followed increases in cotton prices and gross revenues to producers.

Cotton is grown commercially on approximately 187,000 ha in Mali. Yields average about 1,300 kg/ha in the CMDT zone. All of the crop is processed through the CMDT.

3.1 Types of Technology

Exhibit 11 summarizes the sale of inputs, equipment, fertilizer, and insecticides from 1961 to 1989. Agrichemicals are considered as key catalysts to mechanization of farming, because input use leads to use of sprayers and other applicators. Exhibit 11 shows a more than 10-fold increase in the value of the inputs delivered since the inception of the Project Mali Sud in 1974.

3.1.1 Agrichemical Technology

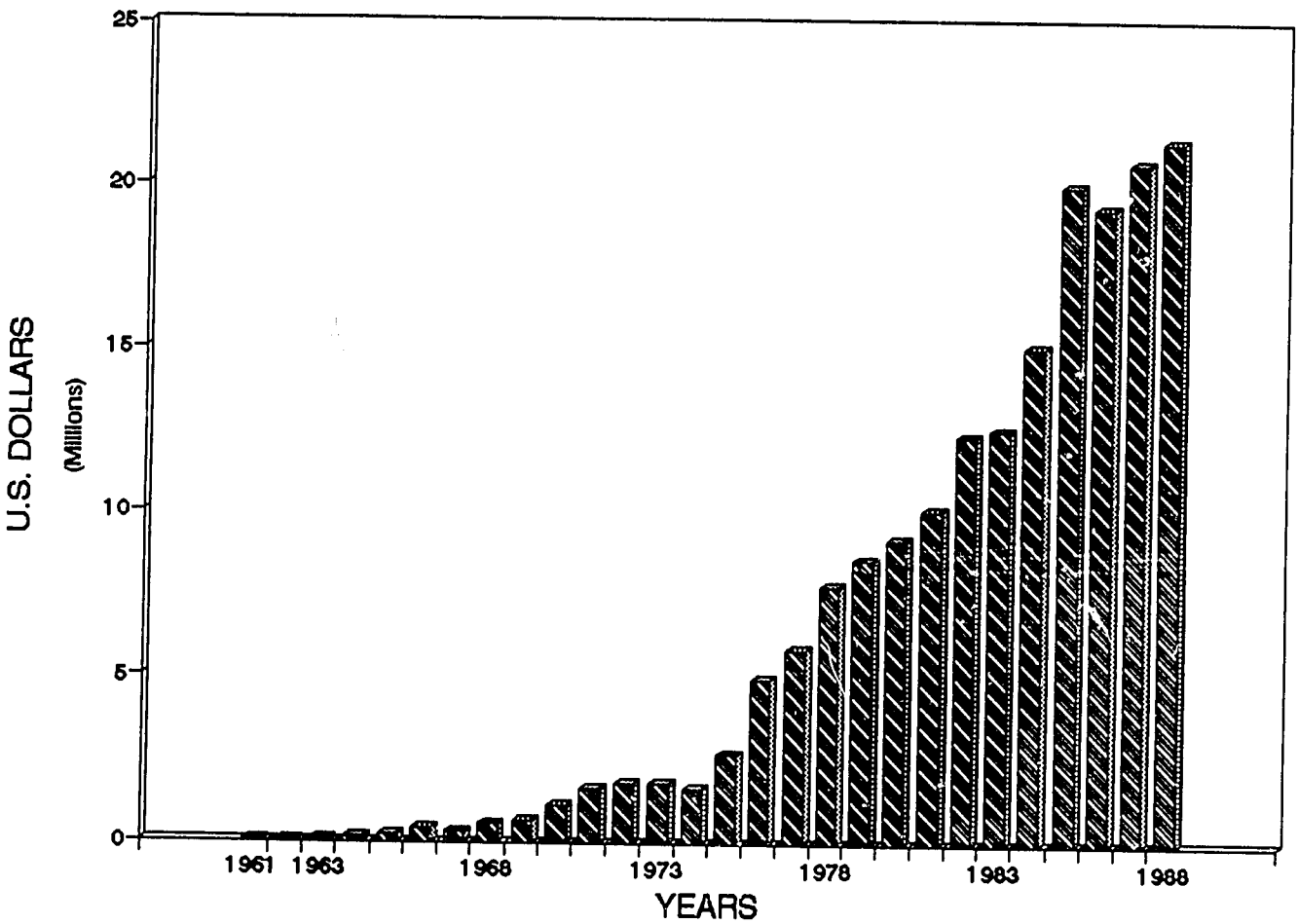
Fertilizer application for cotton production averages 40 kg/ha/yr of nitrogen, 26.5 kg/ha/yr P_2O_5 and 12.5 kg/ha/yr of potassium in the CMDT area. In 1989, 98 percent of the total CMDT area in cotton received an average of 121 kg/ha of "Complex Cotton" (14% nitrogen, 22% Potassium $_2O_5$ and 12% potassium) and 50 kgs/ha of urea (46% nitrogen) (Exhibits 2 and 10) (Naing 1992, p.10). Exhibit 12 summarizes the use from 1978-1987 of Complex Cotton and urea on four farms in a relatively high production area. It is apparent that farmers adjust their levels of fertilizer application and are conservative in doing so, lowering the doses applied if it appears to be to their advantage (Berckmoes et al. 1990, p.40).

Ultra-Low Volume (ULV) insecticides and associated application equipment are widely used on cotton with six applications per growing season recommended. In 1988, 84 percent of the cotton area received four ULV insecticide applications while only 44 percent received five (CMDT 1989, p.41). By 1990 these numbers had risen to 96 percent and 83 percent, respectively. An average of 2.4 l/ha/treatment and 12.9 l/ha total were applied (Naina 1992, p.10). CMDT placed 952,320 l of insecticides and 166,700 l of herbicides with farmers in 1989 (CMDT 1989, p.41).

Weeding and harvest are the principal labor constraints and result in substantial seasonal shifts in both the cost and absolute availability of hired labor. Herbicides are being more widely used to address weed control needs. Substantial amounts are also being delivered through ordinary commercial channels.

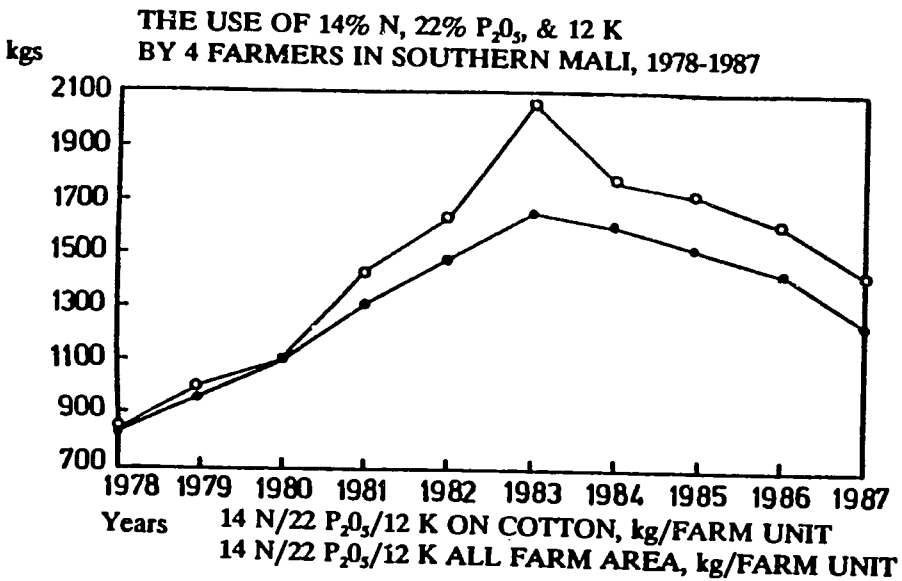
EXHIBIT 11

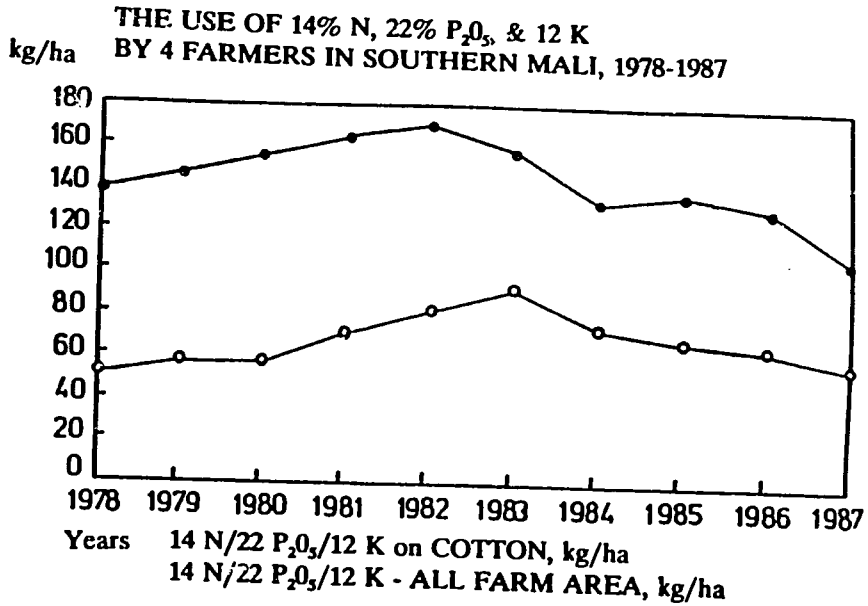
FERTILIZER AND INSECTICIDE SALES
CMDT, 1961-1988



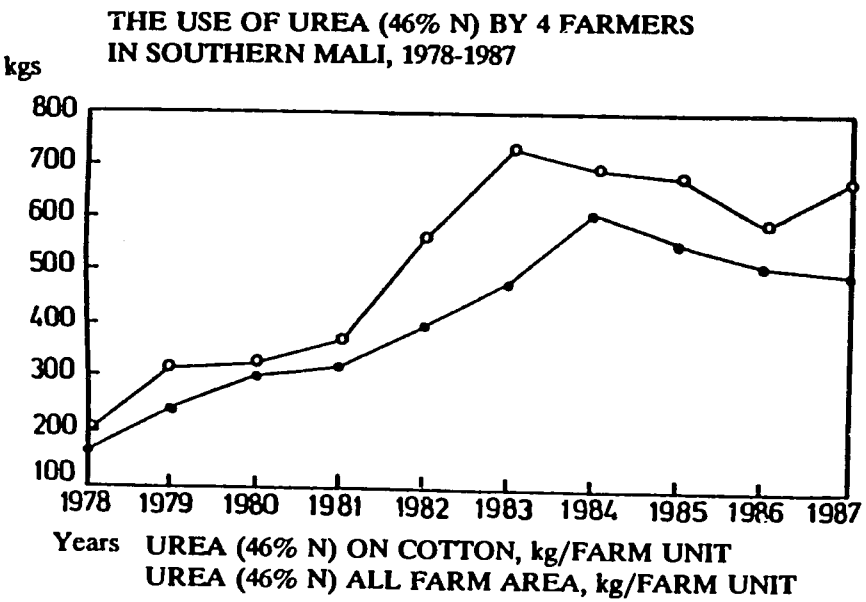
ADAPTED FROM: Rapport Annuel, Campagne Agricole 1988-1989 en Zone Cotonniere, Compagnie Mallein pour le Developpement des Textiles."

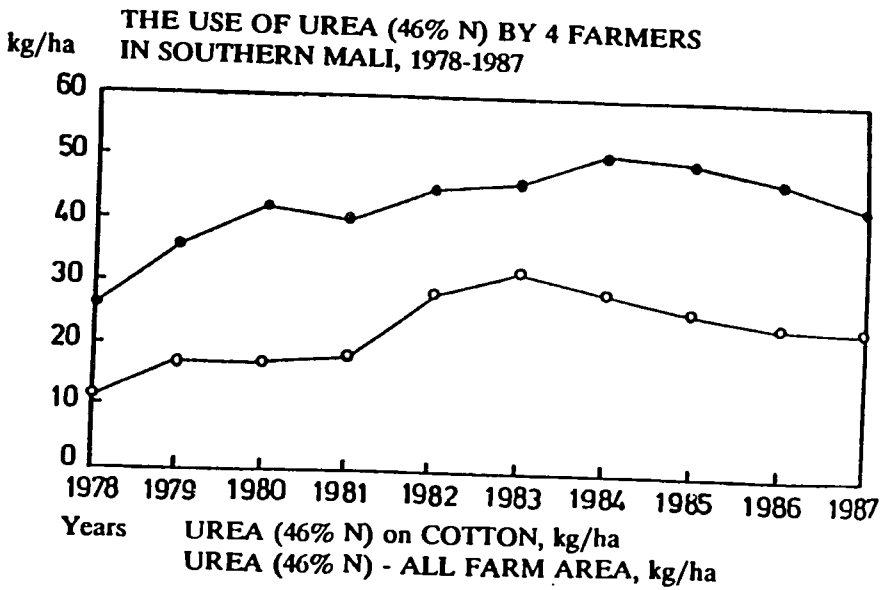
EXHIBIT 12





ADAPTED FROM: Kleeene, Paul, Bakary Sanogo, Gerben Vierstra, "A Partir de Fonsebougou...Presentation, objectifs et methodologie du 'Volet Fonesbougou' (1977-1987), Systemes de Production Rurale au Mali: Volume 1."





3.1.2 Animal Traction

Animal traction (AT) is practiced by more than 80 percent of the cotton growers in the CMDT zone (Exhibit 2). Ninety-eight percent of the cotton area receives some form of preplant tillage with AT (Exhibit 10). The combination of animal traction and cotton production has a marked impact on farm enterprises. For analytical purposes, the CMDT has divided its cotton producers into eight levels of intensification based on the number of animal traction units that are found in the enterprise. The scale moves from non-equipped farms to semi-equipped, then from those with one complete tillage unit to two, and so on, to five units, and finally to those with a tractor.

3.1.3 Tractors

A small but increasing number of farmers use tractors, principally the Boyer™, which is provided through the CFDT. Farms with tractors have somewhat lower per unit area cotton and cereal yields than the best-equipped AT farmers. These farmers cultivate substantially larger areas (equal to 50 percent) and are probably sacrificing somewhat in per unit area yields for higher returns from the larger cropped area. This will be discussed later in this paper.

3.2 Yield Impacts

More fully mechanized farms tend to use higher levels of both insecticides and fertilizers (Exhibit 2). This is reflected in yields of cotton as well as in the principal cereal crops. In 1989, cotton yields for hand-tillage farmers averaged 660 kg/ha. This increased to 965 for partially-equipped farmers. Farm units with one complete traction unit (two bullocks and a plough or tool bar) had yields of 1190 kgs/ha. Yields continued to rise as the level of mechanization increased. Farmers with five traction units had average yields of 1,640 kgs/ha. The same yield trends are evident in sorghum and millet as well, where yields move from 775 and 544 respectively for non-equipped farmers to 1,134 and 1,414 respectively for farms with five traction units. Maize is somewhat different because farmers who do not have AT grow this crop immediately adjacent to their houses where there is relatively high fertility. Yields dropped from 1,342 kg/ha to 936 kg/ha when farmers became partially equipped with AT and began to grow maize as a field crop. Yields trended up from this point to 1,759 kg/ha as the level of AT mechanization increased to five traction units.

Higher yields do not appear to be closely associated with increased AT mechanization for farms where cotton is not grown (Naing 1991, pp.34-41). Especially notable is that only 39 percent of the area in cereals receives chemical fertilizer of any type, only 14 percent receives cotton complex and only 16 percent urea (Naing 1992, p.7). In 1987 and 1988 while about 65 percent of the cotton farmers used cotton complex and urea on maize, only four percent used mineral fertilizer of any type on millet and sorghum (CMDT 1989, p.46). Given the above, it is reasonable to assume that the increased cereal yields experienced by more mechanized farmers were due in large part to the residual fertility from the cotton crop and improved cultural practices due to AT.

With lower fertility, as on farms where cotton is not grown, AT has little impact on yields. That coarse grain crops such as rice, fonio, and peanuts do not conform to these trends, suggests that the differences above are related to the application of the AT technology and intensified cotton culture methods to field crop production (Exhibit 2).

3.3 Mechanization of Coarse Grain Production

This information also suggests that as commercial cotton culture and AT technology are introduced, farmers move from being marginally self sufficient or deficient in grain production to being exporters. This has been reported or is implicit in several studies. When coarse grain production (millet, sorghum, and maize) is pooled and considered on an on-farm per capita basis this trend is clear. The cotton-growing hand-tillage farms are producing 209 kg of coarse grains per person per year, well below the 225 kg per person per year considered the minimum subsistence level. This coarse grain deficit situation of traditional farmers is consistent with results from other regions, and is apparently more severe for those hand-tillage farmers who do not grow cotton (Institut d'Economie Rurale 1991, p.188). As animal traction and cotton production are intensified, per capita coarse grain production increases dramatically with AT-equipped farms growing 300 to more than 500 kg per person per year, well in excess of their subsistence needs. This means that these farmers can market 30 percent to 50 percent of their cereal production (Exhibit 13).

3.4 Labor Impacts

These efficiencies and improvements in productivity resulting from mechanization and chemical inputs frequently shift labor use away from the most arduous tasks (Exhibits 7 and 8). The manual labor that is saved is often reabsorbed in harvesting and processing the larger crop yields from these improved systems so that the total labor requirements per unit area for producing the crop are similar. While the author is not aware of data available to support this conclusion for cotton culture in Mali, anecdotal evidence suggests that this is the case. Interestingly, a Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) study graphically presented information (without substantiating data) indicating that, in northern Côte d'Ivoire, moving from manual cropping without cotton, to manual with cotton, to AT, and finally to small tractors increased the number of days worked per farm family worker from 125 to 290. At the same time, they also increased the area they cultivated from 0.6 ha to nearly 2.5 ha, as well as the cotton they produced from less than 100 kg/yr to 1,400 kg/yr (Exhibits 14 and 15). This study also shows that off-farm employment becomes more important as mechanization and commercial cotton production increases (Exhibit 16). This observation is consistent with data from the CMDT as well (Exhibit 17) (Naing 1992, Annex IV).

Improved mechanical technologies over the last 15 years have affected primary tillage, weed control, pest control, transportation, primary processing, and secondary processing. With further improvements in and increased availability of the animal-traction plow, farmers can now carry out primary tillage and weed control. The use of animal traction-based secondary tillage

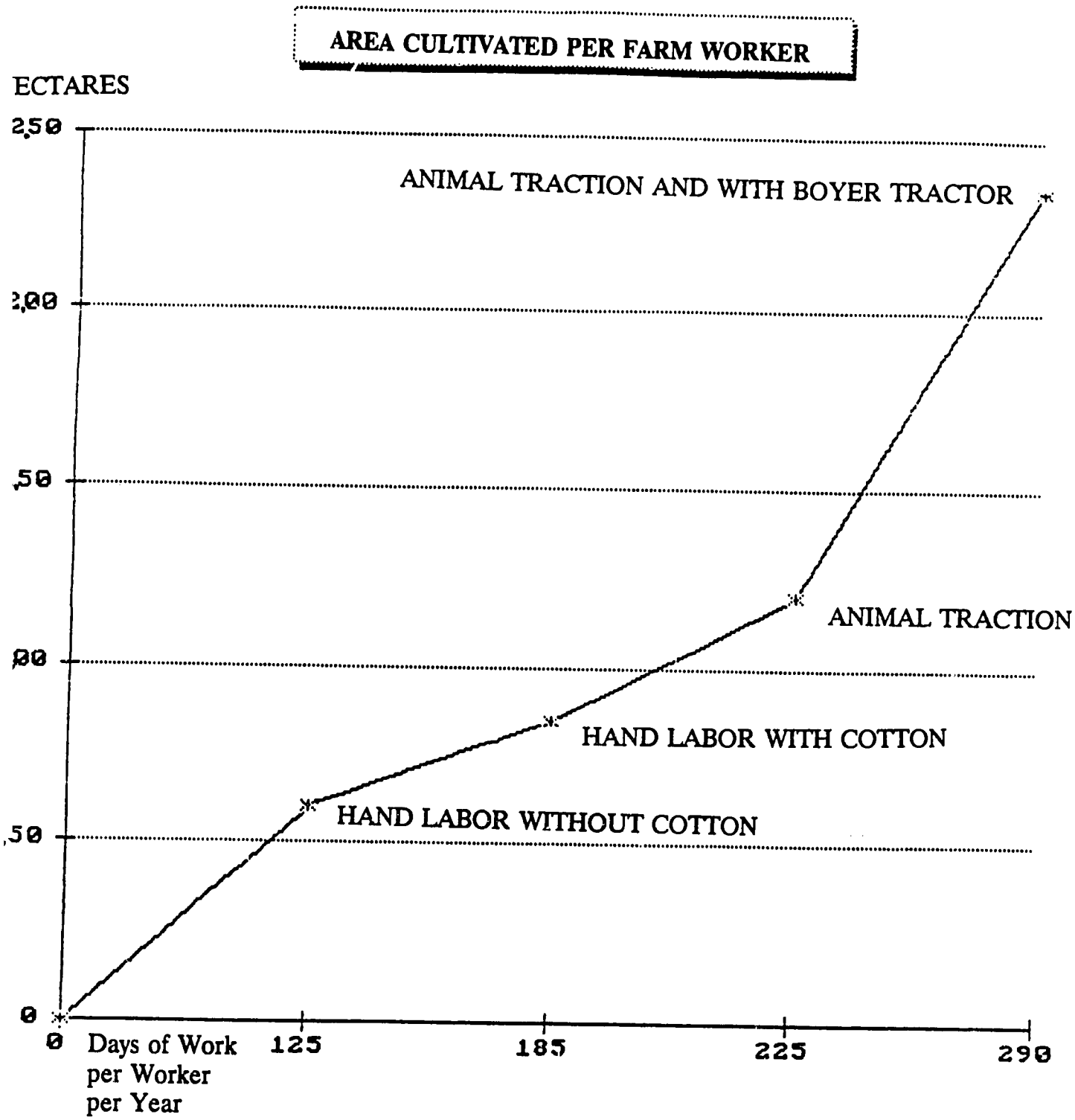
EXHIBIT 13

FARM MECHANIZATION AND COARSE CEREAL PRODUCTION CHARACTERISTICS OF MALI'S COTTON GROWERS, 1989

Level of Equipment	Area in Millet ha	Millet Yields kg/ha	Millet Production tons	Area in Sorghum ha	Sorghum Yields kg/ha	Sorghum Production tons	Area in Maize ha	Maize Yields kg/ha	Maize Production tons	Total Coarse Cereal Production (tons)	Population	Per Capata Coarse Cereal Production
Hand Tillage	22,000	544	11,968	22,453	775	17,401	5,803	1,342	7,788	37,157	177,900	209
AT - Partial	31,400	681	21,383	36,041	713	25,697	8,074	936	7,557	54,638	186,600	293
AT - 1 unit	106,200	928	98,554	107,823	877	94,561	37,250	1,380	51,405	244,519	660,800	370
AT - 2 units	74,000	911	67,414	88,892	940	83,558	36,000	1,447	52,092	203,064	521,100	390
AT - 3 units	20,000	1,243	24,860	30,613	1,155	35,358	8,688	1,601	13,909	74,128	144,300	514
AT - 4 units	6,470	1,310	8,476	12,908	1,119	14,444	3,541	1,579	5,591	28,511	70,600	404
AT - 5 units	4,120	1,414	5,826	5,908	1,134	6,700	3,751	1,714	6,429	18,955	45,000	421
Motorized	1,080	1,150	1,242	1,092	1,155	1,261	1,458	1,485	2,165	4,668	14,400	324
Total/Average	265,270	904	239,722	305,730	913	278,981	104,565	1,405	146,937	665,640	1,820,700	356
Total Best Equipped 25%	105,670		107,817	139,413		141,321	53,438		80,187	329,326	795,400	
Total AT Equipped	211,870		206,371	247,236		235,882	90,688		131,592	573,845	1,456,200	
% of Total Best 25%	40%		45%	46%		51%	51%		55%	49%	44%	
% of Total AT Equipped	80%		86%	81%		85%	87%		90%	86%	80%	

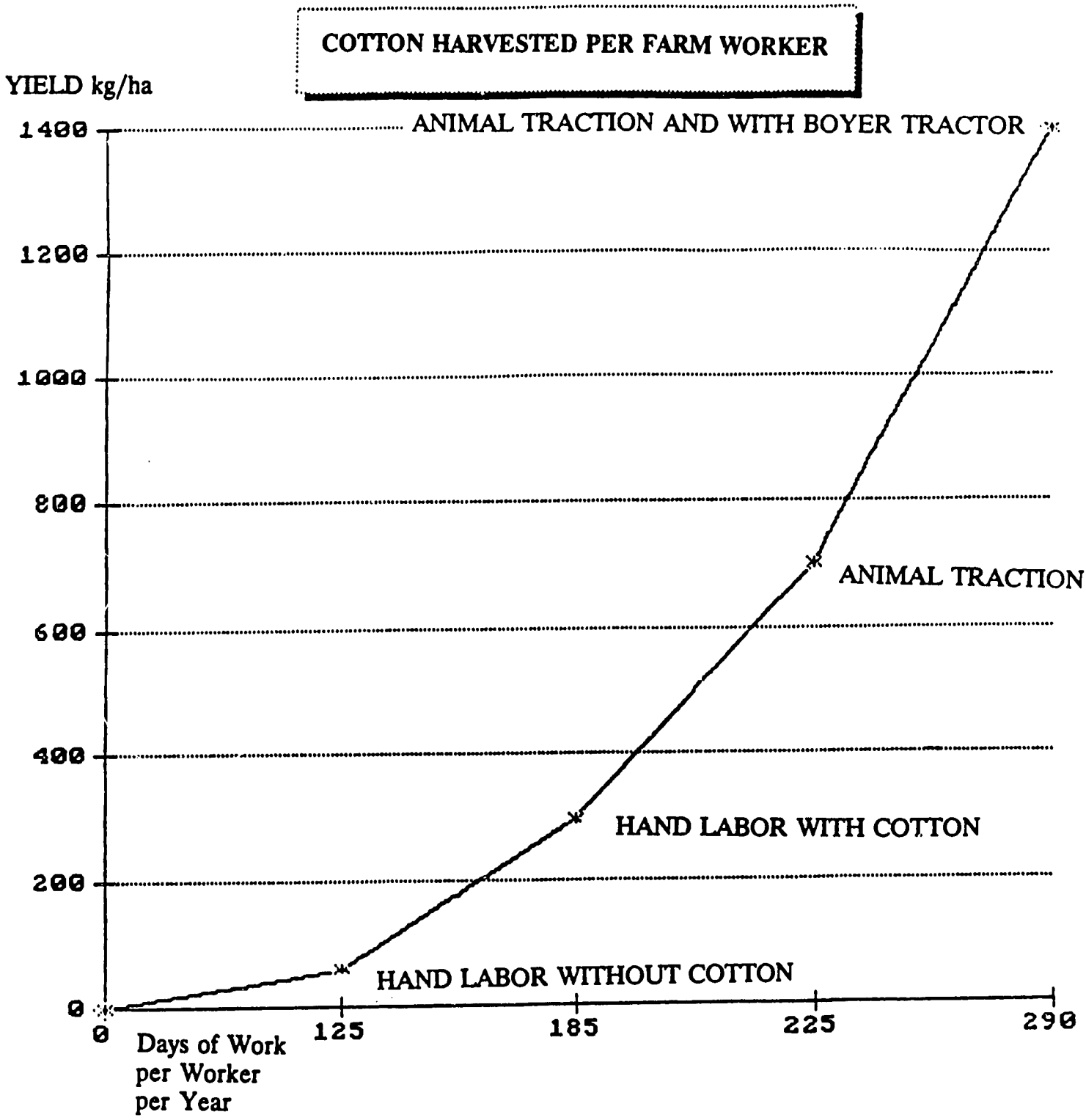
Adapted from: 1. Niang, M., "Resultats de l'Enquete Agricole Permanent: Analyse du Comportement des Exploitations: Generalities, Campagne 1989/90"
2. Niang, M., Personal Communication

EXHIBIT 14



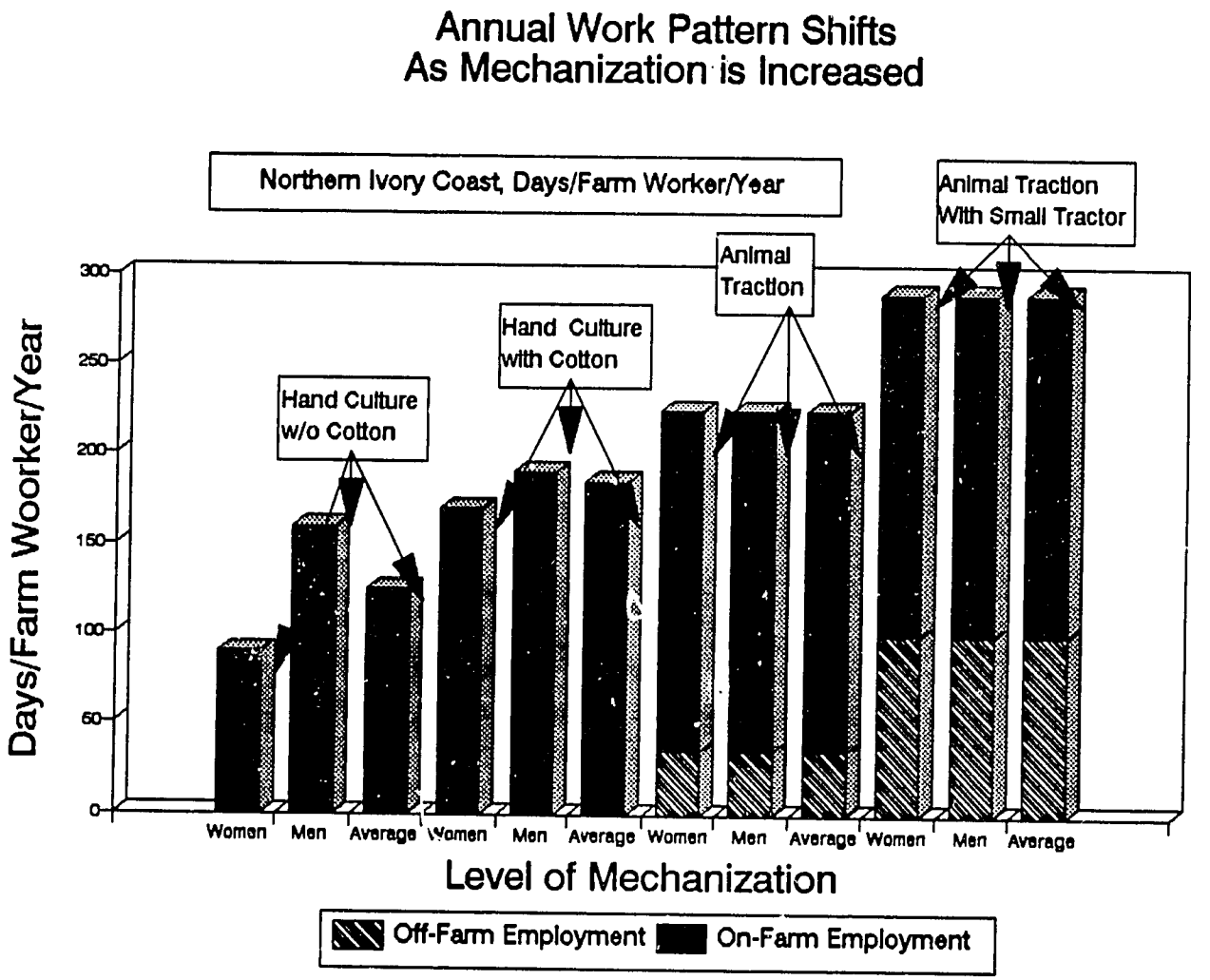
ADAPTED FROM: Bigot, Y. (IRAT), "Mechanisation Agricole et Dynamique des Systemes Agraires en Zone Soudanienne Senoufu: Quelques Aspects Generaux."

EXHIBIT 15



ADAPTED FROM: Bigot, Y. (IRAT), "Mechanisation Agricole et Dynamique des Systemes Agraires en Zone Soudanienne Senoufu: Quelques Aspects Generaux."

EXHIBIT 16



ADAPTED FROM: Bigot, Y. (IRAT), "Mechanisation Agricole et Dynamique des Systemes Agraires en Zone Soudanienne Seuoufu: Quelques Aspects Generaux."

EXHIBIT 17

Proportion of Farms Practicing New Activities Following the Introduction of AT

Agricultural		Non-Agricultural	
Male	% of Farms	**Male**	% of Farms
Mechanized Crop Management		Carpentry	3
Plowing	100	Blacksmith	2
Seeding	45	Masonry	10
Scarafication	30	Weaving	4
Weeding	55	Tailor	3
Ridging	42	Transport	8
Manuring	35	Commerce	8
New Crops Grown		Livestock	8
Cotton	9	Trad. Med.	4
Peanuts	2	Beekeeping	2
Maize	2	Hay Harvesting	1
Kanaf	1	**Female**	
Fresh Vegetables	21	Manufacture and/or Sales	
Fruit	1	Spices	12
Rice	2	Soap	1
Sorghum	0.2	Millet/Sorghum Beer	5
Pest Control	3	Hand-Crafts	12
Female		Wild Fruit Gathering	6
Crop Management		Herding	2
Seed Selection	1	Wood Sales	13
New Crops Grown		Raising Fowl	1
Peanuts	8		
Fresh Vegetables	15		
Rice	3		
Soybeans	1		

Adapted From: Naing, M., "Impact de l'Equipement sur l'Organisation du Travial au Sein de l'Exploitation"

and weeding has also increased through the extension of the "multiculture" and other similar essential weeding tools (Exhibits 6 and 18).

Pesticide-based insect control is by nature a mechanized process. It is in this area, perhaps more than any other, that technical progress in equipment designed especially for limited-resource farmers has resulted in a more effective and user-appropriate situation. The transition from "back-pack" sprayers to the ULV sprayers has made crop protection easier, safer, more economical, and more effective for cotton farmers in Mali.

3.5 Local Fabrication Revenues

The fabrication and repair of animal-traction implements by local blacksmiths, many of whom have received help from the CMDT through the "Action Forgerone" program has played an important role in the increase of mechanization in Mali. For 1988 CMDT reported average gross revenues of $10,825 for blacksmiths within their program (Exhibit 19). About 75 percent of this revenue was directly attributable to fabricating or repairing AT farm equipment or carts. The data generated during this study identified four groups of blacksmiths -- those covered by the CMDT program, those within the CMDT zone but not within the CMDT program, blacksmiths not covered by a program and outside the major cotton-growing area, and some who have businesses around the large urban markets in Bamako. Eight blacksmiths outside the major cotton-growing zone reported gross revenues averaging $886, seven independent CMDT-zone blacksmiths reported gross revenues of $4,148, and five blacksmiths within the CMDT program reported gross revenues of $13,363 and net revenues (income minus costs including capital and labor) of $2,312.

Blacksmiths from the large Bamako markets did not divulge their earnings but from the appearance of their enterprises, earnings seemed considerable with gross revenues exceeding the CMDT blacksmiths. Interestingly the urban-market blacksmiths sold most of their production to traders who took it to the rural markets for resale. It is assumed that a substantial part of their market is also linked to cotton producers.

Clearly cotton farmers are providing a substantial revenue source for the blacksmiths who serve them. While the revenues of the independent blacksmiths (within the cotton zone but not within CMDT) were below that of the CMDT group, they still had relatively prosperous enterprises. Extension and credit support from the CMDT greatly improved the blacksmiths earnings.

3.6 Transportation Efficiencies

Progress in the transportation sector has taken two forms. First, and perhaps most important, animal traction carts are being widely used by cotton farmers (Exhibit 6). This evolution has facilitated access to inputs and markets and transport of cotton to bulking points along major roadways, and promoted the use of animal manure and other locally-available fertilizer materials. Carts have also increased the cost and time-use effectiveness of animal

EXHIBIT 18

The Evolution of Agricultural Equipment Ownership

Type of Equipment	1974	1984	1990
AT-Plows	34,176	64,332	112,067
AT-Tool Bars	14,737	43,956	74,062
AT-Seeders	669	22,543	38,916
AT-Weeders	2,846	3,861	4,905
Insecticide Applicators	14,417	24,783	43,507
Herbicide Applicators	0	1,853	4,551
Carts	14,149	33,389	55,969
Harrows	718	1,437	2,429
Tractors	2	77	141

Adapted From: Naing, M., "Impact de l'Equipement sur l'Organisation du Travail au Sein de l'Exploitation"

EXHIBIT 19

CMDT Supported Blacksmith's Annual Income 1988

($U.S. @ 275 Fcfa/$)

Activity	Koutiala	Sikasso	Fana	Bougouni	San	Average
Spare Parts Mfg.	$364	$1,899	$639	$670	$3,709	$1,456
Equipment Mfg.	$4,665	$2,747	$850	$1,850	$4,152	$2,853
Gas Welding	$200	$15	$227	-	$258	$140
Electric Welding	$1,512	$1,337	$1,151	$2,120	$1,507	$1,525
Grain Milling	$539	$614	$260	$40	$628	$416
Assembling Ag. Eqp.	$1,275	$1,490	$1,743	$2,071	$2,007	$1,717
Assembling Carts	$926	$1,464	$172	$1,780	$2,135	$1,295
Repair and Fabrication	$1,036	$1,950	$722	$858	$2,679	$1,449
TOTAL	$10,515	$11,516	$5,765	$9,390	$17,075	$10,852
# of Blacksmiths	23	20	22	10	12	

Adapted From: "Raport Annuel, Campagne Agricole 1988-89 en Zone Cotonniere," C.M.D.T.

traction. Both on- and off-farm income-generating activities built around the cart are common, diversify the farmers' sources of income, and provide work opportunities in periods that would otherwise be idle. The technology was initially extended and took hold in the cotton production zones and has now become relatively widespread throughout the region. Cotton sales have financed the purchase of this tool and it would be impossible for the cotton industry in Mali to function at its current level of production and investment without the essentially ubiquitous availability of this innovation.

In addition, improvements in the major roadways in the CMDT zones as well as the use of better trucks have resulted in more economical and timely movement of inputs to farmers and the crop to the processing facilities. These developments have required substantial commitment by funding agencies for the cotton industry, such as the WB and GRM.

3.7 Primary Processing

Primary processing has improved through increased ginning capacity and storage, and provision of oil extraction facilities. These developments have increased the direct economic returns on cotton production domestically, provided secondary returns in the livestock industry, and reduced food oil imports.

Industries producing cloth from domestically-grown cotton have generated employment and increased the returns on the cotton industry as a whole, as well as provided cloth that might otherwise be more expensive or unavailable. Similar arguments could be advanced for the cloth that is produced in Côte d'Ivoire with Malian cotton.

3.8 Economic Impacts

Cotton farmers have gross and net incomes that are clearly above those of non-cotton growers both in and outside the region. Their gross revenues average $380/ha in 1988. Aggregate and individual productivity and revenues have been rising steadily since the mid-1960s (Exhibit 1). These gains are clearly linked to the adoption of improved mechanical technologies, among other reasons. The key technological innovations at the farm level were the result of research efforts focused on intensifying cotton production with limited-resource farmers.

Secondary economic benefits are also evident throughout the cotton production zone and tend to be related to the degree of adoption and intensification of cotton production. Cotton-producing farmers, villages, and the adjacent towns have a higher level of economic activity than areas where cotton is not a major crop. In the cotton-growing areas the population tends to be more prosperous, economically active, better fed, better housed, and has better access to transportation, medical, educational, and banking services. This prosperity is at least in some part due to the integrated approach adopted by the CMDT.

3.9 Environmental Impacts

There have been two principal and paradoxical impacts of the intensification of cotton production in Mali. Both are directly related to the widespread adoption of animal-traction-based crop production technologies.

The first impact is an overall improvement in the basic fertility and stability of the crop production system. Cotton and cereal production have been stable or increased over a range of rainfall years. The direct and residual effects of fertilizer are largely responsible for this tendency. The crop production system has become increasingly sedentarized because this added fertility has facilitated the long-term cultivation of the more productive areas. The shift in production technologies has greatly diminished the importance of long-term bush fallow in maintaining or improving the productivity of cultivated land.

The increased revenues from cotton production and improved mechanical efficiencies from the use of AT have permitted and motivated farmers to cultivate more land. Farmers are also moving into more sloping and marginal areas. Intensified tillage practices disturb a larger portion of the soil profile so that, in those situations where surface erosion is a problem, there is greater potential soil loss. This tendency has been widely reported and, as a result, the CMDT and their associated research and extension agencies have placed a major emphasis on dealing with soil erosion (Kleene et al. 1989, pp.1-121). A number of technologies have been elaborated and extended. The increased use of herbicides is likely to improve the quality and range of erosion control approaches. Higher yields per unit area also give farmers the option of focusing their efforts on the highest productivity areas, which also tend to be the most agronomically stable over time.

4. RESEARCH SUPPORT FOR MECHANICAL TECHNOLOGIES

4.1 Mechanical Technologies

A large number of mechanical technologies are applied to cotton production, processing and marketing in Mali. Most technologies, such as trucks, ginning equipment, and industrial looms, have been developed elsewhere and are imported and used effectively without local testing and adaptation. It is at the level of the limited-resource farmer, however, that several key technologies developed specifically for this and similar situations are found. These technologies include all of the AT equipment currently in use and ULV pest control package.

In both the AT and the ULV technology areas, the specific machinery and other products were developed to promote cotton production by poor farmers with a very limited level of traditional technological sophistication. The objective of enhancing cotton production has its roots well into the colonial period. Work on AT equipment for African farmers who were principally dependant on hand labor began before World War II and received substantial support in the 1950s and 1960s from France and England, both before and after independence. Commercial interests, both parastatal and independent, African and European, participated. R&D efforts were generally subsidized by European governments and also benefitted from direct and indirect revenues from cotton production. Equipment development and testing took place in both Africa and Europe.

The ULV technological package is an example of a highly sophisticated group of products that were developed specifically to enable limited-resource farmers to safely and efficiently apply crop production technologies to cotton and other commercial crops. From the outset, the R&D effort was a collaborative one involving large agricultural chemical producers, national research structures in England and France, national research structures in Mali and other cotton producing countries in Africa, and the cotton processing companies such as the CMDT.

4.2 Mechanical Technology Products in Current Use and Their Sources

The processes and relationships described above are ongoing. Current examples include the development of small tractors, further improvements in the ULV application equipment, and electrostatically charged pesticide products, among others. A partial listing of the technologies currently employed and their source of origin follows:

Input delivery and post-harvest transportation:

Trucks - Principally Renault, Mercedes and Saviem

Train - Detroit Diesel and France

AT Carts - Local manufacture, blacksmiths

Tillage

AT equipment - Local manufacture, blacksmiths

Boyer tractor - Local assembly, components from a variety of sources in Europe.

Massey Ferguson - England

Crop Management

AT equipment - Local manufacture, blacksmiths

ULV equipment - European origin principally through Ciba-Geigy and Rone-Poulenc

Primary Processing

Ginning and fiber processing - Principally U.S. origin.

Storage - unknown origin prefabricated buildings

Oil Extraction - German and other diverse European origins.

Secondary Processing

Spinning - Italy, Germany, France and other diverse European origins as well as the PRC.

Dying - Italy, Germany, France and other diverse European origins as well as the PRC.

Weaving - Italy, Germany, France and other diverse European origins as well as the PRC.

4.3 The Research and Development Process

4.3.1 Public Institutions

In the mechanization of cotton production in Mali, two local research organizations (DMA and SRCFJ) have played the principal roles in technology development. The DMA has tested and adapted animal traction equipment from throughout West Africa and elsewhere. They

have received direct and indirect support from French, Dutch, Canadian and other donor groups. They have worked in close collaboration with CEEMAT in France. SRCFJ has worked with the IRCT and CEEMAT to test the ULV sprayer technology under local conditions. Both of these organizations are a part of the Institut d'Économie Rurale (IER), the umbrella organization for agricultural research in Mali. The IER is a part of the Ministry of Agriculture.

A number of local research groups have studied the impact of mechanization on cotton growing from a production (Farming Systems) point of view. These include both the Dutch, United States Agency for International Development (USAID) and Canadian-funded DRSPR in southern Mali and the Cellule d'Évaluation within the CMDT.

4.3.2 Private Organizations

Private organizations such as Ciba-Geigy and Rhone-Poulenc have supported and participated in research on the ULV insecticide sprayer technology. Their roles have been secondary and supportive of the efforts of the national organizations.

4.3.3 Types of Research

Three principal types of research--public sector international, private sector international, and national--have occurred in the mechanization of cotton production in Mali. Research to improve yields and production has been carried out internationally while technology testing and adaptation have taken place at the national level.

Public sector international research has been carried out in governmental research facilities in Europe (in France through CEEMAT, in Great Britain through the NIAE, and in Holland through Royal Tropical Institute (KIT) and the University of Wageningen, among others). These institutes are responsible for the initial development of intermediate-level mechanical technologies for limited-resource cotton farmers in Africa. These developments include improved AT equipment, the ULV and related pesticide application technologies, and the small tractors that are currently being disseminated.

Product manufacturers have frequently collaborated with or supported the work of the above organizations. These manufacturers include ICI, Ciba-Geigy, Rone-Poulenc, and equipment manufacturers such as Mouzon and Bouyer in France, Rumptstad in Holland, and others in the U.K.

Finally the promising technologies have been tested and extended in Mali by a combination of the CMDT and the national research services including SRCFJ, Section de Recherche sur les Cultures Vivrieres et Oleagineuses (SRCVO), and DMA, all subsections of the IER and Ministry of Agriculture. This process has been characterized by a rather long use and adaptation pattern which is perhaps best exemplified by the current evolution of the intermediate technology Bouyer tractor. This tractor has gone through a long series of iterative changes over the 20 or more years since its first introduction in southeastern Africa and in the

14 years since the first introduction of prototype models in Mali. The manufacture, widespread testing, and modification pattern over a long period of time has been characteristic of the development of all of the mechanical technologies used in cotton production, including the pesticide application equipment. This process involves dialogue and participation among the European research and commercial organizations, and the national research and other cotton production support agencies throughout Mali.

Research at the national level also includes "Farming Systems" research activities. These programs monitor the impact of the introduction of AT technologies both within and outside the cotton growing areas.

4.3.4 Joint Conduct and Financing of Research

The CMDT, with support from the CFDT, has extended the entire cotton-production technology package to farmers in Mali. Technical support is frequently provided by the producers of the inputs on both a subsidized and unsubsidized basis. This extension effort is funded from cotton revenues and by direct and indirect support from the multinational input producers and the donor community, both on a bilateral basis and through the WB.

The CFDT, a French parastatal, and the IRCT, the French cotton research organization, work closely with equipment manufacturers and other input suppliers interested in developing and extending mechanical technologies to cotton producers in Africa. These collaborative efforts are frequently subsidized by the French government. In the case of the ULV technology there were important investments made by the multinational pesticide producers who needed this technology to get their products to limited-resource cotton producers in Africa. The ULV technology and pesticide formulations were developed with inputs from CEEMAT, NIAE, Ciba-Geigy, Rone-Poulenc, ICI, CFDT, CMDT, and others in the research and development, petrochemical, and cotton production industries.

Adaptive research and product testing were supported directly and indirectly through the CMDT/CFDT, and by the multinational input suppliers at the national level through the local research organizations. Frequently, the CFDT, bilateral donors, and WB directly or indirectly subsidize these activities.

The "Tropical/Mali" (TM) plow is one of the most successful of the pieces of equipment that were jointly developed by international research organizations and private companies. Research organizations in England (NIAE), France (CEEMAT), Holland (Wageningen - Tillage Laboratory), and West Africa (ISRA-Bombey), (DMA-Mali); private companies such as Rumptstad in Holland and Muzon in France; and several parastatal AT manufacturing concerns in West Africa have contributed to the development and improvement of the AT equipment so widely used in the cotton producing areas throughout the region. More than 80 percent of the farmers (in 90 percent of the area cultivated) in the cotton growing areas in Mali have this piece of machinery which was developed and first extended to the farmers in the region in the late 1950s and early 1960s. Fifty percent of the farm units that do not have

AT equipment cultivate less than 4 ha while those lacking AT equipment with more than 7 ha represent only 17 percent of the non-equipped farms (Naing 1991, p.8).

4.3.5 Governmental Research

Research pertaining to cotton production is carried out in three agencies--the SRCFJ, SRCVO, and DMA--in addition to research/extension efforts within the CMDT. The impetus and direction for this work comes principally from the CMDT. All of these research organizations are a part of the Ministry of Agriculture. The SRCFJ, SRCVO, and DMA are a part of the IER, the organization that oversees most research within the Ministry of Agriculture.

In addition to the institutional research activities within the IER and CMDT, and the extension programs for AT, small tractors and pesticide application equipment have been included in an inherent research component that has been critical to the progress of refining these technologies. The pilot farmers who first work with these technologies are followed very closely. Their problems and attitudes are noted, and modifications in the design, manufacture, extension, and financing procedures are incorporated based on these inputs. During their initial introduction, important changes were made in the technology and delivery systems for the animal traction equipment, the TM plow, the ULV spraying equipment, and the Broyer tractor.

5. ECONOMIC, BUSINESS, AND REGULATORY ENVIRONMENT

This chapter describes the influence of the legal structure on the participation of enterprises in the development and utilization of mechanical technologies in the production and processing of cotton in Mali.

Mali has been involved in a "structural adjustment program" since 1982. In collaboration with the WB and the IMF, the GRM is seeking to reform the size, structure, and involvement of the public sector. As a result of this process, the legislation defining the operating environment has created a business climate conducive to enterprises enlarging their scope and volume of activity and clarifying their relationships with the State.

This structural reform effort has dealt with all areas of socioeconomic activity: macroeconomics, the legal structure, publicly-owned enterprises, agriculture, and education. Thus, during all ten years of reform, the program has progressed satisfactorily except during the last six months of 1986. As a result, those responsible for the program within the IMF and WB rate the program as successful.

5.1 The Pertinent Legal Areas

The laws and regulations which govern the relationships between the state and private businesses in Mali and, in a general way, between the state and third parties are grouped within a certain number of codes of which the most pertinent are:

1. Investment code: Law 91-048/AN RM of 26 February 1991 and its application decree no. 91/079 P RM.

2. Commercial law:

- Law 86-13 AN-RM of 21 March 1986 relating to:

  - Commerce (commercial transactions, businessmen, craftsmen, and the regulations governing commercial professions and licensing)

  - Bankruptcy, judicial regulations, and liquidation of assets

  - The forms of business associations (private, public, mixed, economic interest groups)

  - Commercial bills and transferable securities (stocks and shares)

- Commercial contracts and sales - different types of contracts and specific contracts: shipping contracts, deposits and securities, leases, and insurance

- Law 86-90 AN-RM of 12 September 1986 concerning the general rules relating to prices and the penalties ("repression") for violations of the economic laws

- Decree 89-194/PRM concerning foreign trade

- Law 86-14/AN-RM of 21 March 1986 concerning the general statutes of commercial subsidiaries

3. Customs code: import duties

4. General code of taxes:

- General taxes on income

- Tax assessment on patents and licenses

- Standard contributions made by employers

- Taxes on automobiles

- Taxes on mainmorte property

- Value added taxes for transactions and service (TVA) and taxes on the income for services

5. Laws and regulations governing foreign trade and monetary exchange in Mali (exchange regulations):

- Law 89-12/AN.RM of 2 February, 1989 concerning the organization of Mali's financial relationships internationally as well as the establishment of the foreign balance of payments and the relevant bylaws 3391/MFC-cab of 12 December, 1989 and ministerial instructions no. 003/MFC-cab of 27 April, 1990

- Decree 89-159/P-RM relating to certain international investments and loans with foreign countries:

  - International investments from Mali

- International investments in Mali

- International loans

- Implementation circular no. 035/MFC-cab of 15 May, 1990.

6. Patents and licenses:

Mali is a member of the African Organization of Intellectuai Property Rights and observes their regulations. This organization has its headquarters in Yaounde (Cameroon). The pertinent laws are: Law 87/18/AN-RM of 9 March, 1987, Law 84-01 of 17 March, 1984, Decree 130/PG RM of 18 March, 1987.

7. Labor Code relating to personnel management:

- Hiring and work contracts, dismissal, vacations, etc.

5.2 The Structural Adjustment Program and the Regulatory System

The structural adjustment policy has had the following effects on the regulations applied to companies[2]:

- Relationships between the state and business enterprises have been clarified.
- The marketplace has been liberalized: all commodities are traded at free-market prices except petroleum products.
- The investment code is much more favorable for investors.
- The import tariffs have been revised and simplified.
- The importation code has been simplified.
- Governmental procedures pertaining to business have been simplified and accelerated.

5.3 Commercial Code

Carrying out commercial activities or being so classified by individuals or institutions is subject to registration in the Commercial Register or the Professional Index. For foreign

[2] Largely extracted from the "industrial investors guide" that has recently been published by the DNI.

individuals or institutions (coming from a country which has not concluded an agreement establishing themselves within Mali) a licensing agreement is necessary before initiating any activity and is obtained by requesting such an agreement with the National Director of Economic Affairs.

The basic types of companies that can be formed in Mali are:

- La Société à Responsabilité Limitee (SARL) (company with limited responsibility): minimum capital to incorporate 3,500,000 Fcfa; at least 3 but not more than 50 partners; and,

- La Société Anonyme (SA): minimum of 7 partners, minimum capital to incorporate 50,000,000 Fcfa if the company is to make a public offering for investment and 12,500,000 Fcfa if not.

The SA is administered by a Board of Directors made up of between 3 and 12 members.

A draft revision of the Code is actually being negotiated between the IMF/WB and the GRM to simplify the procedures to create a company. It is expected to be approved by the end of March 1992.

5.4 General Tax Code

The revenue system in Mali has included both direct and excise taxes. During the past few years, this revenue system has been reformed considerably. The reforms in this system have already lowered the IMF (Minimum Tax Obligation) and replaced the IAS (Goods and Services Tax) by the TVA (Value-Added Tax) or TPS (Service Tax).

More reforms are under consideration. Negotiations are currently underway to:

- Replace scheduled taxes by a tax solely on the income of persons residing in Mali and the individuals with business income; and,

- Review the general tax code to identify necessary reforms during 1992.

The current tax system as it affects investment in technology development and utilization follows.

5.4.1 Direct Taxes

Direct taxes are taxes on the profits from manufacturing and commercial activities. They are levied at 15 percent for craftsmen, 25 percent for private individuals and partnerships, and 45 percent for incorporated companies.

In the case in which the company loses money, a minimum tax is levied equal to 0.75 percent of the total monetary volume of business including taxes.

Other direct taxes include:

- The contribution to trading dues. This tax is composed of a fixed fee (a function of the kind, the importance of the commercial activity of the company, and the site where the company exists) and a fee which is proportional to 10 percent of the rental value;

- Tax on the revenues from property. In this category, taxes are levied on all the fixed (to the ground) assets at the rate of 20 percent of the rental value reduced from the income from the investment in the property;

- Tax on the revenue from mainmorte property. This tax is calculated based on the revenue from the property of the organization which has a function of its own and which works independently of proxy transfers occurring from within the makeup of the members. It is fixed at 20 percent of the income from the property;

- The fixed employer contribution, which is levied at 7.5 percent of total wages;

- The tax on motorized vehicles;

- Taxes on income from transferable securities that provide income to their owners; and,

- The general income tax, for all persons resident in Mali.

5.4.2 Excise Taxes

Excise taxes are applied to the volume of business generated in Mali. Excise taxes concern the following:

- The Value-added tax (TVA) for importers and producers. The reduced, normal, and surcharge levies are 10 percent, 17 percent, and 28 percent respectively; and,
- The tax on the provision of services (TPS) for which the reduced and normal levies are 7 percent and 15 percent.

5.4.3 Fees

There are also registration fees, tax stamp fees for official documents, and fees for registering titles.

5.5 The Customs Code

Merchandise that enters the custom area (all of the territory of the Republic of Mali) is subject to the registered custom tariff rates.

As they are imported, products and merchandise are subject to fees for the custom services provided, the custom fees if applicable, importation fees, and the value added tax (TVA). Entry fees are based, depending on the case, either on the value of the merchandise, on a value determined by official assessors, or on a value determined by the official tax schedule for the products in question.

Exported products and merchandise are exempt from all taxes. Reforms are underway to simplify and reduce the taxation system as it relates to supplies, equipment, and raw materials for industrial purposes.

All imported merchandise must have established a detailed declaration fixing the regulations applicable to their importation.

The government can establish by decree a minimum importation tariff rate for goods from countries that establish similar advantages for Malian goods in their country.

Reforms have dealt principally with:

- A simplification and substantial reduction of import duties;
- The elimination of all export taxes;
- The replacement of import or export licenses with certificates of the intent to import or export ("intentions d'importation, intentions d'exportation") that are issued automatically; and,
- The inspection of all merchandise intended for Mali by a monitoring service company (Société de Surveillance - SGS) prior to shipping.

5.6 Investment Code

The investment code is defined by Law No. 91-048/AN-RM of 26 February, 1991 and the Decree No. 91-079/P-RM of 4 March, 1991.

Among others, the objectives of this code are to mobilize national investment, as well as encourage external investment and investment in exporting industries, and the creation of "PME-PMI," the revival and rehabilitation of public enterprises by new investors within the scope of the national effort to privatize publicly owned enterprises. Consistent with the provisions of the new Code, expatriate investors are entitled to the same rights as national investors.

The right to transfer capital and profits is guaranteed to persons or entities who make monetary investments in Mali. In other words, expatriates, who have made investments or are employed in a Malian enterprise, have the right, within the framework of the monetary exchange system, to transfer, within the limits allocated when the initial investments were defined, their dividends, all types of returns on their investment capital, the returns from the liquidation or sale of their property, and their salaries.

To resolve differences that may arise between the foreign investor and the state, it is suggested that a commonly acceptable solution be found, or one within bilateral agreements for the protection of foreign investors.

In case a solution is not found within the above framework, the parties have recourse to arbitration consistent with the Convention of 18 March 1965 that created the International Center for the Resolution of Differences Relating to Investments between States and those coming from other States (Centre International pour le Règlement des Différends Relatifs aux Investissements entre Etats et Resortissants d'Autres Etats - CIRDI) established under the aegis of the WB and ratified by Mali January 3, 1978.

The approval of the Investment Code goes along as well with the acceptance of all the guarantees foreseen within Article 15 of the treaty establishing the Multilateral Agency for Investment Guarantees (AMGI) signed by Mali in October 1990.

The regulations that affect businesses that are covered by the Code are:

- The regulations for small- and medium-sized businesses called "Regime A" (investment less than 100 million Fcfa or 2 million FF);

- The regulations for large companies called "Regime B" (investment greater than or equal to 100 million Fcfa); and,

- The regulations for tax free zones, for new companies who produce principally for export.

These businesses have the possibility to sell 20 percent of their production on the national market with a liability for fees and taxes.

The advantages accorded to businesses are:

- Exemption from taxes on the industrial and commercial profits as well as the payment for licensing (five years for the "Regime A" and eight years for "Regime B);"

- A five year exemption for new buildings from taxes on income from the property and tax on mainmorte goods (for regimes A and B);

- The exemption above may be applied for 10 years to companies who are developing real estate; and,

- Staggering the payment of registration fees for the creation of the business and exemption from these fees if the enterprise's working capital has increased (for regimes A and B) over three years.

Companies classified within a tax free zone may benefit from a total and permanent exoneration from all fees and taxes linked to their activities.

New investors who take over and reorganize publicly-owned companies within the program to privatize state-owned enterprises may, consistent with the size of their investment, benefit from the advantages provided within "Regimes A and B."

Companies that locate within areas in Mali that are not yet sufficiently industrialized may benefit from a longer exoneration from the BIC taxes and payment of licensing fees.

A reduction of the import duties and taxes on inputs and equipment destined for manufacturing is foreseen. Exports are exempt from all duties and taxes.

The procedure for assent to the Investment Code is to register in the framework of the "Gichet Unique," located within the National Directorate of Industries. All requests for assent are addressed to this organization.

The prescribed time for a company's assent to the Investment Code is fixed at 30 days from the date the request is received.

The prescribed time for the authorization of an industrial site, without benefit of the Investment Code, is 15 working days from the date the request is received.

All requests are considered to have been approved if no response is received within the prescribed time.

It is noteworthy that the GRM and the WB have recently begun a project for the "Development of the Private Sector in Mali" that foresees among other things the restructuring

of the Mali's Chamber of Commerce and Industry so that it can play the role of a viable "Chambre Consulaire."

5.7 Labor and Social Security Code

5.7.1 The Labor Law

Law No. 26067/AN-RM of 9 August, 1962 defines the Labor Law. According to the regulations of this law, work contracts may be freely negotiated. Foreign workers cannot undertake contracts until they have received the authorization from the "Direction du Travail" (Directorate for Labor Relations).

A fixed-term work contract cannot be broken before its term because of the wishes of one of the parties unless this condition is foreseen in the contract or unless a breech of contract has occurred and is submitted to the competent legal authorities. A breech of contract that is not justified by one of the parties justifies legal recourse to claim damages for the other party.

An internal settlement is required for industrial and commercial companies that generally employ at least 20 persons and agricultural companies that generally employ at least 30 persons.

For the same work conditions, professional qualifications, and productivity, compensation should be equal for all workers regardless of their age, sex, or national origin.

In nonagricultural companies, the normal work week cannot exceed 40 hours.

The work areas given to personnel must at all times be in a proper state for the work.

Individual grievances relating to work can be submitted either to the "Inspection du Travail" (Office for Labor Relations) or directly to "Tribunal du Travail" (Labor Relations Court) with jurisdiction.

All group grievances must be submitted by the concerned parties to:

- The Labor Relations Officer with jurisdiction if the conflict is limited to the territory of a single region of the Labor Relations Office
- The Director of the Labor Relations Office if the conflict involves more than one region

The procedures referred to above also apply to foreign workers. However, international agreements can determine the particular conditions of the hiring, employment, and repatriation of this category of worker.

5.7.2 The Social Security Code (Code de Prevoyance Sociale)

The social security code applies to workers as they are defined by the Labor Law.

All companies must provide health and medical services. The portion of expenses accruing from the medical services associated with the work place are the financial responsibility of the employer who provides the service and should be spread among the workers in a manner proportional to the number of employees. All workers must have a medical exam before they are employed or at least before the end of the trial period after having been hired.

All workers must have a medical exam at least once a year. Workers under 18 years of age should be examined every 3 months. The business director is held responsible for reacting to the medical advice provided by the worker's doctor especially as is relates to work classification and posting and improving the working conditions whose supervision are the responsibility of the Labor Officer.

Rules governing compensation for and prevention of work-related accidents and illness exists for the benefit of workers in Mali. The employer must immediately (within 48 hours) register all work-related accidents or illness that are observed in the enterprise.

All employers are responsible for informing the National Institute of Social Security of all hiring and layoffs of personnel.

The level of contributions to provide protection for those injured in the work place varies according to the type of professional activity. The contributions are made by the employer to the Institut National de Prevoyance Social (INPS).

Retirement benefits are provided through contributions from both the worker and employer. The worker contributes 40 percent of the rate fixed for his or her particular category.

The Labor Courts are responsible for decisions relating to disagreements arising between the beneficiaries of the Code, the employers, and the Institute.

Companies that do not respect the preventative measures foreseen under these laws or do not follow the recommendations of the Labor Relations Officers in these matters may be prosecuted and fined.

Reforms that are under consideration include the suppression of Article 44 of the Labor Law (the right to layoff workers without informing the Labor Relations Officer, the right to recruit workers without registering them with the ONMOE, and the restructuring of the INPS after further study).

5.8 Rules Relating to Foreign Currency

Mali is a member of the West African Monetary Union ("Union Monetaire Ouest Africaine") and rigorously enforces the rules of this institution which administers the West African Franc, Fcfa.

5.9 Intellectual Property Rights

The reform process has not dealt with this area because Mali is already a member of the African Organization for Intellectual Property Rights ("Organisation Africaine de la Propriete Intellectuelle") that is headquartered at Yaounde, Cameroon. This organization is linked by agreements protecting intellectual property rights with other similar international organizations.

The local taxes to protect intellectual property rights in Mali are modest (Interministeriel decision 319/MDIT-MFC-MJCS of 28 July, 1985). Examples:

- Registration tax for the 1st year: 15,000 Fcfa
- Tax to maintain the registration: 20,000 Fcfa

5.10 Conclusion

Currently, Malian regulations are favorable to business. The ongoing liberalization as well as the structural adjustment programs will only reinforce this situation.

PART II: ISSUES AND IMPLICATIONS

6. GENERAL IMPLICATIONS OF THE MALI CASE STUDY

Several generalizations regarding the application of mechanized technology to agriculture can be drawn from the Mali case study. These are enumerated below.

- A high degree of vertical integration is often a characteristic of successful agricultural enterprises.

- Sustainable investments in infrastructure will generate returns on investment that are identifiable and manageable.

- Technology adoption that involves an investment and a reallocation of the farmer's resources must generate great enough returns to support and reward the investment and resource reallocation.

- Mechanical technologies were adopted in Mali because of synergism with other crop production inputs and intensification practices.

- Farms, as small enterprises, will increase their production and investments if there is a reasonable and stable opportunity to increase their incomes. In Mali, returns to land increased proportionally more than returns per capita due to increased labor usage by enterprises.

- Farm workers will responded to the opportunity to increase farm earnings by working more both on and off the farm.

- Small enterprises such as blacksmiths, custom pesticide supplier/applicators, village cooperatives, and farmers respond to extension and financial support effectively if market conditions are conducive to their success. Donor-initiated support to private enterprise might best be focused on these small enterprises and providing market conditions that are stable and assure reasonable returns on investment.

- International, national and business research capacity can be mobilized to effectively provide appropriate technology when there are clear cut crop and market objectives as well as reasonable potential returns on that investment. If these conditions are met, collaborative research is likely to grow.

- At a macro-level in Mali, the policy issues limiting the private sector seem to have been or are in the process of having been removed.

PART III: CONCLUSIONS AND RECOMMENDATIONS

7. CONCLUSIONS

As regards the application of mechanized technology to Malian cotton production, the case study leads to several conclusions. These are outlined below.

- The CMDT has successfully promoted cotton production in Mali.

- Mali has become a viable cotton producer on the international market.

- The infrastructure is in place to process and export a large and expanding cotton crop.

- Input supply, credit, extension, crop payments, processing, and sale of cotton are provided by the CMDT and OHV. This vertical integration seems to have contributed to the success of technology development and adoption as well as the evolution of the cotton industry in Mali.

- Cotton farmers have moved from being subsistence producers to being commercial farmers with substantial revenues from cotton and surplus coarse cereal production.

- Cotton production with high levels (for Africa) of fertilizer and pesticide inputs have driven the evolution of the production system.

- AT-based mechanized crop production has become very widely practiced within the cotton production zone.

- The combination of cash-crop cotton production and AT lead to rapid increases in yield and area cropped. Increased area has come at the expense of fallow and by moving into new lands. There is evidence that this may lead to increased erosion and a degraded agricultural resource base. Erosion control strategies have been tested and are being extended by the CMDT.

- The ULV sprayer has also been very widely accepted and is the standard method for applying crop protection products on cotton.

- It is possible that there will be a similar growth in the use of small tractors. This evolution is likely to increase the size of individual holdings but will not have much impact on yields per unit area.

- Both the productivity per worker and the total time worked by farm members has increased with cotton production and mechanization. There has been a substantial reduction in the time invested in some of the traditionally more arduous hand-labor

tasks and increases in other farm activities, so that the time invested per unit area is similar. Farm members, both male and female, take on new income-generating tasks as cotton production is intensified.

- Blacksmiths in particular have benefitted from fabricating and repairing AT equipment. Those who have received financial and technical help from the CMDT have done better than those who do not.

- The CMDT is attempting to privatize the provision of credit and some other inputs through the Village Associations and local businesses. As with the local blacksmiths, these efforts have generally been successful and appreciated by the local population.

- There were important investments in research that contributed to the successful introduction of AT and the ULV sprayer-mechanized technologies. This research was carried out by a combination of European national research programs, private sector product development research, and technology adaptation activities at the national and regional level. Funding came from a variety of sources: international, commercial, donor, and national.

- The business climate in Mali is becoming increasingly favorable to private sector development.

8. RECOMMENDATIONS

Based on the conclusions outlined above regarding application of mechanized technology to cotton production in Mali, this study makes the following recommendations:

1) Efforts to increase farm productivity should focus on crop situations where there is a clear and adequate cash market potential for the products.

2) Technical and financial support to private agribusiness sector participants should focus on farmers and those who directly provide them with products and services (blacksmiths, pesticide suppliers, ULV applicator services and distributors, village cooperatives and associations, etc.).

3) In many situations a high degree of vertical integration will be desirable.

4) Technology delivery should be based upon high quality product stewardship at the farm level by both private and public sector extension and sales operatives.

5) Provision of adequate input and crop processing/storage/transport infrastructure will be a characteristic of successful production programs.

6) Technologies should be grouped in technological packages to exploit positive interactions that may exist among them.

7) Macro-policy issues should be identified and resolved early in efforts to increase farm productivity and revenue in order to provide the proper incentives for success.

BIBLIOGRAPHY

Ba, Moussa. "Politique et Programmes de Coopération des Pays-Bas au Mali: Profile Régional du Mali-Sud," Sahel Ingenieurs-Counseils, B.P. 5449, Dakar, Senegal, MATRIX Consultants in Development Management, Korte Jansstraat 7, 3512 G.M. Utrecht, Holland.

Berckmoes, Wilfried M.L., Egbert J. Jager, Yacouba Kone. 1990. "l'Intensification Agricole au Mali-Sud, Souhait ou relaite?" Mali: Bulletin 318, Institut Royal des Tropiques - Pays Bas, Institut d'Économie Rurale (Ministère de l'Agriculture) - Mali. 1990, Institut Royal des Tropiques, Departement des Publications, Mauritskade 63, 1092 AD Amsterdam, Tel: 020 5688272.

Berthe, Abou. "Éléments de Comparison des Systèmes de Production en Zone Mali-Sud," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Mali: Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

"Bibliographie sur l'Elevage au Mali," Centres de Documentation Maliens Participant au RESADOC (Réseau) Sahelien d'Information et de Documentation Scientifiques et Techniques) CILSS/Institut du Sahel, Projet CRDI-3-P-86-0254, Document RESADOC/Mali No. 6, Centre de Coordination du RESADOC/Mali: Institut d'Économie Rurale - Division Documentation Information, Avenue Mohamed V, B.P. 258, Bamako, Mali, Tel: 22 26 06.

Bigot, Y. (IRAT). "Mécanisation Agricole et Dynamique des Systèmes Agraires en Zone Soudanienne Senoufu: Quelques Aspects Généraux," Mission Économie et Sociologie Rural, Centre de Cooperation Internationale en Recherche Agronomique pour le Développement (CIRAD).

CMDT. 1992. "Quelques Renseignements Generaux, 1989/90." Internal Document CMDT, Mali: CMDT, Direction Generale, DTDR.

CMDT. 1989. "Rapport Annuel, Campagne Agricole 1988-1989 en Zone Cotonniere," Compagnie Mallein pour le Développement des Textiles, B.P. 487, Bamako, Mali, Ministère de l'Agriculture, Republique du Mali.

CMDT. 1984. "Bilan et Perspectives de la Motorisation Intermediare au Mali," Mali: CMDT.

Coleman, Jonathan, M. Elton Thigpen. 1991. "An Econometric Model of the World Cotton and Non-Cellulosic Fibers Markets." World Bank Commodity Working Paper, Number 24, The World Bank, Washington, D.C.

DRSPR, "Resultats des Enquetes Économiques, Campagne 1989-1990," internal document DRSPR.

DRSPR/CMDT. Mali: CMDT. "Analyse des Exploitations Comme Moyen de Vulgarisation, (A l'Usage de l'Encadrement)." 1986. Internal Document.

Demba, Kebe, Baba Fomba. "Conseil de Gestion au Stade Experimental," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'comonie Rurale, Division de Recherches sur les Systemes de Production Rurale.

Diarra, Tiecouradie, Boubacar Coulibal. "L'Experimentation en Recherche- Développement - Reflexions sur Quelques Concepts Utilises au Sein de la DRSPR," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Food and Agriculture Organization of the United Nations, "FAO Production Yearbook, 1990," vol. 44, FAO Statistics Series # 102, Rome, 1991.

HUICOMA. 1992. "Rapport de Presentation du President Directeur General a la 11eme Session du Conseil d'Administration," HUICOMA, Direction General, 1992.

Hallam, G.M., "La Lutte Anit-Erosive a Fonsebougou," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Hijkoop, Jan, Piet van der Poel, Bocary Kaya, "Une Lutte de Longue Halein...Amenagements anit-erosifs et gestion de terrior, Systèmes de Production Rurale au Mali: Volume 2," Edite par: Institut d'Économie Rurale (IER), Bamako, Mali, Institut Royal des Tropiques (KIT), Amsterdam, Pays Bas, 1991.

Institut d'Économie Rurale. "Comite National de la Recherche Agronomique, 24eme Session, Bamako 22-25 Avril 1986, Rapport de la Commission Technique Specialisee des Systemes de Production Rurale (reunie du 18 au 20 Mars 1986 a Bamako)." Mali: Ministére de l'Agriculture, Institut d'Économie Rurale.

Institut d'Économie Rurale. "Comité National de la Recherche Agronomique, 25eme Session (Bamako: 26-29 Avril 1988), Rapport de la Commission Technique Spécialisee sur les Systèmes de Production Rurale (Tenu a Bamako du 15 au 17 Mars 1988)," Ministere de l'Agriculture, Institut d'Économie Rurale.

Institut d'Économie Rurale. "Commission Technique sur les Systèmes de Production Rural (Rapport de Synthese), tenue du 31 Mars au 2 Avril, 1987 a Bamako, Ministère de l'Agriculture, Institut d'Économie Rurale.

Institut d'Économie Rurale. 1992. "Commission Technique Spécialisee sur les Systèmes de Production Rurale, Resultats Campagne 1991-1992," Ministère de l'Agriculture, Institut d'Économie Rurale, Division de la Recherche sur les Systèmes de Production Rurale, Volet Sikasso.

Institut d'Économie Rurale. 1992. "Comite Technique Regional sur les Systémes de Production Rurale, Centre de Sotuba, Resultats Campagne 1991-92." Ministère de l'Agriculture de l'Elevage et des Eaux et Forets, Institut d'Economie Rurale, Departement de la Recherche sur les Systèmes de Production Rurale, volet O.H.V., Bamako, 4-7 Mars 1992.

Institut d'Économie Rurale. 1992. "Commission Technique sur les Systèmes de Production Rurale, Synthese des Resultats de la Compagne 1991/92, DRSPR/Sikasso," Ministère de l'Agriculture de l'Elevage et de l'Environnement, Institut d'Economie Rurale, Department de Recherche sur les Systèmes de Production Rurale, Sikasso.

Institut d'Économie Rurale. 1991. "Commission Technique Spécialisee sur les Systèmes de Production Rurale, Resultats Campagne 1990-1991," Ministère de l'Agriculture, Division de la Recherche sur les Systèmes de Production Rurale, Volet O.H.V., Bamako, 18-20 Avril 1991.

Institut d'Économie Rurale. 1985. "Experience de la DRSPR en Matière de Culture Attelee en Zone Mali-Sud," Ministère de l'Agriculture, Institut d'Économie Rurale, Division de Recherches sur les Systèmes de Production Rurale, 1985.

International Cotton Advisory Committee, "Cotton: World Statistics," vol. 43, no. 2 (part II) (USPS 133-960), April, 1990.

Kebe, Demba, Baba Fomba, "Conseil de Gestion au Stade Experimental, Seminaire IER -CRDI, Sisasso 9-15, Septembre 1984," Ministère de l'Agriculture, Institut d'Économie Rurale, Sivision de Recherches sur les Systèmes de Production Rurale, 1984.

Kleene, Paul. 1986. "l'Agriculture en Zone Mali-Sud: Pasee Recent et Perspectives d'Avenir, Texte d'une conference tenue le 5 Decembre 1986 a la DRSPR a Sikasso (Mali)," Institut Royal des Regions Tropicales (IRRT/KIT), Pays-Bas, Ministère de l'Agriculture, Institut d'Économie Rurale, Division de Recherches sur les Systèmes de Production Rurale, Decembre 1986.

Kleene, Paul, "Apercu du Programme de Recherches du Volet Fonsebougou de la DRSPR," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Kleene, Paul, Bakary Sanogo, Gerben Vierstra. 1989. "A Partir de Fonsebougou...Presentation, objectifs et methodologie du 'Volet Fonesbougou' (1977-1987)," Systèmes de Production Rurale au Mali: Volume 1, Institut d'Economie Rurale, Bamako, Mali & Institut Royal des Tropiques, Amsterdam, Pays-Bas eds., Division de Recherches sur les Systemes de Production Rurale (DRSPR), B.P. 9030, Bamako, Mali, Tel. (223) 22 34 45, Institut Royal des Tropiques (KIT), Programme de Développement Rural, Mauriskade 63, 1092 AD Amsterdam, Pays-Bas. 1988.

Kleene, Paul, Yacouba Kone. 1988. "Lee Conseil de Gestion Comme Methode de Recherche - Développement: L'Experience du Mali," Document presente au Farming Systeme Research/Extension Symposium, University d'Arkansas, Fayetteville, AR (USA), 9-12 Octobre, 1988,Ministere de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systemes de Production Rurale.

Lele, Uma J., Nicolas van de Walle, Mathurin Gbetibouo. 1989. "Cotton in Africa, An Analysis of Differences in Performance," Managing Agricultural Development in Africa, Paper 7, The World Bank Washington D.C.

Mungroop, Ruben. 1987. "Resultats sur les Realisations en Culture Attelee dans les Villages de Pre-Vulgarisation CMDT de Sikasso et Koutiala," Ministere de l'Agriculture, Institut d'Economie Rurale, Division de Recherches sur les Systemes de Production Rurale, Volet Fonsebougou.

Naing, M. 1991. "Resultats de l'Enquete Agricole Permanente: Analyse du Comportement des Exploitations: Generalities, Campagne 1989/90," C.M.D.T., Direction Generale, D.P.C.G., Suivi-Evaluation.

Naing, M. 1992. "l'Extension des Superficies: Processus et Causes, Resultats Enquete Agricole Perminant, Vol 1/90/91," C.M.D.T., Direction General, D.P.C.G., Suivi-Evaluation.

Naing, M. 1992a. "Impact de l'Equipement sur l'Organisation du Travial au Sein de l' Exploitation, Campagne 1990/91, Volet Enquetes Specifiques," C.M.D.T. Direction Generale, D.P.C.G., Cellule d'Evaluation.

Naing, M., 1992b. "Revenus Monetaires Nets des Producteurs du Cotton," C.M.D.T., Direction General, Cellule d'Evaluation, 1992b.

Naing, M. 1992c. "Techniques d'Intensification Vulgarisees et Pratiques Paysannes, Resultats Enquetes Agricoles Permanentes, Vol 2/1990-91," C.M.D.T., D.P.C.G., Suivi - Evaluation, 1992c.

Operation Haute Vallee. 1990. "Rapport Annuel Sur les Activites Du Projet (Rapport d'avancement no. 2)," Operation Haute Vallee, Projet DHV, Cellule de Suivi, Mai 1990.

Persoons, Christine. 1987. "la Mechanisation dans les Exploitations Agricoles d'Un Village du Mali Sud: Consequences Économiques et Sociales," Ecole Nationale Superieur Agronomique de Montpellier, Ecole Superierue d'Agronomie Tropical, Institut d'Elivage et de Medicine Veterinaire des Pays Tropicaux, 1987.

"Projet d'Usine de Fabrication de Materiel a Traction Animale," Dossier de Base pour Agrement, Promoteir: Birama Sidi Diallo, Ing. Civil, Paris, Mai 1987. Cabinet de Recherche et d'Études pour les Projets en Afrique, B.P. 1455 Rue Loveran Immeuble Diarrisso Bamako.

Sangare, Moulaye I, "Intensification de l'Agriculture, Système de Culture - Système d'Elevage," Seminiare Atilier IER/CRDI, 9-15 Septembre 1984, Sikasso, Ministere de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Sangare, Moulaye I., Christian Ladrette, Ruben R. Mungroop, and Abou Berthe. 1986. "Contraintes et Ameliorations de la Traction Animale en Zone Mali-Sud: l'Experience de la DRSPR." Animal Power in Farming Systems, proceedings of a seminar Freetown 19-26 Sept. 1986, Sierra Leone.

Sanogo, Bakary, Konimba Bengaly. 1984. "La Productivite du troupeau bovin a Fonsebougou, conditionnement des boefs d'attelage, protection sanitaire," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Sy, Ousmane. 1984. "Enquete Bougouni, (Une experience d'extension des resultats de Sakoro)," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systemes de Production Rurale.

Sy, Ousmane, Mahamadou Tangara, Abou Berthe. 1984. "Methodologie de la Recherche sur les Systèmes de Production Rurale au Mali-Sud, Choix des Villages - Typologie des Exploitations," Seminaire - Atelier IER - CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.

Tangara, Mahamadou 1984. "La Gention Paysanne des Terres et la Reformation Foncière en Zone Mali-Sud CMDT," Seminaire-Atilier IER-CRDI, Sikasso: 9-15 Septembre 1984, Ministère de l'Agriculture, Institut d'Écomonie Rurale, Division de Recherches sur les Systèmes de Production Rurale.