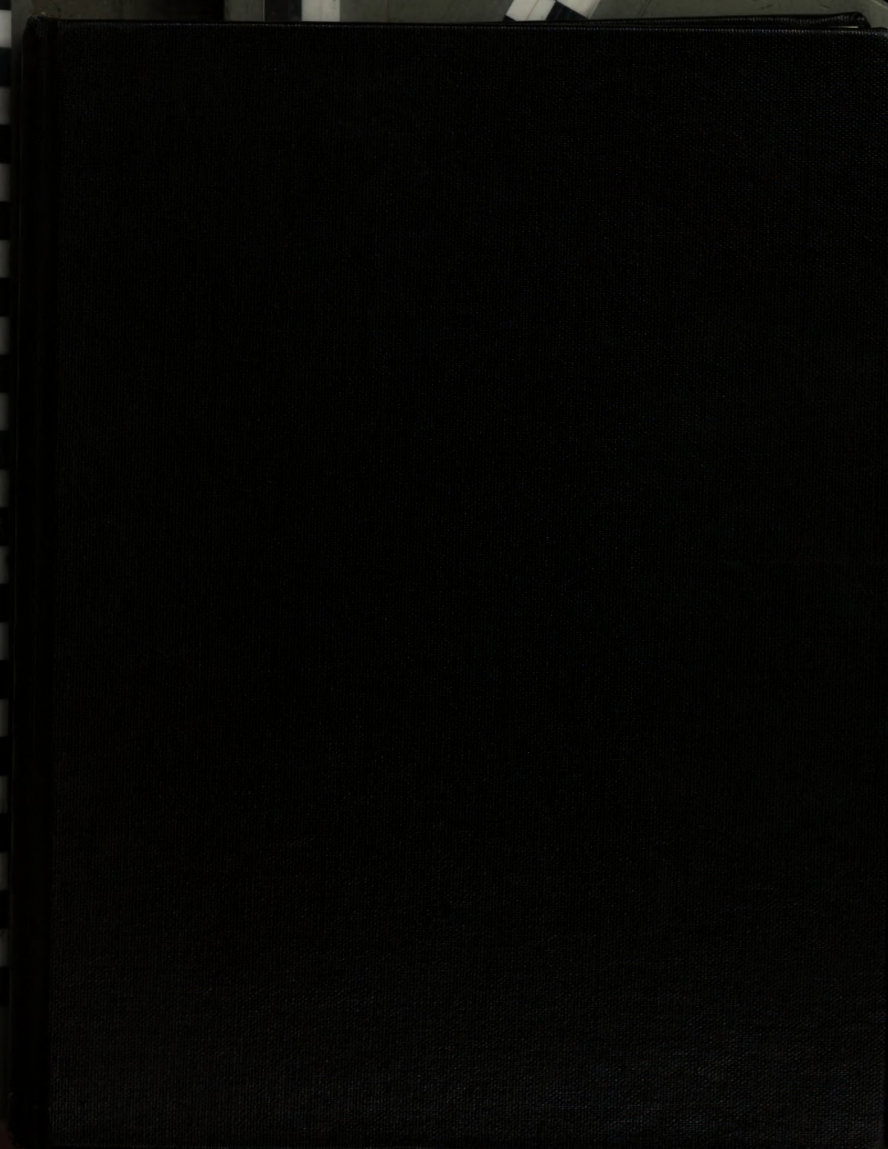






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**SMALLHOLDER CASH-CROPPING, FOOD-CROPPING AND FOOD SECURITY
IN NORTHERN MOZAMBIQUE**

By

Paul J. Strasberg

A DISSERTATION

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

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ABSTRACT

SMALLHOLDER CASH-CROPPING, FOOD-CROPPING AND FOOD SECURITY IN NORTHERN MOZAMBIQUE

by

Paul J. Strasberg

To revive the smallholder economy and reduce its trade deficit, the Government of Mozambique formed Joint Venture Companies in 1990 with three multi-national firms in the north to rehabilitate rural infrastructure and establish an input distribution and extension network. Cash-cropping schemes organized around these companies have provided smallholders with a variety of "high" and "low" input packages for cotton and in some cases also for maize. This study's motivation was to understand the effects of these schemes on household welfare and the macroeconomy and to recommend steps the GOM should take for cash-cropping to contribute to rural development. To gather information to address the study's objectives, 521 rural households across the cotton belt were surveyed at four month intervals from 1994 to 1996.

The study found that low-input cotton raised smallholder income by between 25 and 36 percent in the zones of significant JVC investment relative to non-cotton growers. High-input cotton increased smallholder income by between 97 and 138 percent. Further, Mozambique was found to have a comparative advantage in smallholder cotton.

Maize production was higher among cotton-growers than among non-cotton growers.

Moreover, cotton intensification was shown to have an important effect on maize yields as well. Given the reluctance of private sector firms to support smallholder food crop

intensification directly due to its riskiness, cotton intensification may represent a useful indirect mechanism to improve maize yields and food security.

Key factors instrumental in cotton's resurgence as an important cash crop were the revitalization of input distribution and extension networks and improvements in rural roads. The north does not currently have a comparative advantage in maize primarily due to high transport costs; however, with key investments the region could become an exporter of maize and other food crops within Southern Africa.

The study recommended the GOM promote smallholder cotton through strategies which effectively balance producer and private sector interests in pursuing vertical coordination of the subsector. Promoting farmer associations to increase smallholder bargaining power may be one important step toward this objective.

I would like to dedicate this work in two parts.

To **Julie Strasberg**, my wife. *Eem tirzu, eyn zo agada. If you will it, it is not a dream.* You have always believed in me, my dream of finishing this degree and my dream of marrying you. I love you. I hope and pray we are lucky enough to instill in our children the same commitment to learning and to making the world a better place which has guided my journey.

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List of Acronyms

ae	adult equivalent
CIF	Cost, insurance and freight
CIMMYT	Centro de Investigacao e Melhoramento de Maiz y Trigo
CIMSAN	Centro de Investigacao e Multiplicacao de Sementes de Algodao de Namialo
CIRAD	Centre International de Recherche Agronomique de Developpement
DDA	Direccao Distrital de Agricultura
DEA	Direccao de Economia Agraria
DNER	Direccao Nacional de Extensao Rural
DPA	Direccao Provincial de Agricultura
EC	Emolucao Concentrada
ED	Electro-Dyn
ERP	Economic Reform Program
FOB	Free on-board
FSP	Food Security Project
GDP	Gross Domestic Product
GOM	Government of Mozambique
ha	hectare
HH	household
IAM	Instituto de Algodao de Mocambique
INIA	Instituto Nacional de Investigacao Agricola
IPP	Import Parity Price
JVC	Joint Venture Company
GOR	Ginning Outturn Rate
lae	labor adult equivalent
LTC	Land Tenure Center
LOMACO	Lonhro-Mozambique Agro-Industrial Company
MAP/MSU	Ministerio de Agricultura e Pesca / Michigan State University
MNF	Multi-National Firm
NGO	Non-Governmental Organization
OPEN	Oilseed Press Enterprises in Nampula
PUPI	Pequena Unidade de Producao Intensiva
RCR	Resource Cost Ratio
RPM	Republica Popular de Mocambique
RRA	Rapid Rural Appraisal
SAMO	Sociedade Algodoeira de Monapo
SODAN	Sociedade de Desenvolvimento Algodoeira de Namialo
ULV	Ultra Low Volume
USAID	United States Agency for International Development

Chapter 1

Introduction

1.0 Background

Since 1992, Mozambique has made an impressive transition from war to peace and from a single party state to its first democratically elected government. Since adopting the Economic Rehabilitation Program (ERP) in 1987, it has moved from a centrally planned economy to liberalization and rapidly evolving private markets. The gains from this transition have been substantial: large numbers of displaced rural households have returned to their lands of origin, and many of those who did not leave have taken advantage of improved security to expand agricultural production and farm size; informal traders have begun to penetrate production areas previously isolated from the commercial network, providing a market and a source of cash income for farmers.

Despite this progress, perhaps a majority of households face problems distressingly similar to those that have beset them for many years. In most rural areas, smallholders depend on weak or non-existent markets for agricultural inputs, including seed, farm implements, fertilizers, insecticides and herbicides. Partly as a result, crop yields remain low and the threat of food insecurity from crop failure remains high. Rural markets for food crops, while dramatically improved over the past four years, remain relatively underdeveloped and price variability is often high. Thus, for perhaps most farmers, sales in these markets do not yet represent a reliable and stable source of cash income. The marketing system linking rural with urban areas is increasingly competitive in most areas for many

commodities, but it remains small scale and suffers from limited infrastructure and high per-unit costs. As a result, consumer prices are higher than they could otherwise be, and also quite variable.

With 80 percent of its population living in rural areas, 60 percent of gross domestic product (GDP) coming from the agricultural sector, and favorable agro-ecological conditions across much of the country, improved agricultural performance is key to improved household food security, income growth and broad-based development. Further, when considering the country's recent dependence on food aid to meet basic consumption needs, improving food availability through rapid increases in cereals production is a priority. On the other hand, an important goal of ERP is to increase exports and improve the country's balance of payments deficit. Increasing smallholder production of the country's traditional export crops - cotton, cashew nut, and tobacco - is one important element in achieving this macroeconomic goal.

In this context, policy makers and the donor community are faced with the challenge of designing a policy environment which will simultaneously contribute to:

- 1) improved food market performance for farmer sales and repurchase;
- 2) improved productivity of food and cash crops, leading to increased smallholder incomes and improved food security;
- 3) increased employment opportunities both within and outside of agriculture;
and
- 4) progress toward the macroeconomic goals of ERP.

To help inform these policy issues, the Ministry of Agriculture and Fisheries/Michigan State University Food Security Project (MAP/MSU FSP) has continued its program of socio-economic research begun with a survey of smallholders in Nampula Province in 1991. From April 1994 to February 1996, the FSP carried out data collection, analysis and outreach related to the smallholder sector in Nampula and Cabo Delgado Provinces, in cooperation with the respective Provincial Directorates of Agriculture. Information generated from this research represents the primary data source upon which this dissertation is based.

1.1 Dissertation Objectives

This study was motivated by the desire to understand the effects of cash-cropping on smallholder income and consumption levels, and thus on their food security. The debate over whether cash crops improve or threaten smallholder food security has been ongoing in many developing countries over many years and is a continuing source of controversy. This debate continues despite much evidence that cash-cropping typically has a strongly positive effect on smallholder incomes, and a smaller but still positive effect on consumption and calorie availability (von Braun, Puetz and Webb, 1989; von Braun, de Haen and Blanken, 1991; von Braun and Pandya-Lorch, 1991; Kennedy, 1989; Kennedy and Cogill, 1987; Tschirley and Weber, 1992).

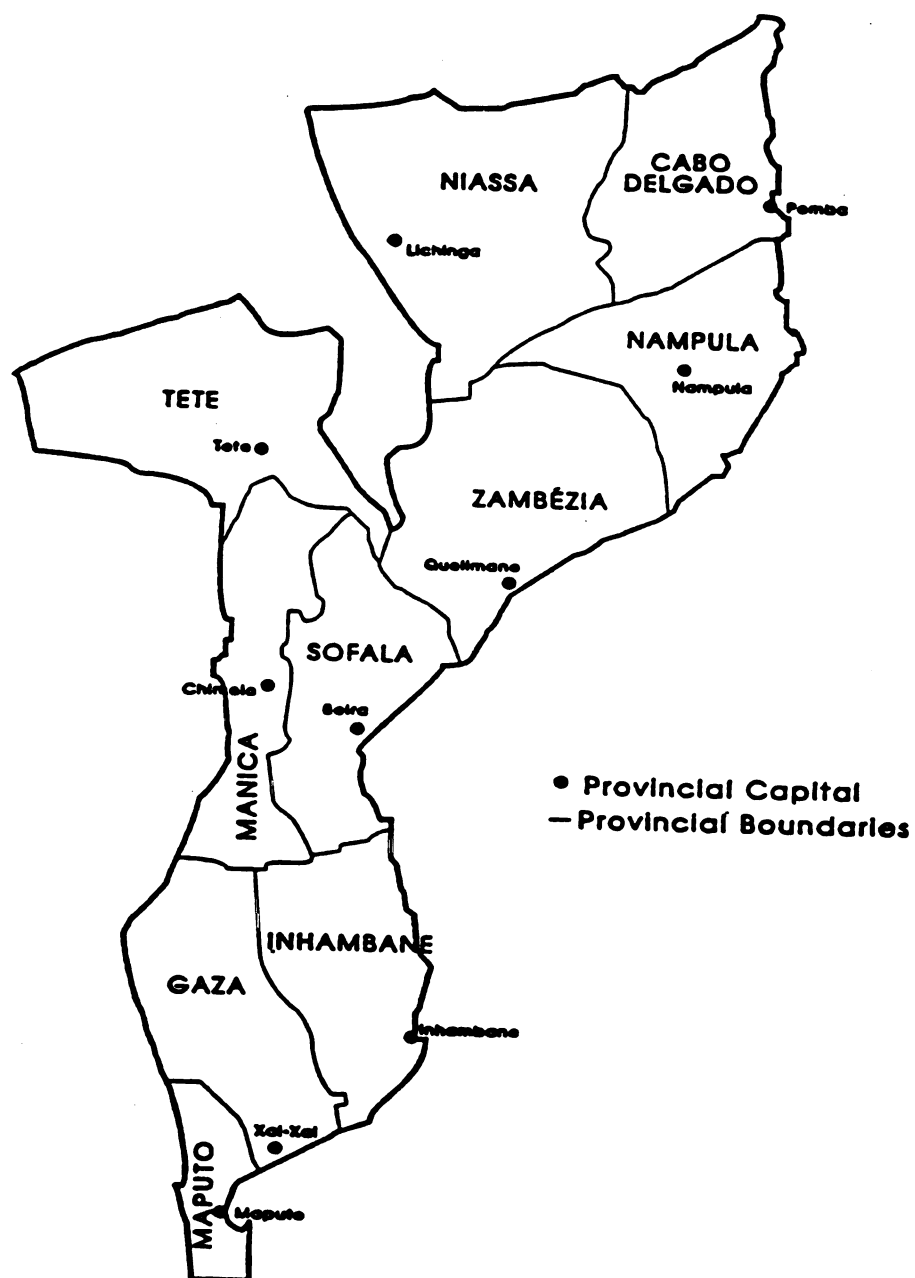
A key finding from much of the literature on smallholder cash-cropping in Sub-Saharan Africa (SSA) is that its effects on participating families depend critically on the organizational details of the scheme. In other words, how input supply, production, output

marketing and processing are organized, it is argued, are what determine, in conjunction with price policy, the impact of cash-cropping on participating smallholders. In the "cotton belt" of northern Mozambique (defined as the provinces of Cabo Delgado, Nampula and Niassa), the geographic focus of this study, cotton is produced under a wide range of technological and organizational approaches. (See Figure 1-1) Improving understanding of this diversity and its implications for smallholders is critical as the Government of Mozambique (GOM) attempts to identify an agricultural strategy that will generate sustainable increases in incomes and consumption in the smallholder sector.¹

Agricultural intensification is an issue closely related to that of cash-cropping. Given the land and labor available to a household, that household's farm income cannot be increased without combining more inputs with their land and labor in the production process. In its broadest sense, this is the meaning of intensification. A key finding from research in many SSA countries is that cash-cropping has been the mechanism through which smallholder food production can be intensified. Smallholder intensification in Mozambique is currently limited almost exclusively to the cotton belt zone of Nampula and Cabo Delgado Provinces (World Bank, 1994). In this region, modern inputs and associated credit are supplied by Joint Venture Companies (JVCs) and are used primarily on cotton, but also by some farmers on maize and other crops. This experience raises at least two key policy issues that need to be better understood by policy makers and donors. First, how can the JVC form of intensification benefit smallholders in terms of improved

¹ See Fok (1995) for a good discussion of this institutional diversity in Mozambique and the potential that it offers for developing a dynamic cotton subsector.

Figure 1-1 Map of Mozambique



food security and income levels? Second, what lessons from this experience can be applied in other areas of the country and to other cash (and food) crops?

Answering these questions requires a detailed understanding of the experience of smallholders and the JVCs in this zone since their inception in 1990. Two factors - broad institutional diversity combined with the nearly unique (in Mozambique) intensification of smallholder agricultural production in the area - were decisive in determining the choice of the cotton belt as the location for this study.

Specific objectives of this dissertation are to:

- 1) Describe the socio-economic characteristics and food security strategies of smallholders in the cotton belt, with attention focused particularly on differences based on a household's level of cash-crop involvement;
- 2) Analyze the determinants of agricultural productivity in key cash and food crops;
- 3) Compare the financial profitability of key cash and food crops from the smallholder and JVC perspectives at varying levels of intensification;
- 4) Determine the extent to which Mozambique enjoys a comparative advantage in cotton, maize and manioc based on the range of existing technologies;
- 5) Determine the extent to which participating and non-participating smallholders enjoy differential levels of well-being (as measured by household income and calorie consumption);
- 6) Determine the extent to which participation in the cash-cropping schemes, as opposed to other factors unrelated to these schemes, are responsible for these differences.
- 7) Recommend key policy changes, investments, project initiatives and other research needed to improve the contribution of cash-cropping to smallholder food security and income.

1.2 Recent FSP Research Findings in the Cotton Belt

This study grew out of a series of farm and market level studies implemented by the FSP since 1991. This section provides a brief overview of these studies.

1.2.1 Nampula Smallholder Survey

In 1991, prior to the ending of the civil war, the FSP conducted a survey of 343 smallholders in the districts of Angoche, Monapo, and Ribaué in Nampula Province. This survey provided the most detailed information then available on the effects of the war and economic reform policies on smallholders. It showed:

- 1) surprisingly large variation in land holdings within the smallholder sector, and a very close correlation between farm size (adjusted for family size) and calorie availability; this implied that smallholder land access may represent a significant constraint to increasing agricultural production and improving food security for many farm families;
- 2) a low proportion (by SSA standards) of total household income from off-farm sources throughout the surveyed districts, meaning that surveyed farmers were strongly dependent on agricultural production from their own fields for their food security;
- 3) the existence of an emerging but still fragile informal trading sector in rural areas; as a result, sales of cereals represented a small proportion of household income for most households interviewed; very few households purchased cereals and food purchases overall provided very few calories for nearly all households; and
- 4) in Monapo District, with the greatest proportion of cotton-growing households among those surveyed, cotton-growing had a neutral effect on smallholder incomes and consumption overall; however, increased smallholder integration into the cash economy as a result of cotton cultivation provided a potential focus for income growth and improved rural food security. (Tschirley and Weber, 1994)

Determining, in the context of the ERP and emerging cash-cropping schemes, an appropriate policy environment to promote balanced growth and improved rural food security was highlighted as a subject for prompt research attention.

1.2.2 Nampula Rapid Rural Appraisal, 1993

Shortly after the signing of the General Peace Accord in October 1992, the FSP continued its rural research effort by conducting a rapid rural appraisal (RRA) in two of the villages surveyed in 1991 in Monapo District of Nampula Province. The purpose of this effort was to increase understanding of the evolution of the post-war economy in northern Mozambique and to help focus a future research agenda in the region.

The RRA found that the material and security conditions of most households re-interviewed had improved since 1991. Yet all families continued to follow a food security strategy dependent on food self-sufficiency, despite relatively greater availability of food and consumer goods in local markets than in 1991. Land area cultivated had increased for many households reflecting improved general security conditions, but inequality between households remained high. Further, land conflicts were discovered between smallholders and larger farmers and agro-enterprises. A significant group of interviewed households was found to have expanded area planted to cotton, the region's traditional annual cash crop. (MAP/MSU FSP, 1994)

In the agro-ecologically similar and adjacent "cotton belt" of Cabo Delgado Province, centered around Montepuez District, smallholder agriculture was for the first time in recent history experiencing agricultural intensification. Use of modern inputs by smallholders in Nampula in the JVC era had been limited to insecticide for growing cotton. By contrast, the Montepuez JVC was promoting use of herbicide, fertilizer and tractorization to a pilot group of farmers in cotton and maize production, though the bulk of Montepuez cotton-

growers used a low-input package for cotton similar to that available through the Nampula JVCs. The uniqueness of the Montepuez JVC's approach to agricultural intensification represented an intriguing contrast to the more traditional approach followed in Nampula. The current research design was structured to understand the implications of these contrasts on smallholders, the JVCs and the broader economy.

1.3 Economic Characteristics and History of Northern Mozambique

Within the north of Mozambique (Cabo Delgado, Nampula and Niassa Provinces), agro-ecological variation from the coast inland gives rise to diversity in agricultural potential across the region. This variation is in three main zones: coastal, intermediate, and interior. Food production in the coastal areas is dominated by manioc, with rice as an important additional crop for many farmers. Moving inland, maize becomes the staple food crop for most farmers, complemented strongly by manioc and sorghum. Key cash crops in the north are cashew and cotton, and each shows a marked geographical focus. Cashew is most adapted to the coastal regions, and remains an important income source for many smallholders in the intermediate zones, but is relatively unimportant in the interior. Cotton is not found at all in the coastal zones. Its production is most intensively and widely developed in the clay soils of the intermediate zone, with significant production also taking place in selected areas of the interior.

The Portuguese colonial regime focused its smallholder cotton and cashew production strategy on the north. Following independence in 1975, this area saw production of both commodities drop dramatically. Nampula and Cabo Delgado Provinces together accounted

for 59 percent of Mozambique's colonial cotton production; seed cotton production in these two provinces decreased from 83,000 metric tons in 1973 to 19,000 metric tons by 1988. (Fok, 1995) Over the same time period, marketing of food crops plummeted by over 50% and cashew production and marketing fell by a similar proportion (Kyle, 1991). As a result, smallholder cash income, their ability to purchase basic consumer goods, and in all probability their food security, all fell sharply.

1.4 Joint Venture Companies and Agricultural Reform

In the late 1980s, as part of its dual strategy of improving smallholder food security and increasing exports, the Government signed agreements with three multi-national firms (MNFs) to rehabilitate cotton gins and associated rural infrastructure which had fallen into disrepair. With the Government as their partner, each MNF formed a joint venture company (JVC), and each JVC was granted monopsony rights over smallholder cotton production within a specific geographic area (its "area of influence").² In return for these exclusive rights to purchase smallholder cotton, the JVCs agreed to provide growers with reliable input supplies, extension advice for cotton and food crops, and timely seed cotton purchase.³ These cotton purchases were to be made at or above minimum price levels

² Chapter 2, Article 2, of the Ministry of Agriculture's Regulamento para a cultura de algodão defines smallholder as any economic entity growing under 20 hectares of seed cotton in a particular year. These producers are required by the Regulamento to sell their seed cotton to the JVC designated to operate in their geographic area. Those with larger holdings, whether within or outside of a JVC area of influence, may sell their seed cotton to whomever they choose.

³ For example, the contract between Lonhro International Limited and the GOM, "Autorização do Projecto "Lomaco Montepuez" (1990) states: "Lomaco - Montepuez, in the region of Montepuez, will develop ... rural extension services for cotton and other crop production together with family sector farmers." The "Autorização do Projecto SODAN" (1990, p.1) contains nearly identical language on this issue.

established annually by the National Commission of Salaries and Prices. These JVC contracts stipulated that the MNF would provide the capital necessary to rehabilitate the cotton gins, provide transport vehicles, and recruit technical expertise (GOM 1990a, 1990b, 1991). Further, the Government established the JVCs as the mechanism through which to distribute to smallholders the insecticide donated by the Government of Japan under the KR-2 program.⁴ (Embassy of Japan, 1994) In short, since 1990 the JVCs have represented a key component of the Government's rural development strategy in the cotton belt aimed at promoting rural food security and income growth. Tables 1-1 and 1-2 provide information on each of the three JVCs in addition to two private firms supporting smallholder cotton in Nampula Province. Figure 1-2 shows the areas of influence of each of these firms within Nampula and Cabo Delgado Provinces.⁵

1.5 Organization of the Dissertation

This dissertation is organized in eight chapters. Chapter 2 provides details of the research design, including sampling techniques, the calendar of data collection activities, and questionnaire design. Chapter 3 provides demographic data concerning the sample and provides descriptive statistics concerning the food security strategies of households in the

⁴ This program was terminated in late 1995. While in operation, it provided a grant of up to one billion Yen per year for the purchase of "fertilizer, agricultural chemicals and agricultural machinery; and services necessary for the transportation of (these) products ... to ... Mozambique." It also called for the GOM to deposit "in Mozambican currency at least an amount equivalent to two-thirds of the yen disbursement". A recent agreement under this program mentions increased food production as the primary goal of each fund. Cotton production is not mentioned. See Embassy of Japan, 1994.

⁵ The three firms listed as JVCs were considered (relatively) mature by the time data collection for this study began in 1994. Two other less capitalized firms - CINPOFIM and Eduardo Baptista Pinto - also support smallholder cotton production in adjacent areas of Nampula Province, though have not yet attained JVC status.

Table 1-1. Joint Venture Companies Supporting Smallholder Cotton Production in Nampula and Cabo Delgado Provinces, 1994/95

	Joint Venture Companies		
	LOMACO-Montepuez (Lonhro Mozambique Agro-Industrial Company)	SODAN (Sociedade de Desenvolvimento Algodocira de Namialo)	SAMO (Sociedade Algodocira de Monapo)
International Firm (where based)	Lonrho (United Kingdom)	Grupo Comercial João Ferreira dos Santos (Portugal)	Grupo Entrepósito (Portugal)
Date of Formation of Joint Venture Company	1990	1990	1990
Location of Cotton Processing Factories	Montepuez (Cabo Delgado) Nametil (Nampula)	Namialo Namapa	Monapo
Location of Smallholder Concessionary Area	Cabo Delgado districts of: Ancuabe, Balama, Montepuez, Namuno	Cabo Delgado district of: Chiure	Nampula district of: Monapo
Crops Supported	Nampula districts of: Angoche, Mogovolas, Moma Cotton, Maize, small amounts of tobacco, peanuts, and beans	Nampula districts of: Meconta, Monapo (Netia only), Muecate, Nacarua, Namapa Cotton only	Cotton only
Participating Smallholders 1994/95	16,180	57,896	7,105
Seed Cotton Production 1993/94 (MT)	6,117	11,543	2,423

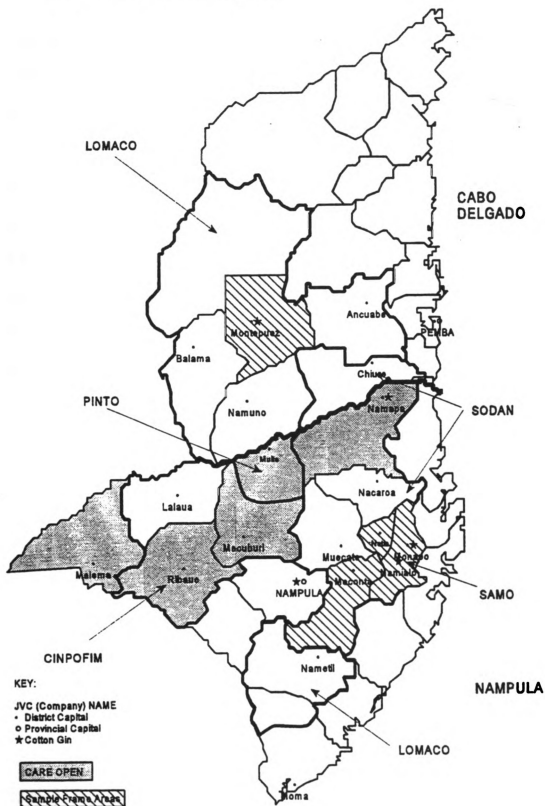
Source: Unpublished materials obtained from Mozambique Cotton Institute, Interviews with Company officials

Table 1-2. Private Firms Supporting Smallholder Cotton Production in Nampula and Cabo Delgado Provinces, 1994/95

	Private Companies	
	CINPOFIM	Eduardo Baptista Pinto
International Firm (where based)	CINPOFIM (Portugal)	Based in Mozambique
Location of Cotton Processing Factories	Ribaué	No gin
Location of Smallholder Concessionary Area	<u>Nampula</u> districts of: Lalaua, Mecuburi, Nampula, Ribaué	<u>Nampula</u> districts of: Mecuburi (Muite only)
Crops Supported	Cotton only	Cotton only
Participating Smallholders 1994/95	n.a.	n.a.
Seed Cotton Production 1993/94 (MT)	406 ¹	n.a.

¹ 1992/93

Source: Unpublished materials obtained from Mozambique Cotton Institute, Interviews with Company officials



study zone. The determinants of cotton and maize productivity are analyzed in Chapter 4 through multivariate regression models of yield of both crops. Chapter 5 analyzes the financial profitability to both smallholders and the JVCs of cotton, maize and manioc through construction of enterprise budgets. The economic analysis in Chapter 6 considers the extent to which Mozambique has (or can develop with improved yields and varieties) a comparative advantage in cotton and maize. Econometric modelling in Chapter 7 seeks to isolate the impact of a household's cash-cropping participation on income and hungry season cereal reserves while holding constant other exogenous factors. Discrete choice models which identify key factors influencing household entry into the JVC schemes are also estimated in Chapter 7. Finally, Chapter 8 summarizes the main findings of the study, proposes key policy recommendations based on lessons learned, and suggests areas of future research.

Chapter 2

Research Design

2.0 Introduction

During the 1993 Rapid Rural Appraisal (RRA), the FSP learned about the activities of JVCs and other agribusiness firms in the cotton belt. The considerable variation found in the input packages and broader smallholder-JVC relationships discussed in Chapter 1 suggested the desirability of a quasi-experimental design for research into the cash crop:food crop debate, as illustrated in Table 2-1. Interviews with smallholders, firm managers and key GOM officials suggested that the most important dimensions of this smallholder:JVC relationship were:

- 1) Intensity of use of imported chemical inputs (insecticides, herbicides, and fertilizers);
- 2) Whether cotton production by the smallholder takes place on their own dispersed fields or on larger contiguous areas (some of which may belong to the JVC) divided into small parcels and cultivated by individual smallholders. These two arrangements are termed "dispersed" and "block" production, respectively;
- 3) Degree of tractorization in "block" production;
- 4) Level and quality of extension services provided; and
- 5) Degree of JVC involvement in smallholder maize cropping; in the LOMACO scheme, smallholders grow both maize and cotton on block land with LOMACO support; the other two JVCs do not deal with smallholder food production or marketing.

As a partner in the JVCs, the GOM potentially wields considerable influence in the JVCs' design and management. To the extent that the management practices and institutional arrangements studied result in differential impacts on smallholders and the country, the

Table 2-1. Types of Rural Household Production Arrangements in *The Cotton Belt*, by JVC Area of Influence, 1994

	Joint Venture Company / District / Province		
	Lomaco Montepuez (Cabo Delgado)	SODAN Monapo ¹ / Meconta (Nampula)	SAMO Monapo ¹ (Nampula)
Smallholder Production Arrangement	(Presence of a Production Arrangement)		
<u>Cotton growers</u>			
Low-input dispersed cotton	X	X	X
Low-input block cotton		X	X
High-input block cotton and maize	X		
<u>Non-cotton growers</u>			
Low-input dispersed food crops	X	X	X

X Indicates the presence of a large number of individuals in the given cell; an empty cell indicates no households were described by this combination.

¹ Two JVCs operate in Monapo District. SODAN's area of influence includes one administrative post, Netia, while SAMO's area of influence includes the remaining three administrative posts in the District.

GOM could use these insights to improve smallholder food security and income growth. Thus, understanding lessons learned in the initial years of the JVC-smallholder relationship is important.

2.1 Research Collaboration with Other Institutions

During the conduct of fieldwork between 1994-96, the FSP realized that its policy research agenda overlapped with the interests of other institutions working in northern Mozambique. Data from these collaborative efforts is used in this dissertation. This section briefly describes research collaboration between FSP and CARE International, The World Bank, and The Land Tenure Center (LTC) of the University of Wisconsin.

2.1.1 CARE International

In October 1994, CARE International in Mozambique began its Oil Press Enterprises Project in Nampula (OPEN). In its initial phase, OPEN supported smallholder oilseed production and processing in districts of Nampula Province adjacent to the SAMO and SODAN areas of influence, the original FSP study area in Nampula. The OPEN areas exhibit key similarities and differences with respect to the original FSP study area. The similarities are in agro-ecological conditions appropriate for cotton, maize and manioc and the presence of two private firms, Cinpofim and Eduardo Baptista Pinto, supporting smallholder production.¹ The key differences are that there is much less investment by these firms in smallholder agriculture than by the JVCs, a generally lower proportion of cotton growers than in the JVC areas, and a somewhat greater importance of other cash

¹ For details about these two firms, see Table 1-2.

crops such as sesame and sunflower. OPEN was designed to promote smallholder production and local processing of these oilseed crops, thereby contributing to income growth and greater availability of edible oil in rural areas of the region.

CARE, as part of its project implementation strategy, had planned to conduct a baseline survey of smallholders in the OPEN districts, with a follow-up survey programmed two years hence to measure project impact on rural incomes and consumption patterns (CARE, 1996). FSP and CARE recognized a mutual interest in collaborating on the OPEN baseline. It would provide CARE with a level of technical assistance not typical of an NGO baseline survey, while access to this data base would allow the on-going FSP research project to develop a geographically wider understanding of smallholder cash-cropping.

Further, results from Round 1 of the FSP smallholder survey (June 1994) had shown a lower than expected proportion of non-cotton growing households in the sampled SODAN/SAMO areas. Given the study's original design, it was desirable to increase the number of non-cotton growing households in Nampula Province within the sample in later rounds for comparison purposes. Thus, including the OPEN areas conferred an additional advantage: greater insight into the income and consumption status of non-cotton growing households in areas where cotton is appropriate but where the role of the JVCs in its promotion was relatively less developed than in Montepuez and Monapo/Meconta Districts.

2.1.2 World Bank

As part of its program to support agriculture in Mozambique, the World Bank's Mozambique mission identified four priority commodities for policy reform and investment: cotton, maize, cashew, and citrus. Aware of FSP's program of research on maize and cash crops, Bank personnel approached the project in 1994 about the possibility of collaboration on the cotton and maize studies. Bank consultants worked closely with FSP personnel in the design and implementation of the research on these commodities. These two studies now form the basis for Bank initiatives in policy reform and investments for these two commodities (Coulter, 1996; Fok, 1995). Data from these two studies also provide key cost parameters for commodity processing and transportation used to compute profitability measures for the JVCs in Chapter 5 and estimates of economic efficiency in Chapter 6.

2.1.3 Land Tenure Center, University of Wisconsin

One of the most surprising findings that emerged from the 1991 FSP survey work in Nampula Province was evidence of highly unequal land holdings within the smallholder sector of sampled areas. (MAP/MSU FSP, 1992) Since that time, FSP has done selected additional analysis on the issue, and published a working paper in conjunction with the Department of Statistics of DEA/MAP (MAP/MSU FSP, 1994). Evidence from the 1993 nationally representative DEA study was compared to 1991 and 1993 FSP Nampula results. Both sets of studies strongly suggested the presence of a significant group of land-poor households in much of rural Mozambique.

The Land Tenure Center (LTC) had also been conducting research in northern Mozambique (among other locations in the country) on the issue of land access and conflict, but with a different methodological approach (case studies) and a different focus (conflicts between large agricultural enterprises and smallholders). To complement this approach, LTC decided to analyze the issue from a household perspective as well. (Unruh, 1997) As a result, FSP and LTC collaborated on the fifth and final round of smallholder data collection among the FSP sample during January and February 1996. The questionnaire developed for this round included most of the sections completed during earlier FSP rounds, and added a module on land conflict, access, and security of tenure. This data forms part of the core smallholder data base analyzed in this study.

2.2 Levels of Data Collection

The 1994/96 MAP/MSU FSP Smallholder Survey was conceptualized to collect data among the major stakeholders in the food and cotton economy of the cotton belt. The centerpiece of the data collection strategy was a survey of rural households, stratified according to whether and how the family grows cotton. A more detailed description of the stratified cluster design in the household survey is provided below. Likewise, the research design emphasized understanding the strategy and operating procedures of the JVCs with respect to smallholders within their respective areas of influence; this includes understanding the JVC extension networks, input distribution systems, and output marketing systems. In addition to the focus on the smallholder and JVC levels, the research program was also designed to gather information from other relevant actors. This included Ministry of Agriculture and Mozambique Cotton Institute officials at the

provincial and district levels, major non-governmental organization leaders operating in Nampula and Cabo Delgado (e.g. the collaboration with CARE International described above), and community leaders in villages where smallholder interviews were conducted. Table 2-2 details all levels of data collection and provides a brief description of the types of research questions to be informed at each level.

2.2.1 The Smallholder Survey

The smallholder survey is the most important primary data source for this study. This section describes the design of the sample, the interview schedule and questionnaire format.

2.2.1.1 First Round Sampling Design

The overall design for the primary sample (Montepuez and Monapo/Meconta) was a stratified random cluster sample applied to purposively selected districts within JVC areas of influence. Stratification was at both the village and household levels. The following sections describe the sampling strategy followed at both levels. Figures A1-1 to A1-3 (in Appendix 1) provide more in-depth explanation of the sampling steps taken for Round 1.

Table 2-3 shows the village sampling strategy applied before Round 1. In the first step, researchers purposively selected districts within JVC areas of influence. The 1993 RRA found that three JVCs (Lomaco-Montepuez, SODAN, and SAMO) were the most established agricultural firms in the North working with smallholders; focusing on those

Table 2-2. Data Collection Activities, Sampling Strategies and Types of Data to be Collected

Data Collection Level	Sampling Strategy	Type of Data
Smallholder	■ Stratified random cluster sampling within purposively selected districts ■ See Tables 2-4 to 2-7 for more detail	■ Family structure and history ■ Ag practices, production and sales ■ Costs of production of maize, cotton and manioc ■ Land access and use ■ Relation to JVC and history in cotton ■ Expenditures ■ Consumption ■ Non-farm income (wage and valued-added)
Village	■ Purposive sampling of traditional and official (party/government) leaders	■ Population and history of village ■ Relationship w/ JVC ■ Infrastructure ■ Land tenure ■ Degree of commercialization
Joint Venture Company	■ JVC managers and field level technicians	■ Management strategy and plans ■ Relationship with smallholders in communities studied ■ Input costs ■ Organization of cotton processing ■ Cotton utilization and export ■ Strategy to select scheme participants
Government	■ Relevant MAP /DPA / DDA officials ■ Cotton Institute managers	■ Role of smallholder agriculture in zone ■ Importance of cotton and other cash crops ■ Relationship with MNFs
Non-Governmental Organizations	■ Officials and workers knowledgeable about agriculture in the study zone	■ Current NGO activity in study zone ■ Observations on key economic problems and successes

Table 2-3. Numbers of Villages by Smallholder Production Arrangement Types and JVC Areas of Influence, 1994

Villages included in Sample Frame and Types of Cotton Systems Present	JVC Area of Influence		
	LOMACO-Montepuez	SODAN-Monapo / Meconta	SAMO-Monapo
	-- Number of Villages --		
Total Number of Villages¹	30	56	39
Villages with Low-Input Block	0	29	18
Number Selected Randomly	0	4	4
Villages with High-Input Block	5	0	0
Number Selected Randomly	4	0	0
Villages with Low-Input Dispersed Growers and Non-Growers only	25	27	21
Number Selected Randomly	4	4	4
Total Number of Villages Selected for Round 1	8	8	8

¹ Limited to those villages where at least 20 smallholders had sold cotton to the JVC during the 1992/93 cropping season.

Source: Interviews conducted by author with staff from each JVC, May 1994.

firms provided the best strategy, at that time, toward understanding the key cash-crop/food-crop relationships to food security. Two of the three JVCs targeted for study have relatively large geographic areas of influence. SODAN's area stretches over five Nampula districts and also includes one district in Cabo Delgado. LOMACO's area of influence is even larger in area, spread over four districts in Cabo Delgado and one (not contiguous with those in Cabo Delgado) in Nampula. (See Figure 1-2)

Given FSP's managerial and logistical constraints in the organization of data collection, the project limited the sample frame for SODAN to the districts of Monapo and Meconta, thus excluding the other four districts within SODAN's area of influence. Monapo and Meconta were selected because they were the areas of longest and most intensive SODAN presence throughout the six district area of influence. Further, a significant number of villages with and without smallholder cotton blocks, a key stratification criterion, were known to exist in those two districts. In the Lomaco-Montepuez area of influence, the project limited the study zone to one of the four districts (Montepuez) where the firm was operating. This district was attractive because it had a significant number of villages where each of the major cotton production systems promoted by Lomaco in the smallholder sector were present. In the case of SAMO, the area of influence is relatively small and wholly contained within Monapo District, so the entire area was included in the sample frame.

The next step at the village level was to limit the study to those villages with at least 20 cotton growers during the 1992/93 growing season.² This ensured that each surveyed village would have a sufficient number of cotton growers to interview. Finally, researchers classified villages within each district into four strata according to the types of smallholder production systems present. All villages had non-growers of cotton and dispersed growers of cotton; the stratification was thus based on whether the village also had cotton growers in low-input block (SAMO and SODAN areas) or cotton/maize growers in high-input block (LOMACO only)³. Researchers then randomly selected four villages from each village strata in each JVC's area of influence. In total, Round 1 was conducted in 24 villages.

2.2.1.2 Household Level Stratification

The household stratification strategy followed directly from that applied at the village level: households were classified with respect to cotton growing as being non-growers, low-input dispersed growers, low-input block growers, or high-input block growers. This information was gathered through a census of each selected villages conducted specifically for this purpose. Following the census, researchers randomly selected 12 households in each category present in each of the villages. Table 2-4 shows the desired number of

² This was the most recent official data available at the time of the survey design from the Nampula and Montepuez branches of the National Cotton Institute (IAM).

³ The high-input block scheme is referred to in Montepuez as *Pequena Unidade de Produção Intensiva* (PUPI), or "small unit of intensive production". In the PUPI block, many farmers have fields of 0.5 to 3.0 ha in a contiguous block, on which they plant both cotton and maize under an intensive input package.

Table 2-4. Number of Households to be Interviewed in Each Stratum, Round 1 (6/94)

<u>Household Production Category</u>	<u>JVC Area of Influence</u>			
	<u>LOMACO</u>	<u>SODAN</u>	<u>SAMO</u>	<u>Total</u>
	---- Number of households ----			
<u>Cotton Growers</u>				
Low-input dispersed	96	96	96	288
Low-input block		48	48	96
High-input block (cotton and maize)	48			48
<u>Non-Cotton Growers</u>				
Low-input dispersed food crops	96	96	96	288
Total	240	240	240	720

households to be interviewed during Round 1 in each stratum. Total sample size was intended to be 720.

Figure A1-4 (in Appendix 1) depicts the sampling strategy in the CARE-OPEN areas, which reflected CARE's need to show the impact of its OPEN project. The different sampling strategy in CARE-OPEN areas of Nampula Province (Ribaué, Namapa, and Mecuburi Districts) requires that results from these areas be presented separately from results of the primary FSP Nampula sample (Monapo and Meconta Districts).

2.2.1.3 Lessons from Round 1 and Sampling Design for Subsequent Rounds

Three insights gained from Round 1 (based on initial analysis of Round 1 data) led to selected adjustments in the sampling strategy for all succeeding rounds. First, non-growers of cotton in the SODAN and SAMO areas proved to be less numerous than indicated in the available official data used in designing the original sample. The original design called for interviewing 12 non-growers in each of the 16 SAMO and SODAN villages, for a total of 192. However, as Table 2-5 demonstrates, only 101 non-growers were actually interviewed in these villages, 52 in SODAN and 49 in SAMO areas.

Secondly, SODAN and SAMO were found to be very similar to each other (and each significantly different from LOMACO) in the following three dimensions:

- 1) **Current management and ownership structures:** The parent company of each JVC are Portuguese corporations which had strong ties to the Mozambican colonial system; many personnel in these JVCs were present in Mozambique and involved in cotton production during the colonial era. LOMACO's parent company is Lonrho, a British multinational.

Table 2-5. Households Actually Interviewed by Stratum, Round 1, June 1994

Household Production Category	JVC Area of Influence			Total
	LOMACO	SODAN	SAMO	
	---- Number of households ----			
<u>Cotton Growers</u>				
Low-input dispersed	103	88	110	301
Low-input block		75	55	130
High-input block (cotton and maize)	41			41
<u>Non-Cotton Growers</u>				
Dispersed food crops	90	52	49	191
Total	234	215	214	663

Source: 1994/96 MAP/MSU Smallholder Survey

- 2) **Input packages:** Both SAMO and SODAN provided low-input packages of cotton seed and insecticide, but provided smallholders with no other components of intensification such as herbicides or fertilizer. LOMACO provided selected smallholders with herbicides and fertilizer in addition to seed and insecticides.
- 3) **Crop orientation and rural extension networks:** SAMO and SODAN each focused exclusively on cotton, providing neither inputs nor extension advice for food or other cash crops. LOMACO worked with selected smallholders to intensify maize production in combination with cotton.⁴ LOMACO also maintained an adaptive research capacity that the other two firms did not.

Given these similarities between SAMO and SODAN, FSP grouped the areas of influence of both firms for sampling purposes. A smaller sample of villages would therefore suffice to attain the same statistical properties, so through a random process the number of villages was reduced to nine for the second through fifth rounds in the combined SODAN/SAMO areas.

Finally, project researchers learned in September 1994 that LOMACO would be working with a group of farmers, using high-input systems (including herbicide and fertilizer, but no tractorization) on dispersed fields. This would be the first time that such an input package had been extended to farmers on their own dispersed fields, and represented an excellent opportunity for an additional dimension to the study. Thus, a randomly selected sample of these households was added to the overall sample for Rounds 2 through 5.

⁴ It is likely that Lomaco chose to support smallholder maize production because it had secured contracts with donors and NGOs to deliver maize for emergency relief purposes elsewhere in the country and its perspective that maize was an attractive rotation crop with cotton. Meanwhile, SAMO and SODAN management, historically more rooted to the colonial approaches to cotton, did not consider supporting smallholder maize to be in their firms' interests.

Figures A1-5 and A1-6 (in Appendix A) summarize the lessons learned and steps taken after Round 1. Table 2-6 presents key characteristics of the final sample interviewed during rounds two through five. Figure 2-1 shows the districts that were included in the final combined FSP and CARE-OPEN sample.

2.3 What Population Does the Sample Represent?

Fundamental to interpretation of forthcoming statistical results from the smallholder data base is understanding the following:

- 1) Of what population are the sampled households statistically representative? and
- 2) Are there other areas with similar agro-ecologic and economic characteristics to which study results are generalizable, though not strictly statistically representative?

In a statistical sense, study results are representative of only those parts of each area of influence included in the sample frame.⁵ However, the agro-ecological similarity across the JVC areas of influence, and the fact that the JVCs operate in similar ways throughout these areas, both suggest that lessons learned from the study are generalizable to the non-sample areas of each area of influence.

It is important to examine again Figure 1-2 in this context: these areas of influence cover well over one-third of the land area of Nampula and Cabo Delgado provinces. Adding the Cinpofim and Pinto areas (contained within the CARE-OPEN sample), more than half

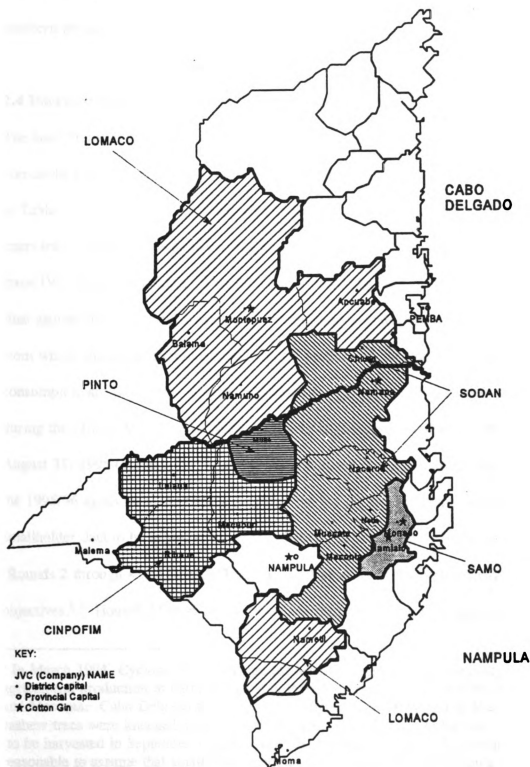
⁵ Specifically those villages with greater than 20 households growing cotton during the 1992/93 year were part of the sample frame.

Table 2-6. Final Sample Design, Rounds 2-5 (January 1995 - January 1996)

Household Production Category¹	Area of Influence / CARE Mozambique			Total
	LOMACO	SODAN /SAMO	CARE OPEN	
Number of Villages Sampled	(7)	(9)	(5)	(21)
	----- Number of Households -----			
High-input block cotton and maize	39	n.a.	n.a.	39
High-input dispersed cotton	27	n.a.	n.a.	27
Low-input block cotton only	n.a.	47	n.a.	47
Low-input dispersed cotton	78	86	48	212
No cotton	57	42	97	196
Total	201	175	145	521

¹ Household Production Category as of December, 1994.

Source: 1994/96 MAP/MSU Smallholder Survey



the area of these two provinces is covered. Thus, study results will be broadly generalizable to the maize- and manioc-based cropping systems of interior areas of northern Mozambique where cotton is or can be grown.

2.4 Interview Schedule and Questionnaire Design

The basic framework for the smallholder study was a repeat visit survey whereby each household was interviewed five times between June 1994 and February 1996 as indicated in Table 2-7. The first round, conducted in June 1994, was conceived as an "entry interview". Its purpose was to provide basic information on households of each of the three JVC areas of influence. This information would be used, in part, to determine a final sample for subsequent rounds (e.g., modifications to the sample discussed above) from which annual (and seasonal) estimates of production, income, sales, and consumption are calculated. Rounds 2 through 4 were conducted each four months during the official Mozambican agricultural year beginning September 1, 1994 and ending August 31, 1995 (Table 2-7). Round 5 was conducted in January 1996, four months into the 1995/96 agricultural year at the height of the hungry season. This enables smallholder data to be aggregated into two distinct, but overlapping twelve-month periods (Rounds 2 through 4 and Rounds 3 through 5) depending upon specific analytical objectives.^{6 7} Household food consumption was measured using a 24 hour recall

⁶ In March 1994, Cyclone Nadia reached the Mozambican coast and seriously affected agricultural production in parts of Nampula Province, including the districts of Monapo and Meconta. Cabo Delgado Province was unaffected. In Monapo and Meconta, many cashew trees were knocked down, maize was damaged just prior to harvest, and manioc (to be harvested in September/October) was also damaged. Due to this event, it was reasonable to assume that smallholder incomes and consumption in Nampula would be

(continued...)

technique. The enumerators, resident throughout each round in the given village, asked the person who most often did the food preparation/cooking (generally the wife or an older daughter) to identify the type and quantity of each food ingredient prepared and consumed during the previous 24 hours. Two consumption interviews per household, separated by between two and seven days, were conducted during each of Rounds 2 through 5. These interviews were always conducted at the household, facilitating volumetric measurement of the numerous non-standard units the household used for cooking. Other modules conducted with the woman (or other individual in charge of food preparation) concerned grain processing and the seasonal management of household food stocks and income. Table 2-8 provides an inventory by survey round and study zone of smallholder survey modules.

2.4.1 Organization of Fieldwork

Twenty-one individuals with education levels of at least 6th grade worked as enumerators during the current study. Six of the 21 were female. To select these key field staff

⁶(...continued)

lower than they would otherwise have been. The effects might be especially strong during the following hungry season, approximately January-March 1995. Preliminary analysis of consumption data from Round 2 (these data refer to consumption during January 1995) appeared to confirm these suspicions, showing lower consumption levels in the SAMO/SODAN areas than in the LOMACO area. As a result, FSP leadership decided to conduct a fifth round of data collection during January 1996. The primary objective of this round was to have hungry-season consumption data during a more "normal" year in both Montepuez and Monapo/Meconta to compare with the previous year which was affected by the cyclone. Thus, the fifth round was conducted in all areas covered in previous rounds, and most components from previous rounds' questionnaires were included.

⁷ Annual aggregation of CARE-OPEN household data is possible only for the period January - December 1995.

Table 2-7. Agricultural Calendar for Key Food and Cash Crops, and Smallholder Survey Rounds, 1994-96

[illegible]

Table 2-8. Smallholder Survey Content by Study Zone, Rounds 1-5, 6/94-1/96

Topic	Principal Study Zones (Montepuez and Monapo/Meconta)					CARE- OPEN	
	Survey Round and Date					1	2
	1 6/94	2 1/95	3 5/95	4 9/95	5* 1/96	3/95	8/95
Core Modules							
Demographics of all members	X	X	X	X	X	X	X
Off-farm members / remittances	X	X	X	X	X	X	X
Land resources / crop mix, field history, soil texture and color	X	X	X	X	X	X	X
Agricultural sales		X	X	X	X	X	X
Consumption (24-hour recall)		X	X	X	X		
Expenditures (food and non-food items)		X	X	X	X	X	X
Household labor on household land	X	X	X	X			
Off-farm income	X	X	X	X	X	X	X
Labor hired	X	X	X	X			
Agricultural inputs and farm implements	X	X	X	X			X
Fruit and vegetable production and sales		X	X	X	X	X	X
Livestock		X	X	X	X	X	X
Additional modules							
Family history	X			X			X
Relationship with traditional and local GOM authorities	X			X			X
Relationship with JVC	X		X	X			X
Cotton-grower marketing		X		X			X
Agricultural production		X		X		X	X
Food stock management and storage methods			X	X	X	X	X
Cashew stock management				X			X
Grain milling and processing				X		X	X
Allocation of women's time					X		
Land tenure and conflict					X		

* CARE 3rd round interviews were conducted with like sections as FSP 5, with the exclusion of consumption module.

members, FSP requested the District Directors of Agriculture of the original study districts (Meconta, Monapo and Montepuez) to recommend candidates familiar with agricultural in the district and who spoke the local Macua dialect. These candidates underwent training in Nampula for one week in June 1994, at which time successful candidates were selected to participate in Round 1. Field supervision was conducted by staff members from the Nampula DPA/DEA, the Mozambique Cotton Institute, and the DDA Montepuez. Additional training was conducted with field staff prior to each of Rounds 2-5 and the CARE-OPEN baseline.

During the conduct of the fieldwork, enumerators were resident in the villages in which they worked during each round in which consumption data was collected (Rounds 2-5 in Montepuez, Monapo and Meconta only). Furthermore, enumerators were assigned to visit the same households during each round to establish a high level of trust, thus facilitating a fruitful atmosphere in which to carry out interviews.

2.4.2 Data Entry and Cleaning

Following completion of interviews by enumerators, field supervisors carefully reviewed questionnaires while still in the field for logical errors and internal consistency. Any questions were resolved in consultation with the enumerator who conducted the interview. If clarification was not possible through this process, the enumerator (and sometimes supervisor) return to the household to resolve the problem.

After this data cleaning in the field, questionnaires were sent to FSP offices in Nampula. DEA staff and selected enumerators post-coded open-ended questions and carried out other steps necessary for preparing the questionnaires for data entry. At that point, all data from the household surveys were entered in Nampula by DPA staff using SPSS/PC + 5.0 software. Following each round, the Coordinator and DEA staff carried out significant data cleaning activities; through this process, many data inconsistencies and data entry errors were discovered by referring back to the original questionnaires, with corrections being made to the original data files.

2.4.3 Creation of a Data Archive

Following the completion of round 5, the Nampula Coordinator worked with other FSP staff to create a "data archive." This archive consolidates data across all rounds and computes selected variables such as standard unit quantities produced, sold, and purchased (among others), and incorporates these variables into the archive's "final data files."⁸

⁸ See Nampula/Cabo Delgado Household Data Archive Documentation (MAP/MSU FSP 1996) for further details of data organization.

Chapter 3

Demographic Characteristics and Food Security Strategies of Sample Households

3.0 Introduction

The quasi-experimental design of this study was motivated by the belief that, prior to the arrival of the JVCs, households between the study zones were similar in terms of demographic characteristics, the agro-ecological conditions in which they farm, and their level of wealth. If this were a true experimental design, it would be straightforward to relate differential levels of welfare to the key factor thought to differentiate households - the type of cash-cropping relationship each has with their JVCs. This is obviously not a pure experimental design, and other factors are likely to figure in the determination of household welfare. To investigate this issue and to lay the foundation for the analytical chapters, this chapter serves two functions. First, selected demographic characteristics of the household sample are discussed. Results are presented by study zone and crop production category. Second, data concerning farm size, household assets, land use, agricultural production and sales and household consumption characteristics are presented. The discussion will compare the two major study zones (Montepuez and Monapo/Meconta), focusing on those factors hypothesized important in the determination of household well-being and their association with the household's cropping category.

3.1 Demographic Characteristics of Cotton Belt Households

Mean levels of six household level demographic variables are shown in Table 3-1. With respect to the variables displayed - family size, age, proportion of households which are

Table 3-1. Demographic Characteristics of Sample Households by Zone and Cotton Production Category

Zone / 1994/95 Cotton Production Category	Demographic Characteristics						
	Population Proportion	HH Size (residents)	Age of HH Head (years)	Female Headed HHs (percent)	Polygamous HHs (percent)	Education Level, HH Head (years)	HH Head Native to Village (percent)
Montepuez	100	5.2	39	<1	12	2	69
High-Input Block	1	5.3	39	0	19	2	44
High-Input Dispersed	1	5.3	37	0	6	3	88
Low-Input Dispersed	24	5.2	44	0	17	1	64
Non-Cotton Growers	74	5.2	38	<1	10	2	70
Monapo/Meconta	100	5.0	40	3	5	2	78
Low-Input Block	38	5.7	45	0	5	2	79
Low-Input Dispersed	46	4.8	36	2	6	3	82
Non-Cotton Growers	16	4.2	42	12	1	2	62
CARE OPEN	100	4.6	39	3	12	2	88
Low-Input Dispersed	33	4.2	36	2	8	2	90
Non-Cotton Growers	67	4.8	40	4	13	2	88

Tests of statistical significance between mean values discussed in text.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

female-headed and polygamous, education level and whether a household head is native to their current village - there are no statistically significant differences between study zones. Results presented provide strong evidence that households across the two principal study zones of Montepuez and Monapo/Meconta are similar with respect to these variables.¹ To the extent that it is appropriate to characterize a "typical" household from the study zone, that household would be composed of five resident members headed by a 40 year old monogamous male with little formal education who lives in the village where he was born.

Within the two principal study zones, some demographic differences stand out between households which are associated with their cotton production category. In Montepuez, for example, high-input block cotton households are significantly more likely to be headed by an individual not native to their current village than the typical Montepuez household. Further examination of this non-native group shows that many of these individuals arrived in their current villages between 1967 and 1992.²

A key difference between Monapo/Meconta cotton-growers and non-growers is also evident, as the latter are more likely to be female-headed and have fewer household

¹ In each tables in this chapter, statistics are weighted to be representative at the zone and zone-category level. For more details, see Chapter 2.

² Several high-input block household heads migrated to their current villages from neighboring villages and districts in association with attempts by the colonial and post-colonial government to develop large scale cotton farming in Montepuez. They were, in all probability, more likely to participate in the high-input block cotton scheme at its inception in 1990/91 than their neighbors because of this experience. The question of how household participation in the various cotton schemes is determined and its importance to household welfare determination will be considered in Chapter 7.

members. This suggests that non-cotton growers in this zone may lack sufficient labor to grow cotton, a relatively labor intensive crop.³

3.2 Farm Size, Land Use and Agricultural Production Characteristics

Table 3-2 displays farm size characteristics of sample households. Farm size on a per household and per labor adult equivalent (LAE) basis are statistically indistinguishable between Montepuez and Monapo/Meconta, with the typical household in both zones cultivating approximately three hectares (or one hectare per labor adult equivalent).⁴

Meanwhile, significant variation in area cultivated per laborer is found within each district and cotton production category, a pattern which is consistent with FSP findings from 1991 and 1993. It is hypothesized that area cultivated will be an important determinant of household well-being while the sources of this inequality remain an important research priority.⁵

There is a strong positive association between cotton intensification and area cultivated. High-input block cotton households cultivate more area, both on a per household (5.4 to 5.8 ha) and per adult equivalent basis (1.6 to 1.9 ha) than low-input cotton growers (2.8 to 3.9 ha and 1.0 to 1.2 ha) in both zones. These differences are significant at the .01 level.

³ Non-cotton producing households were asked their primary reason for choosing not to grow cotton. Lack of family labor was cited by 78, 95 and 64 percent of this population in Montepuez, Monapo/Meconta and CARE-OPEN respectively.

⁴ See Chapter 4 for labor adult equivalent conversion factors.

⁵ See MAP/MSU (1994b) and Marrule (1997, forthcoming) for discussion concerning the sources of these differential levels of land access within the smallholder sector.

Table 3-2 Farm Size, Cultivated and Fallow, by Zone and Cotton Production Category, 1994/95

Zone / 1994/95 Cotton Production Category	Area Cultivated (ha)	Area Cultivated per LAE (ha/lac)	Farm Size (w/ fallow) (ha)	Farm Size per LAE (ha/lac)	HH LAE
Montepuez					
High-Input Block	2.6	0.9	3.6	1.2	3.3
High-Input Dispersed	5.4	1.6	5.8	1.7	3.8
Low-Input Dispersed	5.8	1.9	6.4	2.1	3.1
Non-Cotton Growers	3.5	1.2	4.6	1.6	3.4
	2.3	0.7	3.2	1.0	3.3
Manapo/Meconta					
Low-Input Block	3.1	1.1	4.5	1.5	3.1
Low-Input Dispersed	3.9	1.2	5.7	1.7	3.6
Non-Cotton Growers	2.8	1.0	3.9	1.5	2.9
	2.0	0.9	3.2	1.4	2.5
CARE OPEN					
Low-Input Dispersed	3.3	1.3	3.9	1.6	2.7
Non-Cotton Growers	3.4	1.4	3.8	1.6	2.6
	3.3	1.3	4.0	1.6	2.8

Tests of statistical significance between mean values discussed in text.

LAE = labor adult equivalent

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Meanwhile, low-input cotton growers in both zones cultivate more area than non-cotton growers (2.0 to 2.3 has and 0.7 to 0.9 has), with these mean differences also statistically significant at the .01 level in Monapo/Meconta and Montepuez. Three factors are hypothesized to explain this relationship. First, high-input households have access to labor-saving technologies (e.g., herbicide and mechanization) associated with the high-input packages. Second, Table 3-3 reveals that high-input cotton households hire statistically greater quantity of non-family labor (98 to 110 days) than low-input cotton growers (14 to 52 days), with non-cotton growers hiring in relatively little non-family labor (4 to 11 days). An important question is the source of operating capital these households can draw upon to hire in such significant amounts of on-family labor. Finally, high-input block households gain access to block land as part of their arrangement with the JVC.

In contrast to the areas of significant JVC involvement, within the CARE-OPEN areas, there is no statistical difference in farm size (regardless of the indicator used) between cotton growers and non-growers. This suggests that JVC presence in a zone results in participating farmers expanding farm size relative to their neighbors.

Food crops account for greater than one-half of all cultivated area within each zone-cotton production category strata. Tables 3-4 and 3-5 show that maize is the most important food crop in terms of area planted in both Montepuez and Monapo/Meconta. While manioc is an important part of the food security strategies in both zones, it is relatively more important in Monapo/Meconta in terms of the percent of households producing, proportion

Table 3-3 Labor Hired-in by Sampled Households by Zone and Cotton Production Category, 1994/95

Zone^a / Crop Production Category	HH Hiring Off-Farm Labor	Labor Hired^c
	(percent)	(days)
Montepuez	55	19
High-Input Block	100	98 ^b
High-Input Dispersed	97	110 ^b
Low-Input Dispersed	80	26 ^c
Non-Cotton Growers	46	11 ^c
Monapo/Meconta	55	32
Low-Input Block	71	52 ^d
Low-Input Dispersed	51	14 ^c
Non-Cotton Growers	25	4 ^c

^a This data was not included in CARE-OPEN household surveys.

^b T-tests show significant differences between both high-input categories in Montepuez compared to all other strata in both zones (p-value=0.01).

^c T-test show significant differences between group means of low-input dispersed and non-cotton growers within each zone (p-value=0.01).

^d T-test shows significant difference between this category and both other Monapo/Meconta categories (p-value=0.01).

^e Weighted mean of those who hired non-family agricultural labor.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 3-4 Land Use and Production Characteristics by Crop Production Category, Montepuez, 1994/95

	Cotton			No Cotton
	High-Input Block	High-Input Dispersed	Low-Input	
Percent producing:				
Cotton	100	100	100	-
Maize	100	100	97	100
Manioc	59	74	85	89
Percent cropped land to: ¹				
Cotton	42	36	29	-
Maize	36	34	37	54
Manioc	12	10	26	45
Percent monocrop				
Cotton	100	100	100	-
Maize	71	51	55	39
Manioc	24	21	18	17
Total production (kgs) ²				
Cotton	3387 ^a	2577 ^a	591 ^a	-
Maize	2159 ^a	2295 ^a	592 ^{ab}	424 ^{ab}
Manioc	357	210	281 ^b	382 ^b

^a T-tests comparing joint high-input group means with other groups individually for the same crop show significant differences (p-value=0.01).

^b T-test comparing group means shows significant difference between these two categories (p-value=0.01).

¹ May add to greater than 100 percent because both monocropped and intercropped fields are included.

² Mean of those producing.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 3-5 Land Use and Production Characteristics by Crop Production Category, Nampula, 1994/95

	Monapo / Meconta			CARE OPEN	
	Cotton		No Cotton	Low Input Dispersed	No Cotton
	Low-Input Block	Low-Input Dispersed			
Percent producing:					
Cotton	100	100	-	100	-
Maize	100	99	100	85	93
Manioc	99	90	73	85	100
Percent cropped land to:¹					
Cotton	32	34	-	27	-
Maize	30	38	61	16	29
Manioc	30	27	31	19	27
Percent monocrop					
Cotton	100	100	-	100	-
Maize	31	42	32	55	65
Manioc	41	25	29	74	72
Total production (kgs)²					
Cotton	932 ^a	459 ^a	-	396	-
Maize	391 ^a	338 ^a	277 ^a	609 ^b	832 ^b
Manioc	697 ^a	347 ^a	231 ^a	494	472

^a T-tests show each pair of group means within a given crop and zone to be significantly different (p=0.01 level).

^b T-test shows group means significantly different (p=0.05).

¹ May add to greater than 100 percent because both monocropped and intercropped fields are included.

² Mean of those producing.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

of cultivated area and as a calorie source (see Table 3-7). Other key food crops in both zones include beans, cowpeas, groundnuts and sorghum.

Critics of SSA cash-cropping schemes frequently argue that cash-cropping causes food insecurity because it reduces the availability of family resources for food production. Results from both Montepuez and Monapo/Meconta provide strong evidence to the contrary. Table 3-3 shows that greater maize production is positively associated with cotton production in Montepuez. High-input cotton households produced both significantly more maize and cotton than low-input or non-cotton households in either zone. Further confirmation of the positive cash crop:food crop interaction is the greater level of maize produced in both zones by low-input cotton producing households compared to their non-cotton growing neighbors.

3.3 Household Assets at the End of the War

Table 3-6 displays data concerning three types of household assets at the end of the war, broken down by three discrete asset types: durables, livestock, and agricultural tools. The two most important of these asset types related to agricultural income are livestock and agricultural tools. Between zones, there is no significant difference in terms of quantity of agricultural tools or value of livestock, largely a reflection of the general devastation from war characterizing most of rural Mozambique related to the civil war.

The low number of agricultural tools held by sampled households reflects the extremely low level of agricultural technology employed at war's end throughout rural Mozambique.

Table 3-6 Household Assets at End of War (1992) by Zone and Production Category

Zone / Household Production Category	Asset Type		
	Durables	Livestock	Agricultural Tools ¹
	---- (value in dollars ²) ---		--- number ---
Montepuez	38	11	5
High-input block	121	6	6
High-input dispersed	130	5	5
Low-input dispersed	58	13	5
No cotton	29	10	5
Monapo/Meconta	51	10	6
Low-input block	86	6	7
Low-input dispersed	32	13	5
No cotton	20	8	5
CARE-OPEN	37	3	³
Low-input dispersed	38	2	
No cotton	36	4	

¹ Number of agricultural tools as of 1995; data unavailable from 1992.

² Assuming 1996 prices, given the absence of prices during 1992.

³ This data was not collected in CARE-OPEN household surveys.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

The most important agricultural tools were hoes, machetes and axes; no sampled households owned tractors or animal traction equipment. Smallholder livestock herds were decimated during the war such that at war's end virtually no smallholders had livestock assets of significant value.⁶

With respect to durable assets, survey results indicate significantly greater amounts of these items held by high-input households (\$121 to \$130 vs. \$20 to \$86) compared to all other strata. Bicycles, radios, sewing machines and household furniture were the most important assets in this category. At least two competing explanations are hypothesized to explain the difference in levels of consumer durables held by high-input households compared to their neighbors. First, it is possible that the wealth differential reflects higher levels of past agricultural (cotton) income during the initial years (1990-1994) of the high-input scheme. An alternate explanation is that high-input households were relatively better off than their neighbors before participating in the scheme.

3.4 Household Calorie Consumption Sources

Tables 3-7 and 3-8 display the proportion of calories by source and food type for Montepuez and Monapo/Meconta based on 24 hour recall consumption data. As found in the 1991 MAP/MSU FSP Nampula study, retained production continues to represent the most important calorie source for each zone-category group. The role of purchased food in the typical household's food security strategy has increased, however, since 1991 when

⁶ Chickens were the most frequent animal type owned by smallholders, followed by goats, swine and sheep. No sampled smallholders owned any cattle.

purchases made up only two to five percent of total calorie availability in the three surveyed districts. Purchased calories were markedly more important in Monapo/Meconta than in Montepuez, particularly during the hungry season, where purchases accounted for between 23 and 39 percent of consumption.⁷ It is logical that purchases would be relatively more important in Monapo/Meconta, in light of its lower maize production per household compared to Montepuez low-input households.⁸ Maize grain and flour represent the single most important calorie source in both zones during the January to April and May to August recall periods, representing between 30 to 69 percent of total consumption. Manioc (primarily harvested in the hungry season months of September and October), is a key part of the household food security strategy in the period following its harvest, particularly in Nampula where it represents from 27 to 54 percent of calories consumed.

3.5 Food Market Participation

Table 3-9 presents a classification of households by their food market participation status with respect to six staples (maize, manioc, beans, sorghum, groundnuts and rice). In the bottom portion of the table, households are classified based on whether they were net

⁷ The definition of "purchased calories" used here includes both market purchases as well as calories received for off-farm work when payment was made in food. Unfortunately, it is not possible to segregate calories from these two sources within the calorie consumption data set. Note, however, that off-farm labor sales for food by net food-deficit households represent a significantly higher number of calories than for net food-surplus households in both provinces. This suggests that food obtained through this mechanism represents a particularly important source for the most vulnerable households.

⁸ It is likely that lower maize production in Monapo/Meconta is a function of lower yield levels per hectare than in Montepuez among households using similar (and low) levels of technology. These critical productivity-related issues are examined in Chapter 4.

Table 3-7 Household Calorie Consumption by Food Type and Origin by Cotton Category and Season, Montepuez, 1995/96

By Food Type	Cotton Production Arrangement											
	High-input block			High-input dispersed			Low-input dispersed			No cotton		
	May	Sept	Jan	May	Sept	Jan	May	Sept	Jan	May	Sept	Jan
	(Percent of total calories)											
Maize	60	56	57	69	53	66	60	38	52	61	38	29
Mamlec	1	3	9	1	2	6	4	12	14	8	25	28
Beans and Cornmeal	15	9	8	14	9	7	12	11	9	13	8	11
Groundnuts	10	7	6	9	13	7	13	11	4	12	14	7
Sorghum	2	6	5	2	10	6	2	14	8	<1	10	7
Fruits & Vegetables	2	2	6	2	1	<1	2	<1	6	2	1	16
Beef and Poultry	2	3	1	<1	4	2	2	3	<1	1	2	<1
Fish	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1
Sugar and Oil	2	4	3	<1	1	1	1	1	1	0	1	0
By Origin												
Own Production	71	71	71	84	82	81	77	81	67	73	73	63
Purchased	13	17	16	9	13	15	11	7	16	8	11	22
Gift	17	11	13	8	5	4	13	12	17	19	16	14

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 3-8 Household Calorie Consumption by Food Type and Origin by Cotton Category and Season, Monapo/Meconta, 1995/96

By Food Type	Low-input block			Low-input dispersed			No cotton		
	May	Sept	Jan	May	Sept	Jan	May	Sept	Jan
Maize and Derivatives	56	30	22	63	53	34	63	49	50
Manioc and Derivatives	11	27	54	5	13	40	5	15	27
Beans and Cowpeas	16	15	12	18	13	14	15	12	16
Groundnuts	10	3	2	7	5	1	12	5	3
Sorghum and Derivatives	1	13	0	1	9	1	1	11	3
Fruits and Vegetables	3	1	2	4	2	2	3	1	3
Beef and Poultry	1	1	2	1	2	4	1	1	1
Fish (Dried and Fresh)	<1	<1	<1	1	<1	<1	<1	<1	<1
Sugar and Oil	1	1	4	1	<1	1	<1	1	1
By Origin									
Own Production	93	90	59	88	86	64	85	76	43
Purchased	3	6	25	5	6	23	4	9	39
Gift	4	3	15	5	6	9	8	13	12
In-Kind	<1	1	<1	1	1	1	3	1	5

(Percent of total calories)

sellers, net buyers, or non-food market participants during 1995. Again, in contrast to results from the 1991 Nampula Smallholder Survey, food market participation increased dramatically. For example, the war-time survey showed that 28 percent of Monapo households did not participate at all in food markets during the preceding twelve months, while only 26 percent purchased food. In 1995, almost all Monapo/Meconta households purchased some food, with 67 to 79 percent of these households categorized as net food buyers.

Food sales represented a source of cash income for between 55 and 97 percent of households. Not surprisingly, the largest food sellers were those high-input cotton households in Montepuez. These households sold between five and 20 times as many calories as any other zone category group. A significant proportion of these sales were made to Lomaco as part of the high-input block maize scheme in which many of these households participated.

3.6 Summary

Results in this chapter have shown that the cotton belt populations in Montepuez, Monapo and Meconta Districts are similar in key ways, providing empirical evidence to justify the rationale of the quasi-experimental sampling design designed to investigate the effect of cash-cropping on smallholder food security and income. Within the two principal study areas, however, significant differences were found based on cotton production category. Generally, greater intensification in cash-cropping was shown to be positively associated with area cultivated and durable assets held at the end of the civil war.

Table 3-9 Food Market Participation by Zone and Cotton Production Category, 1995

	Montepuez				Monapo/Meconta		
	Cotton Production Arrangement				Cotton Production Arrangement		
	High-Input Block	High-Input Dispersed	Low-Input Dispersed	No cotton	Low-Input Block	Low-Input Dispersed	No cotton
Market Sales and Purchases							
% selling	78	97	78	65	60	59	55
Mean sales, those selling ('000s calories)	6967	3725	544	752	701	388	280
% buying	88	90	71	82	100	100	92
Mean purchases, those buying ('000s calories)	358	319	296	266	800	528	428
% net seller	69	89	67	52	21	22	28
% not in market	6	0	3	6	0	0	6
% net buyer	25	11	30	42	79	78	67
Mean purchases, net buyers only ('000s calories)	259	121	487	223	1033	440	624

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Additional factors further rationalize the research design strategy. For example, rural households in these areas are almost completely from the Macua ethnic group, live in similar agro-ecological conditions, had similar experiences under the colonial and post-colonial governments, and were affected comparably by the war which ended in 1992. Given this, the effect of household involvement in the JVC cotton schemes on welfare indicators will be examined through econometric modelling in Chapter 7.

Preceding this, however, Chapters 4 through 6 analyze the productivity, profitability and economic efficiency of smallholder cotton, maize and manioc in northern Mozambique based on household level data from the 1994/95 cropping season. This chapter has provided evidence showing the strategic importance of these three crops to cotton belt smallholders in their food security and income strategies. Maize and manioc are generally the most important food crops in terms of area planted, production, sales (maize only) and consumption. Meanwhile, cotton is the region's most important cash crop, representing between 29 and 42 percent of area planted.

Chapter 4

Determinants of Productivity in Cotton and Maize

4.0 Introduction

Near complete input and credit market failure characterize the situation of smallholders in much of Mozambique. In this context, the JVC approach in the "cotton belt" in the North has a key attraction. It jointly provides agricultural inputs and credit to liquidity-constrained farmers over the course of the growing season and access to a guaranteed cotton output market at an official minimum price. Smallholders produce cotton under a range of input packages organized through Joint Venture Companies (JVCs). One JVC also supports smallholder food-cropping by facilitating access to an input package for maize. Results in Table 4-1 from smallholder surveys from both the 1993/94 and 1994/95 cropping seasons show that mean yields for high-input producers of both crops are greater than their neighbors in low-input cotton and maize. These differences are statistically significant for both years and both crops at the .01 probability level. These results point to four key questions addressed in this and the succeeding two chapters.

4.0.1 Linking Intensification and Yield

Can yield differences for maize and/or cotton be linked to differential input use and/or JVC service provision? For example, the comparison of group means shows that Montepuez high-input cotton farmers had statistically greater yields per hectare than dispersed cotton growers in the same region during the same season. While being suggestive of a causal relationship between greater input use and productivity gain, it does

Table 4-1 Mean Seed Cotton and Maize Yields, by Zone and Cotton Production Category, 1993/94 and 1994/95

Zone	Cotton Production Category	Cotton		Maize ¹	
		1993/ 94	1994/ 95	1993 /94	1994/ 95
----- kgs/ha -----					
Montepuez	High-input block	1099	1442	1756	1985
	High-input dispersed	²	1179	²	979
	Low-input dispersed	434	569	776	634
	No cotton	n.a.	n.a.	772	606
Monapo /Meconta	Low-input block	656	693	291	514
	Low-input dispersed	551	501	300	395
	No cotton	n.a.	n.a.	252	374

Tests of statistical significance between mean values discussed in text.

¹ Limited to monocropped maize fields.

² There were no households in this cotton production category in 1993/94.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

not exclude the possibility of other exogenous factors contributing to differential yields. Through a multivariate regression model, however, this link could be established in a more rigorous way by separating the effects of natural factors, such as differential rainfall and land quality, and thus isolate the effects of input use on productivity. If statistical results showed strong evidence of this relationship, it could strengthen the voice of proponents of expanding smallholder intensification in cash crops elsewhere in Mozambique.

4.0.2 Yield Variation Under Similar Technological Packages

Second, Table 4-2 shows a high degree of variation in yields within zone-cotton production category strata for cotton, maize and manioc. For example, when ranking Nampula low-input block cotton producers into per-hectare yield terciles, the upper tercile:lower tercile (1080 v. 337 kgs/ha) yield ratio exceeds three to one. Assuming similar technological packages were available to producers within groups, such a high level of variation found throughout the sample merits analytical attention. Possible explanations include JVC-related input or extension factors, though it is also plausible that exogenous factors, such as lack of labor or poor land quality are important in yield variation. Assuming smallholder productivity growth in key crops is a necessary condition for improved rural welfare, gaining an understanding of the causes of such within-group variation is valuable. To analyze these first two issues, multivariate regression models of cotton and maize production per hectare are developed using field-level labor, input, and production data from sampled households in Monapo, Meconta, and Montepuez based on the 1994/95 cropping season. Based on parameters from the yield equations and input and

Table 4-2 Cotton, Maize and Manioc Tercile Yields by Zone and Cotton Production Category, 1994/95

Zone / Cotton Production Category	Crop								
	Cotton			Maize¹					
	Yield Tercile								
	1	2	3	1	2	3	1	2	3
Montepuez	--- kg/ha ---								
High-input block	1045	1483	1796	871	1900	3185	234²	440²	875²
High-input dispersed	649	1227	1661	328	1000	1610			
Low-input dispersed	200	501	1010	238	475	1188	174	316	612
No Cotton	n.a.	n.a.	n.a.	194	434	1190	205	411	833
Monapo / Meconta									
Low-input block	337	627	1080	218	423	918	408	854	1638
Low-input dispersed	155	448	917	181	332	657	257	511	1210
No cotton	n.a.	n.a.	n.a.	162	339	593	200	478	1016

¹ Limited to monocropped maize fields only.² Due to limited number of observations, these two categories were grouped in yield tercile computation.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

output prices faced by farmers in 1994/95, the marginal benefits and costs to producers of key chemical and labor inputs found important to productivity are computed.

4.0.3 Shared JVC and Smallholder Interest in Linking Productivity and Profitability

Assuming that without the JVCs, smallholders would not have access to modern inputs in the study zone, successful agricultural intensification in the cotton belt requires that these schemes be profitable to both smallholders and the JVCs. Thus, Chapter 5 addresses the overall financial profitability of the range of high- and low-input cotton and maize schemes through the computation of enterprise budgets from the perspectives of both smallholders and the JVCs. To provide greater analytical breadth in terms of key food crops, the profitability of manioc to smallholders is included in this chapter given its importance as a source of calories throughout the study zone, particularly during the hungry season.¹ (See Tables 3-7 and 3-8)

The enterprise budgets are intended to complement insights from the yield equations. Suppose, as hypothesized above, that productivity can be statistically tied to increasing input use in cotton and maize yields. The next logical question becomes the financial profitability of these enterprises to both smallholders and the JVCs. Do cropping enterprises with greater input costs enhance yields sufficiently to result in greater financial profitability for participating farmers and the JVCs in comparison to the low-input schemes? From the smallholder perspective, two measures of profitability are evaluated:

¹ Note, however, that no JVC is involved in supporting smallholder manioc production.

net returns per adult-equivalent labor day and net returns per hectare. Given the nature of within zone-cotton production category-crop yield variation highlighted above, the enterprise budgets are divided into yield terciles. This permits consideration of financial profitability across the range of yields and input levels obtained and an initial consideration of the role of yield risk toward the profitability of the JVC schemes. To evaluate profitability from the JVC perspective, net returns per hectare in each scheme in cotton and maize are computed based on data provided by the JVCs and Fok (1995).

4.0.4 The Need to Reconcile Social, Producer and JVC Interests

Chapter 6 considers the extent to which the north of Mozambique enjoys a comparative advantage in producing cotton, maize and manioc at varying levels of intensification found in the study zone. This, in turn, raises the question of long-run sustainability of intensification in cotton and maize. Recall from Chapter 1 that agricultural intensification in the study zone had been facilitated during the JVCs' initial years through external subsidies of key inputs using the KR-II and Ciba-Geigy programs. In a policy environment where these subsidies are reduced or eliminated, it is important to determine with which crop(s), and under which input package(s) northern Mozambican smallholders are economically efficient. The importance of this issue was underscored by the sudden termination of the KR-II cotton insecticide subsidy program beginning during the 1995/96 cropping season. To gain insight into the question of comparative advantage, two measures of economic efficiency are computed: net social profitability per hectare and the resource cost ratio. These two measures allow us to ignore the effects of distortions in the economy related to government and donor policies, and calculate the economic cost of

producing a unit of foreign exchange. The economic analysis relies on the cotton, maize and manioc enterprise budgets from Chapter 5 for key labor and input quantity parameters. However, economic prices for tradables replace those market prices used in the enterprise budgets. Thus, non-tradables such as family labor and land, not accounted for in the enterprise budgets because they do not represent a cost to the farm household, are valued at their opportunity cost, allowing us to calculate the social cost of producing these three crops under the relevant input packages and JVC arrangements. We then compare the economic costs of production for each commodity to the foreign exchange generated to determine indicators of comparative advantage.

The base case financial and economic analyses use producer and border prices, as well as yield and technology levels for each commodity prevailing relevant to the 1994/95 harvest. It is important, however, to consider the implications of variations in these price parameters on profitability to smallholders, the JVCs and the nation. Chapter 6 concludes, therefore, by integrating the interests of these three groups. To do this, we incorporate lessons learned from the earlier financial and economic analyses through sensitivity analysis: under what producer price, world price, yield, and ginning outturn rates² do all three groups benefit? By identifying the intersection of profitability of the three groups, a framework is suggested for policy-makers to use in determining the minimum producer price JVCs pay producers.

² Note that in the study zone, the current ginning outturn rate (GOR), the rate which seed cotton is transformed into cotton fiber, is 34 percent compared to the near 40 percent levels achieved in Francophone West Africa. The sensitivity analysis considers the implications of increasing the GOR to West African levels through varietal improvements.

4.1 Cotton and Maize Yield Equations

The purpose of this section is to develop, test, and interpret statistical models of the determinants of smallholder cotton and maize productivity.

4.1.1 Description of Cotton and Maize Samples

The 1994/96 MAP/MSU FSP Socioeconomic Study drew a stratified random sample of rural households in Monapo, Meconta, and Montepuez Districts.³ Recall from Chapter 2 that the sample was stratified within both principal study zones to incorporate households in each cotton scheme in the Lomaco, SODAN, and SAMO areas of influence as well as a non-cotton growing control group. Stratification took place based on two criteria: whether a household grew cotton in 1994/95, and for cotton-growers, the type of input scheme vis-a-vis the regional JVC under which it did so. The cotton model uses production, labor and input data related to principal⁴ cotton fields of 279 sampled smallholders from Montepuez, Monapo, and Meconta Districts from the 1994/95 production season. Table 4-3 shows the distribution of the cotton sample across zones and input packages. While the Nampula area is limited to low-input cotton growers - block and dispersed - the Montepuez area provided a useful contrast in that two high-input packages and a low-input package were available.

³ Note that the CARE-OPEN sample is excluded from this analysis because data necessary for estimating yield equations was not incorporated as part of the surveys in these areas.

⁴ Given the objective of measuring field level productivity, for the small proportion of households with more than one cotton field in 1994/95 (7 percent of the sample had two cotton fields), they were asked to designate a single field as their most important. Detailed production, labor, and input data were gathered in Rounds 2 through 4 about this field.

Table 4-3 Sample Households Included in Cotton Yield Model by Zone and Production Category

Cotton Input level ¹	Land Type	Zone	
		Montepuez	Monapo / Meconta
		-- number of households --	
High-input	Block	40	n.a.
	Dispersed	27	n.a.
Low-input	Block	n.a.	49
	Dispersed	80	83
Total number of households		147	132

¹ As of 1994/95.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Principal maize plots from 196 households comprise the sample used in the maize yield model. To maintain analytical simplicity, only mono-cropped maize fields are included.⁵ There is much less variation in terms of maize input packages and JVC involvement in comparison to cotton input packages in the study zone. Only one JVC, Lomaco-Montepuez, supported smallholder maize production and marketing during the study year. The Lomaco maize package provided a high-input package to a limited number of households, all of whom were participating in the high-input cotton scheme.⁶ Table 4-4 describes the maize sample by input package, land type and zone.

4.1.2 Theoretical Framework and Model Specification

The following theoretical framework is hypothesized to characterize the level of cotton and maize production per hectare among northern Mozambican smallholders:

$$Y = f(N, I, H)$$

where:

Y	=	yield seed cotton or maize grain per hectare (kgs)
N	=	natural/agronomic factors
I	=	inputs and support services provided by the JVC
H	=	household resource allocation and management decisions

Both cotton and maize yield relationships are estimated using the standard Cobb-Douglas log-log form commonly used for production function analysis. Below we consider the rationale for model specification, and how available data are used to develop explanatory variables in the yield equations.

⁵ Tables 3-4 and 3-5 display the proportion of all maize area which is monocropped.

⁶ See Table 4-9 for input types and quantities provided in these schemes.

Table 4-4 Stratification of Sample Households Included in Maize Yield Model by Zone, Input Level and Land Type¹

Input level	Land type	Zone	
		Montepuez	Monapo / Meconta
		-- Number of Households --	
High input	Block	30	n.a.
Low input	Dispersed	91	75
Total Number of Households		121	75

¹ Limited to monocropped maize fields.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

4.1.3 Natural Factors

Three natural factors, beyond the control of the smallholder and the JVC, believed to affect cotton and maize productivity are land quality, rainfall and levels of pest infestation prior to planting.

To instrument for land quality, two variables are developed. First, a measure of farmers' opinions concerning soil color, texture and current fertility level for the relevant crop was used to create a dichotomous variable. Under this approach, 51 percent of cotton fields and 49 percent of maize fields were classified as relatively fertile.⁷ The second proxy for land quality (only among cotton fields) is whether the field lies within a colonial era plantation, or "block," a variable upon which sample stratification was done. The 1993 Rapid Rural Appraisal provided evidence that land in these blocks was of a higher quality for cotton than other adjacent areas, given that their suitability for cotton was the chief criterion for their initial delineation.⁸ While this would suggest that growing cotton on a block would have a positive effect on yield, Nampula Ministry of Agriculture officials suggested that this yield effect might be negated by continuous monocropping of cotton

⁷ Though not a part of the available data set, precise measurements of soil nutrients of each plot would be the preferred method to account for differential land quality in the yield model. It would allow for the estimation of the role of soil fertility in determining yield, as well as the soil's potential fertilizer response.

⁸ Interviews conducted with SODAN and SAMO officials during the Rapid Rural Appraisal (1993) indicated that on blocks in their areas of influence tractorization services were provided to smallholders for field preparation. In 1994/95, according to smallholder surveys and field observation, no such services were provided in Monapo/Meconta by either of these two firms.

with no chemical fertilizer over many years, resulting in nutrient depletion (and buildup of pest populations). (Personal communication, Antonio Cobre, 1994)

The second natural factor is precipitation. Rainfall quantity and its distribution within the cropping season is essential to agricultural production in the study zone, given the absence of irrigation. In this context, analysis of data from a single season needs to be viewed with caution. Table 4-5 displays ten year mean monthly rainfall as well as 1994/95 rainfall for the most relevant reporting stations in both zones with available data. It shows that the two study zones have similar average annual rainfall in terms of quantity and intra-annual distribution, an attractive aspect of the study's quasi-experimental design. Table 4-5 also shows similarities in rainfall quantities and distribution between the two zones during the 1994/95 cropping season at slightly below ten year mean levels. This implies a low probability that rainfall variation between study zones caused significant yield differences during the study year. Nonetheless, significant micro-level rainfall variation may have occurred and affected production. To proxy for abnormal precipitation on their plots, and in the absence of plot-level rainfall data, farmers were asked to compare actual quantity and distribution of rain during the production season to a normal year. Sixteen percent of cotton plots and 41 percent of maize plots were judged by smallholders to have received too little rainfall during key parts of the production cycle on their particular fields. This data is used in the model to compute a dichotomous variable to control for the effect of abnormal rainfall on plot-level production.

Table 4-5 Rainfall Statistics, by Zone and Month, for Typical Years and for 1994/95

Month	Rainfall			
	Montepuez		Namialo (Meconta)	
	1985-94 mean	1994/95	1985-94 mean	1994/95
	---(mm)---			
Total rainfall	922	771	1024	833
September	0	0	8	0
October	6	8	9	8
November	61	0	36	0
December	200	93	135	58
January	230	343	267	325
February	249	204	240	245
March	117	103	205	140
April	48	20	73	17
May	6	0	17	40
June	1	0	19	0
July	1	0	5	0
August	3	0	10	0

Source: Meteorological records provided by Rafael Uaiene, CIMSAN, Namialo and Carlos Henriques, Lomaco-Montepuez.

The final natural factor hypothesized to influence agricultural production is the level of insect pest populations prior to the cropping season. Insect control is fundamental to cotton production in the study zone and as such, insecticides represent a critical input to cotton production provided by the JVCs. To measure the effectiveness of insecticide on plant protection, it is necessary to control for the level of a field's initial infestation. A field with low levels of damaging insects at planting would have less need for, and likely show less response to insecticide applications, and vice versa. To proxy for insect infestation levels, farmers were asked the extent to which they considered their field to have had a relatively high initial pest population, relative to what they considered normal. Nine percent of cotton growers said this had been a serious problem. Fourteen percent of maize producers complained of a serious insect problem, though it is important to note that no insecticides are used in smallholder maize production in the study zone.

4.1.4 JVC-Related and Household-Specific Factors

This section considers how input usage and household resource allocation decisions are hypothesized to affect yields, and is divided into seven parts: 1) field preparation and planting date; 2) weeding labor; 3) insecticide; 4) timeliness of JVC-input provision; 5) inputs unique to the high-input systems; 6) the effects of cotton intensification on maize yields; and 7) farm management skills and a potential self-selection bias.

4.1.4.1 Field Preparation and Planting Date

Cotton varieties grown in the study zone have a longer vegetative cycle (150-160 days) than maize varieties (100-120 day) grown in the zone. (Personal communication, Rafael

Uaiene, Centro de Investigacao e Multiplicacao de Sementes de Algodao de Namialo (CIMSAN), 1995) This implies that cotton yield is likely to be more sensitive to early planting than maize. However, for food security concerns, farmers tend to plant maize (and other food crops) in both Montepuez and Nampula prior to cotton. The extent to which farmers can prepare and seed cotton fields relatively early, either through the use of family or hired labor, or through tractorization, is hypothesized to have a significant effect on yield. Meanwhile, it is not as likely that maize seeding date will be as significant in influencing yield (over a reasonable range).

Research by CIMSAN-Namialo underscores the importance of early cotton seeding. Specifically, yields from on-farm trials were found to decrease on average by one percent for each day planting occurs past December 10. (Personal communication, Peter Wegener, CIMSAN, 1994) Surveyed farmers reported seeding week of both crops; tabular results are presented in Table 4-6. Seeding week is included as an explanatory variable in both the cotton and maize models.

Table 4-6 also highlights the usefulness of the JVC providing smallholders a tractor as part of the high-input block package for both maize and cotton in terms of facilitating early planting. The table illustrates that among non-mechanized farmers in Montepuez and Nampula, 54 and 32 percent of farmers, respectively were able to plant cotton by the

Table 4-6 Seeding Week of Cotton and Maize by Zone and Level of Mechanization

Seeding Month- Week	Montepuez				Monapo / Meconta	
	Cotton		Maize		Cotton	Maize
	Tractor	Hand- hoe	Tractor	Hand- hoe		
-- (percent of farmers seeding) --						
11-2	0	1	0	0	0	0
11-3	0	4	0	0	0	0
11-4	100	8	100	14	0	11
12-1	0	24	0	31	23	14
12-2	0	18	0	33	9	23
12-3	0	22	0	10	11	10
12-4	0	13	0	11	20	15
1-1	0	8	0	1	27	18
1-2	0	2	0	0	6	8
1-3	0	1	0	0	2	1
1-4	0	0	0	0	2	
2-1	0	0	0	0	2	
Total	100	100	100	100	100	100

Totals may not add to 100 percent due to rounding.
Source: 1994/96 MAP/MSU FSP Smallholder Survey

CIMSAN recommended date. Meanwhile a higher proportion in each zone (78 percent and 38 percent) had already planted their maize by that date.⁹

4.1.4.2 Weeding Labor

The above discussion highlighted the rationale for using seeding week as a proxy to account for all labor activities through seeding. Weeding between two and ten weeks following germination is the most critical period of labor demand for cotton, maize, and other key food crops in the study zone. In fact, as shown in Chapter 3, the dominant reason cited by non-cotton growers for not growing cotton was a family labor shortage. It is likely that weeding labor demand is the most important season at which non-growers anticipated a labor shortage. Tables 4-7 and 4-8 display mean labor utilization by activity by zone and category for both cotton and maize. Note the significantly higher amount of labor used for weeding cotton among low-input growers compared to maize.¹⁰

The extent to which smallholders are able to alleviate the labor constraint for weeding, either through hiring non-family labor¹¹ and/or the use of the pre-emergent herbicide

⁹ Smallholders were asked about the quantity of seed used on each field included in this analysis. However, because of missing or data which was otherwise difficult to interpret, the analysis assumes homogeneous seeding rates of 40 kgs/ha on cotton fields and 25 kgs/ha on maize fields. Cotton seed varieties used by the three JVCs are assumed similar in quality. Meanwhile, maize varieties used are assumed to be unimproved, with the exception of the high-input maize scheme where the JVC provided an improved variety.

¹⁰ Labor adult equivalent conversion factors are: individuals 7-8 years old = 0.3, 9-12 = 0.5, 13-15 = 0.7, males 15-54 = 1.0, females 15-54 = 0.85, and individuals >55 = 0.7. These conversion factors are maintained in all further analyses of household labor.

¹¹ The role of non-family labor is discussed in detail in Chapter 5.

Table 4-7 Labor Utilization on Cotton by Zone, Production Category, and Activity in Adult Equivalent Labor Days per Hectare, 1994/95

Activity	Montepuez			Monapo / Meconta	
	High- input block	High- input dispersed	Low- input dispersed	Low- input block	Low- input dispersed
-- adult equivalent labor days per hectare --					
Field clearing, preparation and seeding	0	17	32	27	32
Thinning and weeding	38	38	50	71	67
Harvest	58	47	23	28	20
Total Labor Days	96	102	105	126	119

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 4-8 Labor Utilization on Maize by Zone, Input Level, and Activity in Adult Equivalent Labor Days, 1994/95

Operation	Montepuez		Nampula
	High-input block	Low-input	Low-input
	(adult equivalent labor days per hectare)		
Field clearing, preparation and seeding	0	17	21
Thinning and weeding	21	29	27
Harvest	24	17	14
Total Labor Days	45	63	62

Source: 1994/96 MAP/MSU FSP Smallholder Survey

which is part of the high-input packages is hypothesized to be key in improving yields. Total adult-equivalent labor days per hectare is used as a proxy for weeding labor in the model.

Harvest is the final period of high labor demand for both crops. The maize harvest is performed in April and May and must compete with the harvest of other key food crops, while the cotton harvest takes place in June and July. During neither of these periods is the demand for farmer's labor from competing activities likely to be as high as during the weeding period; therefore harvest labor is assumed not to be a constraint in production of either crop and is excluded from both yield models.

4.1.4.3 Insecticide Use in Cotton Production

Insecticide is the only modern input, other than seed, provided to low-input cotton growers by the JVCs. Table 4-9 shows the distribution of insecticide applications among cotton growers in the sample by zone and production category. That some smallholders applied insecticide with significantly less frequency than their neighbors is intriguing, given its then-prevailing low farmgate cost, and its low labor requirement in terms of application.¹² The cotton model uses the number of insecticide applications on each plot,

¹² The variability in insecticide sprays per farmer, and its low farmgate cost, raises an issue which cannot be resolved with existing data concerning whether the JVCs actually strategically ration insecticide to smallholders based on their own objectives, rather than allowing equal access to all cotton growers.

Table 4-9 Insecticide Applications on Cotton by Zone and Production Category, 1994/95

Applications	Montepuez			Monapo / Meconta	
	High- input block	High- input dispersed	Low- input dispersed	Low- input block	Low- input dis- persed
	-- number of applications --				
Mean applications	5.0	3.8	2.8	3.6	2.8
Percent with	-- percent of households --				
0 applications	0	0	6	2	8
1 application	0	0	8	2	12
2 applications	0	0	20	8	12
3 applications	0	22	30	31	37
4 applications	0	74	35	38	26
5 applications	100	4	1	15	6
6 applications	0	0	0	2	0
7 applications	0	0	0	2	0

Columns may not add to 100 percent due to rounding.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

assuming each to be of equal strength.¹³ The question of insecticide applications on maize yields is not relevant, because no insecticide was used on any maize field in the study zone.

4.1.4.4 Timing of Input Provision and JVC Extension Services

To this point, we have considered the quantity of inputs provided, but have not given attention to the timing of input delivery and application. In the case of the two chief inputs provided by JVCs to low-input growers, seed and insecticide, should they arrive later than their recommended application dates, their potential impact on yield is diminished. Among smallholders in Montepuez and Monapo/Meconta, 20 and 41 percent respectively cited late provision of either seed, insecticide and/or spraying equipment as a complaint it had with their JVC during the 1994/95 season. Responses from this question are used in the cotton model to control for JVC input delivery system problems affecting yield. This issue is not relevant to the maize model because there was uniformity in terms of timing of input distribution and application in the high-input block scheme.

4.1.4.5 Inputs Unique to the High-Input Systems

The use of fertilizer, herbicide and tractorization is confined among all sampled cotton growers to those 40 high-input block and 27 high-input dispersed households, and in

¹³ Differing chemical formulations (Ultra Low Volume (ULV), Electro-Dyn (ED) and Emulcao Concentrada (EC)) with equivalent levels of active ingredients were distributed by the three JVCs during the study year, rendering insecticide quantity data from smallholder surveys difficult to interpret. Consider, for example, that three liters of ULV formulation has an equal amount of active ingredient as 750 mls prepared using the ED formulation. (Personal communication, Phil Tonks, 1996) This rendered data about insecticide quantity applied difficult to interpret.

maize to the 30 high-input maize growers. All these households are from Montepuez District. No other surveyed household used either fertilizer, herbicide or a JVC-provided tractor on their cotton or maize plots in 1994/95.

Initially a study goal had been to estimate the marginal physical product (MPP) of each input. To do so statistically requires that there be meaningful variation in application rates of each input across the sample. Without this variation, the problem of multicollinearity arises and estimates of standard errors are raised. This diminishes the probability that any or all of the highly correlated variables will be statistically significant, when in reality they may be quite important.

There is a potentially severe problem of multicollinearity in terms of herbicide, fertilizer and JVC-provided tractorization, as demonstrated in Table 4-10 within both the cotton and maize models. Consider first that in both cotton and maize high-input block schemes, farmers received a uniform package of herbicide, fertilizer, and tractorization from the JVC. High-input dispersed cotton producers demonstrate limited variability in terms of fertilizer use but no variation in terms of herbicide from high-input block fields. Meanwhile, no high-input dispersed field benefitted from JVC-provided tractorization.

During the process of model development and estimation, analysis of pairwise correlation coefficients confirmed a high degree of multicollinearity between herbicide, fertilizer and tractorization. This prohibits these variables from being included separately in each model and estimating the marginal effects to each. Given this problem, the following solution

Table 4-10 Input Package Description by JVC and Production Category, 1994/95

Input	Montepuez			Montepuez and Monapo /Meconta	
	High-input block		High-input dispersed	All low-input	
	Maize	Cotton	Cotton	Maize	Cotton
Tractor	Field prepared and seeded	Field prepared and seeded	None	None	None
Fertilizer (12-24-12)	150 kgs /ha	100 kgs/ha	14/27 use, mean quantity = 89 kgs	None	None
Herbicide	3.5 l/ha	3.5 l/ha	3.5 l/ha	None	None
Insecticide applications	None	5	Varies	Varies	Varies

Source: Interviews with Lomaco-Montepuez, SODAN, SAMO (1995)

was applied. In the cotton model, high-input block and high-input dispersed cotton are each treated as dichotomous variables, representing the packages of fixed combinations of the inputs as outlined in the above table.¹⁴ Similarly, in the maize model a dichotomous variable is computed for high-input block. Based on the parameters of each of these dichotomous variables, therefore, we will be able to compute the mean incremental effect of the respective packages.

4.1.4.6 Effect of Cotton Intensification on Maize Yields

An important food security benefit of cash-cropping is the extent to which intensification, driven in this case by cotton production, may have on food crop yields. Among the sample of 196 monocrop maize growers, 30 high-input maize growers also participated in the high-input cotton scheme. However, there are 21 households which did not participate in the high-input block scheme for maize, but who did participate in the high-input cotton scheme. By examining the production characteristics of this group we may gain insights into the potential effect of cotton intensification on maize yields.

Univariate analysis indicates that these 21 households, who according to initial categorization were considered "low-input maize growers," had mean maize yields statistically greater than the other 145 low-input maize growers included in the sample.¹⁵

¹⁴ High-input dispersed households show some variation in terms of fertilizer use. Caution must therefore be used in interpreting the parameter on the dichotomous variable used to represent this package in the cotton yield model.

¹⁵ The mean maize yield of the 21 high-input cotton households was 979 kgs, with standard deviation of 571 kgs. For the 145 other low-input maize households, their mean yield was 522 kgs, with standard deviation of 397 kgs. A t-test showed the former group

Smallholder survey data does not suggest any straightforward reason for these higher yields (i.e. use of herbicide, fertilizer, improved seed). To test for the potential cash crop intensification influence on food production, a dichotomous variable is incorporated into the maize model; this variable is equal to one if a household participated in the high-input block cotton scheme and zero otherwise.

4.1.4.7 Farm Management Skills and a Potential Self-Selection Bias

Farm management skills are an important productivity-related factor. Because this variable was not measured directly in the smallholder surveys, there is an potentially omitted variable problem in estimating the yield equations.

The JVCs may have knowledge of farmers' management capacity; if so, they undoubtedly use this information in determining who participates in the various cash-cropping schemes. For instance, it is probable that Lomaco attempts to allow only those households with a relatively high level of management and agronomic skills to participate in its high-input systems.¹⁶ This suggests that there is a potential "selection bias" which should be corrected for in modelling. Suppose that dichotomous variables relating to particular cotton production categories were included in a cotton yield model. These dichotomous variables would be designed to measure the "program effect," while holding constant other exogenous factors. With a serious selection bias, program estimates would be biased

to have statistically greater yields than the latter group at the .01 level.

¹⁶ The determinants of household cotton production category will be examined explicitly in Chapter 7 through discrete choice econometric models.

upwards. For example, consider the possibility that households in a particular cotton production category (e.g., high-input block) had been selected by the JVC partially because of better management skills. Without correcting for the problem, the coefficient on the high-input block cotton dichotomous variable would then over-estimate the program effect. That is, the coefficient would be capturing both the effects of the omitted management skills as well as the effect of the package of herbicide, fertilizer and tractorization. Farmers with lower skill levels would not be expected to attain productivity levels implied by such a coefficient using the same input package.

Given existing data, and with the possible selection bias, what is the best econometric technique to correct for this problem? Two models are estimated. First, the yield models are run with an additional explanatory variable, KGSTOR95 - the level of household cereal reserves during the 1995 hungry season, corresponding to the peak weeding labor demand period as well. KGSTOR95, measuring an important hungry season household asset, is designed to proxy for unobserved, productivity-related factors such as farmer management skills and capital. Note, however that interpretation of this variable is not conceived as capturing the effect of cereal storage on productivity, but rather as a proxy for the effect of unobserved variables important to yield determination with which KGSTOR95 is hypothesized to be highly correlated. Second, to the extent that KGSTOR95 may be simultaneously determined by the household when other production decisions are made, the yield models are estimated without this variable to test for robustness.

4.1.4.8 Village-Level Infrastructure

Village-level dichotomous variables (VIL1..n) are included in the yield models to control for variation in infrastructure across villages. Key types of infrastructure which may affect productivity include distance to JVC supply depots, road quality, market access, water resources and the availability of maize milling services. Table 4-12 identifies each village as it is defined in the models.¹⁷

4.2 Cotton Yield Model

The following two equations were estimated using a Cobb-Douglas functional form:

Equation 4-1

$$\ln(\text{YIELD}) = f(\text{HIGH_INB}, \text{HIGH_IND}, \ln(\text{INSECT}), \ln(\text{TOTWAE}), \ln(\text{SEEDWEEK}), \text{INSPESTS}, \text{VIL1..n}, \ln(\text{KGSTOR95}))^{18 \ 19}$$

Equation 4-2

same as Equation 4-1, but excludes $\ln(\text{KGSTOR95})$

where:

¹⁷ For an inventory of infrastructure in each surveyed village, see MAP/MSU FSP, 1996.

¹⁸ It was hypothesized that interaction terms should be included between INSPESTS and INSECT, and TOTWAE and herbicide use. These interaction terms were found to be statistically insignificant using F-tests of the constrained vs. unconstrained forms of the model.

¹⁹ As per the conceptual framework developed above, the model was run originally with four additional variables, all instrumented in a dichotomous manner. These were 1) whether the field was in a block, 2) soil quality, 3) unusual rain quantity, and 4) late input deliveries by JVCs. None of these variables was statistically significant. An F-test jointly testing the hypothesis that each was simultaneously equal to zero was accepted, and the more parsimonious model is reported here. Results of the fuller models are included in Table A2-1 (in Appendix 2).

YIELD=	kgs seed cotton production per hectare
HIGH_INB=	1 if high-input block package 0 otherwise
HIGH_IND=	1 if high-input dispersed field 0 otherwise
INSECT=	number of insecticide applications
TOTWAE=	total adult-equivalent weeding days per hectare, family and non-family included
SEEDWEEK=	seeding week, 1=earliest seeding week (2nd week, November), 2=3rd week, November...
INSPESTS=	1 if excessive insect infestation reported on field during growing season 0 otherwise
KGSTOR95=	cereal reserves, January 1995 (kgs)
VIL1..n=	village level dichotomous variables (see Table 4-12 for identification of each village)

Descriptive statistics of variables used in this model are provided by zone in Table 4-11 and the results of the model are reported in Table 4-13. Overall performance of the model indicates a high degree of explanatory power, with an adjusted R-square greater than 0.67 in both specifications. The signs of all variables are as expected, and each of the input and labor-related variables included in the final model are statistically significant at the .10 level or lower. Table 4-14 provides estimates of the marginal product of seeding date, insecticide and weeding labor, and the incremental effects of high-input block and high-input dispersed in each zone. INSPESTS - is assumed to be zero (no heavy insect infestation problem) in these calculations.²⁰

²⁰ To derive the marginal physical products, Equation 4-2 was re-estimated without $\ln(\text{TOTWAE})$ given that it is endogenously determined by the household, and we are interested in determining the effects of the various inputs and packages independent of any variable which arguably could be considered endogenous. Note, however, that estimates of marginal physical product change little in the with and without $\ln(\text{TOTWAE})$ cases. The marginal physical product of labor is derived directly from Equation 4-2.

Table 4-11 Mean and Standard Deviation of Variables in Cotton Yield Model

Variable	Montepuez		Monapo/Meconta	
	Mean	S.D.	Mean	S.D
YIELD	880	580	550	388
HIGH_INB	27 percent=1		0 percent=1	
HIGH_IND	18 percent=1		0 percent=1	
INSECT	3.61	1.30	3.13	1.30
TOTWAE	36.13	17.39	60.61	27.14
SEEDWEEK	4.68	1.80	6.61	1.91
INSPESTS	10 percent=1		7 percent=1	
KGSTOR95	385.5	446.3	73.2	138.7

Note: Arithmetic means and standard deviations are presented for all continuous variables, though natural logs are taken of these variables in the regression model.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 4-12 Definition of Village Level Dichotomous Variables^a

Variable	District	Village Name
VILMTZ1	Montepuez	Marrarange
VILMTZ2	Montepuez	Nacuaia
VILMTZ3	Montepuez	Nacuca
VILMTZ4	Montepuez	Nropa/Mondiane
VILMTZ5	Montepuez	Nacimoja
VILMTZ6	Montepuez	25 de Setembro
VILMTZ7	Montepuez	Linde
VILMON1	Monapo	Mepine
VILMON2	Monapo	Natete
VILMON3	Meconta	Napipine
VILMON4	Meconta	Varrua
VILMON5	Meconta	Napita
VILMON6	Monapo	3 de Fevereiro
VILMON7	Monapo	Namacopa
VILMON8	Monapo	Nacololo
VILMON9	Monapo	Picadane
VILCAR1	Ribaue	Namwali
VILCAR2	Mecuburi	Namina
VILCAR3	Mecuburi	Ratane
VILCAR4	Namapa	Nametumula
VILCAR5	Namapa	Jakoko

^a Variable names are given here for villages in each of the study zones, though CARE-OPEN villages are not incorporated into the yield models. These village level dichotomous variable names will be maintained for further econometric modelling in Chapter 7.

Table 4-13 Cotton Yield Equation Results

Variable	Equation 4-1			Equation 4-2		
	Coef- ficient	S.E.	P- value	Coef- ficient	S.E.	P- value
HIGH_INB	0.94	0.25	0.00	0.94	0.25	0.00
HIGH_IND	0.73	0.26	0.00	0.67	0.26	0.01
ln(INSECT)	0.82	0.06	0.00	0.81	0.07	0.00
ln(TOTWAE)	0.22	0.12	0.06	0.23	0.12	0.05
ln(SEEDWEEK)	-0.86	0.21	0.00	-0.85	0.21	0.00
INSPESTS	-0.45	0.22	0.04	-0.43	0.22	0.05
ln(KGSTOR95)	---	---	---	0.06	0.04	0.08
VILMTZ1	-0.25	0.27	0.36	-0.38	0.28	0.18
VILMTZ2	-0.15	0.32	0.64	-0.24	0.32	0.46
VILMTZ3	-0.56	0.28	0.05	-0.62	0.28	0.03
VILMTZ4	-1.60	0.29	0.00	-1.72	0.30	0.00
VILMTZ5	-0.38	0.36	0.29	-0.45	0.36	0.21
VILMTZ6	-0.71	0.41	0.08	-0.83	0.42	0.05
VILMON2	-0.31	0.36	0.39	-0.27	0.36	0.44
VILMON3	-0.03	0.48	0.95	0.05	0.48	0.91
VILMON4	0.31	0.28	0.28	0.28	0.28	0.32
VILMON5	-0.08	0.32	0.81	-0.13	0.32	0.69
VILMON6	-0.41	0.28	0.15	-0.33	0.28	0.24
VILMON7	0.10	0.30	0.75	0.16	0.30	0.59
VILMON8	-0.73	0.35	0.04	-0.63	0.35	0.07
VILMON9	-0.38	0.36	0.30	-0.28	0.36	0.44
Constant	6.00	0.57	0.00	5.79	0.58	0.00

Dependent variable=ln(YIELD)

N=279

Adjusted R-square = 0.676

F-stat = 30, Significance = 0.00

Adjusted R-square = 0.679

F Stat = 29, Significance = 0.00

Source: 1994/96 MAP/MSU FSP Smallholder Survey

The negative sign and level of statistical significance on seeding week is consistent with CIMSAN's on-farm research findings concerning the importance of early seeding. Estimates of the marginal effect of a one week delay in seeding date show a loss of between 51 and 115 kgs, representing roughly nine percent of mean yields, depending on zone and category.

The marginal product per day of weeding labor in cotton is positive and ranges from 1.6 to 4.1 kgs based on parameters from Equation 4-2. Assuming the official minimum farmgate seed cotton price of \$0.155/kg²¹ of 1994/95, this implies a marginal value product (MVP) of weeding labor of between \$0.25 and \$0.64. By comparison, the mean wage rate paid for agricultural labor during the principal weeding period was \$0.42-\$0.51. That the mean wage rate during this period was generally higher than or equal to the MVP_{labor} in cotton production (with the exception of the high-input block cotton scheme) is consistent with economic theory. MVP_{labor} in the high-input packages in Montepuez (3.1-4.1 kgs) is at least twice that in low-input schemes (1.6 kgs), indicating a strong complementary between intensification and labor. Determining economically efficient methods to increase labor productivity is fundamental to improving welfare, and these results begin to suggest that the intensification in cotton in the study zone may be one such method.

²¹ All values quoted in dollars in this section assumes a metical:dollar exchange rate of 9702:1, corresponding to the parallel market rate from July/August 1995.

Table 4-14 Estimation of Marginal Products and Incremental Effects of Selected Cotton Yield Equation Independent Variables, by Crop Production Category

	Production Category ¹		
	High-input block	High-input dispersed	Low-input (block and dispersed)
	-- kgs seed cotton/ha --		
Marginal product			
INSECT	279	154	89
TOTWAE	4.1	3.1	1.6
SEEDWEEK	-115	-88	-51
Incremental effect			
HIGH_INB	781		
HIGH_IND		598	

¹ Results in this table do not differentiate between the impacts for low-input cotton between Montepuez and Monapo/Meconta. This is appropriate based on the results of two statistical tests conducted. First, a t-test showed that a dichotomous variable for study zone (Montepuez vs. Monapo/Meconta) was not statistically significant. That is, parameter estimates are not statistically different between the two study zones, allowing for a single estimate of marginal physical product to be computed. Second, as explained in the accompanying footnote in the text, block (in Nampula) was found not to be statistically significant in the model. Therefore, separate estimates of the impact of INSECT, TOTWAE and SEEDWEEK for low-input dispersed and low-input block are not necessary.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Does insecticide, the only "modern" input used among low-input producers, pay off for farmers at subsidized prices in the low-input systems? To determine the significance of the effect of insecticide on yields, recall mean yield figures in Table 4-1 which showed Montepuez mean low-input cotton yields equal to 498 kgs, and those in Nampula equal to 574 kgs.²² Further, Table 4-8 showed insecticide application rates for the typical low-input smallholder in both zones at approximately 3 sprays. Evaluated at mean yield levels, Table 4-14 indicates the marginal effect of an additional (or fourth) insecticide application is to enhance yields by 89 kgs, representing a jump in cotton output of 17 percent. Assuming the 1994/95 farmgate insecticide prices of \$3.09 in Montepuez, an incremental application of insecticide showed a benefit:cost ratio from the farmer perspective of 4.5:1 in Montepuez (and near infinity in Monapo/Meconta due to its near zero price). This confirms that at very low costs, it is efficient for farmers to use more insecticide than was used in 1994/95. This further raises the question of what factors constrained those farmers with relatively low insecticide use rates from using higher quantities and, in all probability, achieving higher yields and financial profits.²³

Concerning the impact of intensification in cotton, the model provides convincing evidence that, compared to low-input cotton schemes, both high-input packages dramatically increase yields in a profitable way to smallholders. Table 4-14 shows that, on average, the incremental effect of the high-input block package is 781 kgs, representing a gross gain in

²² Assuming a simple average of the Monapo/Meconta block and dispersed categories.

²³ Even assuming insecticide costs at their non-subsidized 1995/96 levels (\$7.82 per application per hectare) and maintaining 1994/95 farmgate prices, the benefit:cost ratio to the farmer was still an attractive 1.8:1.

production value of \$121.05 to the smallholder. The high-input dispersed incremental effect was lower at 598 kgs, with farmgate value of \$92.69. Farmgate costs per hectare were \$80.04 (block package) and \$37.51 (dispersed package) for the dispersed package.²⁴ This generates a private benefit:cost ratio for the farmer of 1.5:1 and 2.5:1 in the high-input block and dispersed schemes, respectively.

Importantly, coefficient estimates of the variables of analytical interest related to productivity are robust to the two model specifications (with and without KGSTOR95). Related to the selection bias problem which KGSTOR95 was intended to alleviate, the robustness of the model indicates either 1) that KGSTOR95 is a poor proxy for unobserved productivity-related factors; or 2) that these factors and hence the selection bias are not important. While it is not statistically possible to distinguish between these two possibilities, it is difficult to believe that there is not some strategic behavior on the part of the JVCs to select those it considers most likely to succeed to participate in its more intensive input packages. Of greater relevance, however, is the observation that the yield results are robust between the two specifications, providing strong evidence concerning the impact of those variables estimated.

²⁴ See Table 5-2 for a breakdown of these costs.

4.3 Maize Yield Model

The following models were estimated using a Cobb-Douglas functional form:

Equation 4-3

$$\ln(\text{YIELD}) = f(\text{HIGH_INB}, \text{HIGH_LOW}, \text{LANDQUAL}, \ln(\text{TOTWAE}), \text{RAINPROB}, \text{VIL1..n}, \ln(\text{KGSTOR95}))^{25}$$

Equation 4-4

same as Equation 4-3, but excludes $\ln(\text{KGSTOR95})$

where:

YIELD =	kgs maize grain production per hectare
HIGH_INB =	1 if high-input maize block 0 otherwise
HIGH_COT =	1 if high-input cotton participant 0 otherwise
LANDQUAL =	1 if soil quality is judged high for maize w/no nutrient depletion 0 otherwise
TOTWAE =	total adult-equivalent weeding days, family and non-family included
RAINPROB =	1 if drought reported on field during growing season 0 otherwise
KGSTOR95=	cereal reserves, January 1995 (kgs)
VIL1..n=	village level dichotomous variables (see Table 4-12 for identification of each village)

Descriptive statistics of all variables used in this model are shown in Table 4-15, with model results found in Table 4-16. Overall model performance for one year cross-sectional analysis is good, with an adjusted R-square of 0.465. Comparison of model performance to similar cross-section single season cereal yield models in the Southern Africa region suggests a relatively good statistical fit. For example, yield models developed from single year cross-sectional data for maize in Zimbabwe in (1985/86)

²⁵ The model was originally run including variables for seeding week and level of insect infestation. Each of these variables was individually statistically insignificant based on t-tests. A joint F-test of their parameters simultaneously being equal to zero was accepted. Thus, the model presented is considered the final model, given its advantage of being parsimonious. The fuller model with these additional variables is presented in Table A2-2.

Table 4-15 Mean and Standard Deviation of Variables in Maize Yield Model

Variable	Montepuez		Monapo/Meconta	
	Mean	S.D.	Mean	S.D
YIELD	994	851	422	273
HIGH_INB	24 percent=1		0 percent=1	
HIGH_LOW	41 percent=1		0 percent=1	
LANDQUAL	44 percent=1		64 percent=1	
TOTWAE	34.31	16.30	39.23	17.67
RAINPROB	58 percent=1		26 percent=1	
KGSTOR95	400.9	483.8	86.1	167.5

Note: Arithmetic means and standard deviations are presented for all continuous variables, though natural log are taken of these variables in running the model.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 4-16 Maize Yield Equation Results

Variable	Equation 4-3			Equation 4-4		
	Coef- ficient	S.E.	P- value	Coef- ficient	S.E.	P- value
HIGH_INB	0.71	0.19	0.00	0.71	0.19	0.00
HIGH_LOW	0.30	0.18	0.09	0.31	0.18	0.09
LANDQUAL	0.19	0.10	0.05	0.19	0.10	0.05
ln(TOTWAE)	0.14	0.08	0.08	0.14	0.08	0.09
RAINPROB	-0.26	0.12	0.03	-0.26	0.12	0.03
ln(KGSTOR95)	---	---	---	-0.01	0.03	0.79
VILMTZ1	0.57	0.21	0.01	0.58	0.22	0.01
VILMTZ2	0.90	0.22	0.00	0.90	0.22	0.00
VILMTZ3	0.59	0.21	0.00	0.59	0.21	0.00
VILMTZ4	0.37	0.21	0.08	0.37	0.21	0.08
VILMTZ5	-0.12	0.28	0.66	-0.13	0.28	0.65
VILMTZ6	-0.33	0.32	0.30	-0.33	0.32	0.30
VILMON2	-0.21	0.32	0.51	-0.22	0.32	0.49
VILMON3	-0.36	0.35	0.29	-0.39	0.36	0.28
VILMON4	0.28	0.23	0.23	0.27	0.23	0.24
VILMON5	-0.33	0.26	0.21	-0.33	0.26	0.22
VILMON6	-0.32	0.21	0.14	-0.34	0.23	0.13
VILMON7	0.16	0.25	0.53	0.14	0.27	0.61
VILMON8	-0.25	0.25	0.33	-0.27	0.27	0.32
VILMON9	0.05	0.35	0.88	0.03	0.36	0.93
Constant	5.40	0.32	0.00	5.44	0.35	0.00

Dependent variable=ln(YIELD)

N=196

Adjusted R-square = 0.468

F-stat = 10, Significance = 0.00

Adjusted R-square = 0.465

F Stat = 9.5, Significance= 0.00

Source: 1994/96 MAP/MSU FSP Smallholder Survey

showed adjusted R-square = 0.31 and 0.22, for millet in Namibia (1992/93). (Rohrbach (1988) and Keyler (1996)) Further, the signs of individual parameters are all as predicted.

Table 4-16 shows the marginal physical product (MPP) of labor and the mean incremental effects of high-input block maize and of high-input block cotton participation on maize yields. Clearly, the dominant explanatory variable in terms of its magnitude is the high-input maize package itself, with an impact of 1,056 kg/ha. HIGH_COT is both statistically significant and meaningful in magnitude, improving yields by 720 kg/ha. This provides statistical evidence of a significant impact of cotton intensification on maize yields. The question of whether low-input cotton has an independent effect on maize yields was tested with a dichotomous variable (equal to one if the household was in a low-input cotton scheme, zero otherwise) and found to be statistically insignificant.

To calculate a realistic benefit:cost ratio of the high-input maize scheme, given that 24 of its 30 participants were also high-input cotton participants, we add the high input block cotton effect ($720 \text{ kgs/ha} * (24/30) = 600 \text{ kgs/ha}$) to the 1,056 kg/ha individual impact, resulting in an overall effect of 1,656 kgs/ha. Recall that Lomaco paid high-input block maize participants the government minimum of \$0.088; thus, the high-input maize scheme generated gross revenues on a per hectare basis of \$145.72 to the producer. With gross costs per hectare of \$110.02, the scheme was, on average, profitable to participants with a private benefit:cost ratio of 1.3:1.²⁶

²⁶ Computations in Table 4-15 were made assuming the farmer experienced normal rainfall and had relatively fertile land quality.

Table 4-17 Estimation of Marginal Products and Incremental Effects of Selected Maize Yield Equation Independent Variables, by Production Category¹

	Production Category	
	High-input block	Low-input dispersed
	(kgs)	(kgs)
Marginal product		
TOTWAE	5.9	2.1
Incremental effect		
HIGH_INB	1056	
HIGH_COT	720	

¹ Results in this table do not differentiate between the impacts for low-input maize between Montepuez and Monapo/Meconta. This is appropriate based on the results of a t-test which showed that a dichotomous variable for study zone (Montepuez vs. Monapo/Meconta) was not statistically significant. That is, parameter estimates are not statistically different between the two study zones, allowing for a single estimate of marginal physical product to be computed.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 4-17 also presents the marginal product of weeding labor. Low-input weeding labor marginal products are, as was the case in the cotton model, well below labor productivity when labor was combined with high-input packages, further suggesting high-input packages and manual labor are complements in the production process. Evaluated using the official minimum maize price, the MVP_{li} is \$0.18, compared with MVP_{hi} is \$0.53. Further, as would be predicted from economic theory, MVP_{li} is lower than (or roughly equal to) the average wage level paid (between \$0.42 and \$0.51) for agricultural labor by sampled households.

Returning to the question of a possible selection bias in high-input block maize scheme, the proxy attempted to correct for this factor, KGSTOR95, was not statistically significant in this case. Note, however, that model results were robust to the two specifications - with and without KGSTOR95. Again, this does not necessarily mean that the selection bias does not actually occur with respect to the high-input block maize scheme. That the results are robust to the two specifications, however, indicates the strength of the other results generated by the model.

4.4 Conclusions

As outlined in the introduction to this chapter, two important and related goals of this dissertation are to understand the determinants of productivity in smallholder cash- and food-cropping in the study zone and the relative attractiveness of these crops to smallholders, the JVCs and the nation. This chapter has provided strong evidence concerning what factors are significant in determining cotton and maize yields. Low-input

cotton was shown to be highly responsive to early seeding and to a sufficient amount of insecticide applications and weeding labor. The high-input packages available to selected households in Montepuez were shown to have high and statistically significant effects on yield. Partial farm level benefit:cost ratios for each of these inputs showed that, on average, they were privately profitable to the farmer.

Maize model results showed a significant yield effect from the high-input package.

Further, cotton intensification was shown to have a strong effect on maize yields.

Univariate analysis showed that maize yields in Monapo/Meconta were significantly below those of Montepuez, though the econometric modelling did not point to a clear reason to account for this difference in food crop productivity across study zones. In any case, developing a strategy for improving the very low maize yields in Monapo/Meconta represents a plausible and important opportunity to reduce food insecurity in that zone.

Chapter 5

Financial Analysis of Cotton, Maize, and Manioc Enterprises:

The Smallholder and JVC Perspectives

5.0 Introduction

Profitability of cotton, maize, and manioc to farmers in the "cotton belt" is analyzed in this chapter through the use of enterprise budgets. Farm-level budgets are presented for high-input cotton and maize schemes in Montepuez, low-input cotton schemes in both Montepuez and Monapo/Meconta, and traditional maize and manioc enterprises in both zones. Although it is typical in the literature to report a single enterprise budget for a given zone, crop, and farming system as representative, a modification is made here. In the context of a high degree of variation in yield and input use within groups and the richness of the cross-sectional data set in terms of detailed labor, input, and production data, budgets are broken out by yield tercile. And to provide additional insight into the cash crop:food crop relationship, maize and manioc results are grouped according to the household's cotton production category.

From the smallholder perspective, analysis will focus on two key profitability indicators: net returns per adult equivalent (ae) family labor day and net returns per hectare. In similar settings of relatively low levels of agricultural technology and seeming land abundance, it would be typical to give less attention to returns to land, assuming family labor represents the key production constraint. However, recall evidence cited earlier from the 1991 and 1993 FSP Nampula studies, and results from Chapter 3 from 1994/95 suggesting that access

to land may be a constraining factor for a meaningful proportion of households in the cotton belt. This would imply that a focus on land-saving technologies may be key for these households, and thus justifies the attention to private returns to land.

This chapter compares profitability between technology groups for each crop by zone. Likewise, the sample is broken within crop-yield tercile categories to consider the relationship between yield variation, input use and financial profitability. The chapter is organized in five sections. First, there is a review of insights gained from the yield models in Chapter 4 and a consideration of how enterprise budget analysis may complement these results. The second section briefly explains the sub-sample used for each crop and the methods used in computing the budgets. The enterprise budgets and profitability measures are presented and analyzed in the third section.

Sensitivity analysis in the fourth section tests the robustness of smallholder profitability indicators to changes in key input and output price parameters. With regard to cotton, the official minimum output price increased 119 percent in real terms (from \$0.155 to \$0.339 per kg) in 1995/96 from the previous year. Gains to farmers were moderated, however, by considerable increases in the price of insecticide in the wake of the elimination of donor subsidies. How do 1995/96 price parameters change the private profitability of cotton relative to maize and manioc? Sensitivity analysis is also conducted on maize price. Recall from Chapter 3 that a low proportion of total maize production is sold in the case of most smallholders, and that many households, particularly in Monapo/Meconta were actually net food buyers during the relevant twelve month period. Based on a similar smallholder cash

crop-food crop setting in Zimbabwe, Jayne (1994) argues that for net food buying households, profitability measures of food crops should value production at the price which farmers as consumers must purchase food during the hungry season, rather than the farmgate sales price at harvest. The implication of valuing maize at the higher purchase price rather than the sales prices for the relative profitability of maize and cotton is addressed.

Having identified which cash-cropping schemes are most attractive to smallholders, in the fifth and final section we consider JVC profitability in each relevant cotton and maize scheme. In the context of severe input and credit market failure, it is of key importance to ask: Are those JVC-related cash-cropping schemes which show favorable returns for smallholders profitable to the JVCs? For those schemes where both JVCs and smallholders demonstrate attractive performance, the JVCs represent a useful device for policy-makers to look toward as they attempt to improve rural incomes. Where JVCs are found to experience losses, regardless of smallholder performance, the JVC is likely to exit with previous input and credit market failures again limiting these opportunities.

5.1 Yield Model Insights and the Farm-Level Budgets

The yield models provided statistical evidence of a causal link between intensification and productivity in both maize and cotton. Partial private benefit:cost estimates based on model parameters and farmgate input and output prices showed the incremental effects of the high-input schemes, on average, were profitable to participating farmers. Further, intensification dramatically increased the marginal product of household labor in both cotton and maize.

The cotton yield equation showed the marginal product of an additional insecticide

application was privately profitable and equal to 89 kgs/ha or 17 percent of mean yields in low-input schemes. An important goal of the enterprise budgets will be to determine the extent to which the relationships identified between input use and its marginal and incremental profitability corresponds to overall profitability for the household.

5.2 Enterprise Budget Methods and Assumptions

The methods used in computing the cotton, maize, and manioc enterprise budgets attempt to mirror the financial costs and revenues experienced by farmers on a per hectare basis during the 1994/95 cropping season. The budgets maintain the sample of 279 cotton plots and 196 maize plots from the 1994/95 cropping season used in the yield equations, while the manioc budgets use data from 198 plots where manioc was the principle crop. The relevant production costs are divided into the following four categories and are discussed below: 1) labor and land; 2) seed; 3) agricultural chemicals and tractor services; and 4) farm implements.

5.2.1 Valuation of Labor

At the prevailing low state of agricultural technology in rural Mozambique, family labor and land are the most important inputs in any smallholder agricultural enterprise. However, since no payments are made to these two inputs¹, both are excluded from the enterprise budgets as costs. Detailed family labor data is displayed by activity in the budgets, permitting a comparison of the quantity of labor used by crop across zone-production

¹ Note the lack of a land sales or rental market throughout the study zone.

category-crop-yield tercile groups. Labor hired by the family represents a cost and is therefore incorporated within the budget. To value hired-labor accurately, smallholder surveys carefully distinguished within each activity and labor episode between family and non-family labor. In each activity, when labor was hired by the family, smallholders were asked the number of days and hours each non-family member was employed and the total compensation provided. This data was used to calculate an average amount of family and non-family labor hired for each budget. Mean wage rates were calculated for each zone and two-month period to compute the value of payments to hired labor and are shown in Table 5-1.²

5.2.2 Valuation of Seed and Manioc Planting Material

Cotton seed is distributed at no cost by the JVCs to low-input smallholders in both zones and to high-input dispersed growers in Montepuez. Smallholders in the high-input block scheme paid \$5.62 for mechanical seeding per hectare in 1994/95.

Neither maize seed nor manioc cuttings represent a financial cost for the vast majority of low-input households. Ninety-three percent of smallholders reported that they had stored maize seed from production from the previous year. For those low-input maize producers

² Smallholder surveys did not include the labor activity component during the fifth round (January 1996), and thus did not ask about the amount of labor used on the principle manioc harvest in September-October 1995. Data supplied by the Posto Agronomico de Nampula concerning manioc harvest labor is therefore used, and assumed constant across the sample. In on-farm trials, it was reported that 37 labor days were required to harvest 1.67 tons fresh manioc per hectare. Assuming relevant conversion factors, this translates into a daily harvest rate of 9.42 kgs dried manioc equivalent per labor day during harvest.

Table 5-1 Mean Daily Wage Rates Paid by Smallholders, by Zone and Two-Month Period, 1994-95

<u>Two-month period</u>	<u>Montepuez</u>	<u>Monapo/Meconta</u>
	(\$ equivalent) ¹	
September-October	\$ 0.47	\$ 0.44
November-December	\$ 0.52	\$ 0.60
January-February	\$ 0.51	\$ 0.53
March-April	\$ 0.42	\$ 0.40
May-June	\$ 0.45	\$ 0.53
July-August	\$ 0.45	\$ 0.46
Annual unweighted	\$ 0.47	\$ 0.49
Official minimum agricultural wage	\$0.41 to \$ 0.50 ²	

¹ Of 4,003 instances where sampled households hired labor, in 50 percent of those labor episodes, remunerations were made in cash, with all other episodes being made in in-kind payments, inherently more difficult to value. Mean daily wage rates are calculated using exclusively the payments made in cash. It is assumed that this results in unbiased estimates of mean wage rates.

² Note that the minimum wage was adjusted during the study period. The values shown here reflect the extremes of the real minimum wage experienced during the study period.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

purchasing seed, the value spent per hectare on purchased seed is incorporated in the budgets. Meanwhile high-input block maize participants were charged \$18.34 per hectare.³

5.2.3 Agricultural Chemicals and Tractorization Costs

A complete list of input costs for the Montepuez high-input packages is shown in Table 5-2.⁴

5.2.4 Output Valuation

Survey data shows all seed cotton sales were made at the official government minimum of 1500 Mts or \$0.155 per kg assuming a mid-1995 parallel exchange rate of 9,702 Mt per dollar. All high-input block maize participants received the minimum price of 850 Mts or \$0.088 per kg from the JVC. Mean maize sales prices at harvest (June 1995) for other surveyed households was slightly less: \$0.084 per kg in Montepuez and \$0.074 per kg in Monapo/Meconta. Farmgate sales prices for dried manioc at its principle harvest period (October 1995) were \$0.146 per kg in Montepuez and \$0.105 per kg in Monapo/Meconta. These prices are used to value production in their respective zones in the enterprise budgets.

³ It is also assumed that planting material for manioc comes from either cuttings from that household's fields or was otherwise obtained at no cost to the household; data specifying the source of manioc cuttings was not included in the smallholder survey.

⁴ Hoes and machetes, the principle farm implements used by smallholders, are assumed to cost 10,000 Meticaïs per unit based on smallholder expenditure data, with an assumption of three implements purchased and fully used per hectare, in the absence or plot specific data. This equates to a \$3.09 cost per hectare.

Table 5-2 Farmgate Cost of Purchased Inputs for Maize and Cotton Charged by JVCs, 1994/95

Input / operation	Montepuez				Monapo / Meconta
	Maize	Cotton			Cotton
	High- input block	High- input block	High- input dispersed	Low- input dispersed	Low- input block and dispersed
	(\$ per hectare)				
Mechanized field preparation	\$32.87	\$23.59	n.a.	n.a.	n.a.
Mechanized fertilizer application	\$36.44	\$25.58	n.a.	n.a.	n.a.
Mechanized seeding	\$18.34 ¹	\$5.62	n.a.	n.a.	n.a.
Fertilizer (per kg)	n.a.	n.a.	\$0.26	n.a.	n.a.
Insecticide	n.a.	\$7.73	\$5.65	\$4.94	\$0.72
Herbicide	\$22.37	\$25.25	\$25.25	n.a.	n.a.
Total package cost	\$110.02	\$87.77	\$43.21 ²	\$4.94	\$0.72

¹ Includes \$6.80 charge for fungicide treatment of maize seed.

² Assumes fertilizer usage by the same proportion (53 percent) in this category as of sampled high-input dispersed households at the same mean application rate of 89 kgs/ha.

Source: Interviews with officials at Lomaco-Montepuez, SODAN-Namialo, and SAMO-Monapo, 1995 and 1994/96 MAP/MSU FSP Smallholder Survey.

5.3 Enterprise Budgets and Analysis

Tables 5-3 through 5-8 present summaries of the cotton, maize, and manioc enterprise budgets by zone, cotton category and yield tercile. Table 5-9 provides mean returns to labor and land in each crop by zone and cotton category; values from this table are compared frequently for statistical testing purposes below.

5.3.1 Analysis of Cotton Enterprise Budgets

Tables 5-3 and 5-4 show that Montepuez high-input cotton growers experience returns for their own labor (\$1.91 to \$2.41 per ae day), on average, two to four times greater than low-input cotton growers in either Montepuez or Monapo/Meconta (\$0.62 to \$0.93). These differences are statistically significant at the .05 confidence level. While not as dramatic, returns to land for high-input cotton growers (\$102 to \$105 per ha) are also greater than for low-input cotton growers (\$65 to \$93 per ha).

Examination of the enterprise budget summaries suggests the explanation of these differences in returns to labor goes beyond the variation in input packages. For example, in the second yield tercile, high-input participants used much less household labor (42.40 to 45.39 ae labor days per ha) compared to low-input participants in both zones (90.39 to 115.86 ae labor days per ha). Weeding labor (including hired labor) for high-input households at the second yield tercile ranged from 26.02 to 35.69 ae labor days per ha, compared to 49.06 to 73.46 ae labor days per ha across low-input cotton groups. That herbicide users employed much less weeding labor overall than non-herbicide users is logical, and points out herbicide's labor-saving attribute in cotton production.

Table 5-3 Cotton Enterprise Budget Summary, Montepuez, by Cotton Production Category and Yield Tercile, 1994/95

Budget Item	Cotton Production Category								
	High-input block			High-input dispersed			Low-input dispersed		
	1	2	3	1	2	3	1	2	3
	Cotton Yield Tercile								
Seed cotton yield (kgs/ha)	1045	1483	1796	649	1227	1661	200	501	1010
Seed cotton price (\$/kg)	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155
Gross revenue (\$/ha)	\$161.49	\$229.26	\$277.73	\$100.34	\$189.64	\$256.73	\$31.00	\$77.47	\$156.13
Purchased inputs excluding labor	\$95.00	\$95.00	\$95.00	\$49.97	\$55.75	\$53.72	\$10.08	\$13.01	\$14.92
Hired labor (\$/ha)	\$16.86	\$24.18	\$36.24	\$7.66	\$32.33	\$31.47	\$4.70	\$10.15	\$15.07
Insecticide applications	5.00	5.00	5.00	3.78	3.67	4.00	2.26	3.21	3.83
Herbicide applications	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
Fertilizer applications	1.00	1.00	1.00	0.53	0.53	0.53	0.00	0.00	0.00
Tractor provided	Yes	Yes	Yes	No	No	No	No	No	No
Weedings	2.38	2.36	2.62	2.22	2.56	2.44	2.35	2.75	2.74
Family ac labor days	44.37	42.40	42.07	55.39	45.39	65.32	72.06	90.39	89.48
Net returns to land (\$/ha)	\$49.63	\$110.07	\$137.51	\$42.72	\$101.56	\$171.54	\$16.21	\$54.31	\$126.13
Net returns to family labor (\$/ac day)	\$1.12	\$2.60	\$3.48	\$0.77	\$2.24	\$2.63	\$0.22	\$0.60	\$1.41

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-4 Cotton Enterprise Budget Summary, Monapo/Meconta, by Cotton Production Category and Yield Tercile, 1994/95

Budget Item	Cotton Production Category								
	Low-input block			Low-input dispersed					
	1	2	3	1	2	3	1	2	3
Maize Yield Tercile									
Seed cotton yield (kgs/ha)	337	627	1080	155	448	917			
Seed cotton price (\$/kg)	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155	\$0.155			
Gross revenue (\$/ha)	\$52.12	\$96.98	\$166.93	\$23.91	\$69.31	\$141.79			
Purchased inputs excluding labor	\$3.71	\$3.84	\$3.93	\$3.53	\$3.75	\$3.86			
Hired labor (\$/ha)	\$2.24	\$8.35	\$19.18	\$1.62	\$3.93	\$5.95			
Insecticide applications	3.00	3.65	4.06	2.12	3.19	3.73			
Herbicide applications	0.00	0.00	0.00	0.00	0.00	0.00			
Weedings	3.14	3.71	3.56	2.62	3.30	3.73			
Family ac labor days	96.42	116.86	104.48	88.33	110.64	141.91			
Net returns to land (\$/ha)	\$46.17	\$84.79	\$143.82	\$18.76	\$61.63	\$131.98			
Net returns to family labor (\$/ac day)	\$0.48	\$0.73	\$1.38	\$0.21	\$0.56	\$0.93			

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-5 Maize Enterprise Budget Summary, Montepuez, by Cotton Production Category and Yield Tercile, 1994/95

Budget Item	Cotton Production Category											
	High-input block			High-input cotton/ Low-input maize			Low-input dispersed			No cotton		
	1	2	3	1	2	3	1	2	3	1	2	3
Maize Yield Tercile												
Maize grain yield (kg/ha)	871	1900	3185	328	1000	1610	238	475	1188	194	434	1190
Harvest farmgate price (\$/kg)	\$0.088	\$0.088	\$0.088	\$0.084	\$0.084	\$0.084	\$0.084	\$0.084	\$0.084	\$0.084	\$0.084	\$0.084
Gross revenue (\$/ha)	\$76.28	\$166.46	\$279.05	\$27.58	\$84.10	\$135.49	\$20.01	\$39.98	\$99.93	\$16.32	\$36.52	\$100.12
Purchased inputs excluding labor (\$/ha)	\$113.12	\$113.12	\$113.12	\$3.09	\$3.70	\$3.70	\$3.09	\$3.09	\$3.09	\$3.56	\$3.09	\$3.09
Hired labor (\$/ha)	\$4.09	\$8.31	\$7.62	\$3.21	\$9.34	\$9.06	\$3.96	\$2.98	\$2.34	\$1.03	\$4.11	\$1.62
Weedings	1.56	1.40	1.40	1.86	1.71	1.86	1.80	1.87	2.00	2.00	2.00	1.89
Herbicide applications	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer applications	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tractor provided	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
Family labor (ac days/ha)	26.68	19.84	49.28	49.08	29.11	39.79	56.33	51.06	59.57	81.74	55.46	68.65
Net returns to land (\$/ha)	(\$40.93)	\$45.03	\$158.31	\$21.28	\$71.06	\$122.73	\$12.96	\$33.91	\$94.50	\$11.73	\$29.32	\$95.41
Net returns to family labor (\$/ac day)	(\$1.53)	\$2.27	\$3.21	\$0.43	\$2.44	\$3.08	\$0.23	\$0.66	\$1.59	\$0.14	\$0.53	\$1.39

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-6 Maize Enterprise Budget Summary, Monapo/Meconta, by Cotton Production Category and Yield Tercile, 1994/95

Budget Item	Cotton Production Category									
	Low-input block					Dispersed				
	1	2	3	1	2	3	1	2	3	No cotton
Maize Yield Tercile										
Maize grain yield (kg/ha)	218	423	918	181	332	657	162	339	593	
Harvest farmgate price (\$/kg)	\$0.074	\$0.074	\$0.074	\$0.074	\$0.074	\$0.074	\$0.074	\$0.074	\$0.074	
Gross revenue (\$/ha)	\$16.11	\$31.24	\$67.82	\$13.38	\$24.50	\$48.57	\$12.01	\$25.05	\$43.80	
Purchased inputs excluding labor (\$/ha)	\$3.80	\$3.70	\$3.09	\$4.72	\$4.00	\$4.00	\$3.09	\$5.64	\$3.94	
Hired labor (\$/ha)	\$0.20	\$0.25	\$6.24	\$1.40	\$0.74	\$0.09	\$0.00	\$0.00	\$0.36	
Weedings	1.83	2.17	2.00	2.15	2.14	2.21	2.00	2.00	2.00	
Herbicide applications	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Family labor (ac days/ha)	52.53	48.14	60.35	49.33	62.97	75.30	55.12	75.96	59.46	
Net returns to land (\$/ha)	\$12.11	\$27.29	\$58.49	\$7.26	\$19.76	\$44.57	\$8.92	\$19.41	\$39.50	
Net returns to family labor (\$/ac day)	\$0.23	\$0.57	\$0.97	\$0.15	\$0.31	\$0.59	\$0.16	\$0.26	\$0.66	

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table S-7 Manioc Enterprise Budget Summary, Montepuez, by Cotton Production Category and Yield Tercile, 1994/95

Budget Item	Cotton Production Category									
	High-input cotton (block and dispersed)					Low-input dispersed				
	1	2	3	1	2	3	1	2	3	No cotton
Manioc Yield Tercile										
Dried manioc yield (kg/ha)	234	440	875	174	316	612	205	411	833	
Dried manioc farmgate price (\$/kg)	\$0.146	\$0.146	\$0.146	\$0.146	\$0.146	\$0.146	\$0.146	\$0.146	\$0.146	
Gross revenue (\$/ha)	\$34.13	\$64.24	\$127.84	\$25.46	\$46.14	\$89.28	\$29.99	\$60.06	\$121.57	
Purchased inputs excluding labor (\$/ha)	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	
Hired labor (\$/ha)	\$2.94	\$9.41	\$5.26	\$1.83	\$1.37	\$1.72	\$1.83	\$0.86	\$0.39	
Family labor (ac days/ha)	56.20	62.40	128.76	46.42	87.41	103.08	51.65	98.81	139.59	
Net returns to land (\$/ha)	\$28.13	\$51.74	\$119.40	\$20.48	\$41.68	\$84.54	\$25.01	\$56.06	\$118.14	
Net returns to labor (\$/ac day)	\$0.50	\$0.83	\$0.93	\$0.44	\$0.48	\$0.82	\$0.48	\$0.57	\$0.85	

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-8 Manioc Enterprise Budget Summary, Monapo/Meconta, by Cotton Production Category and Yield Tercile, 1994/95

Budget item	Cotton Production Category								
	Low-input block			Low-input dispersed			No cotton		
	1	2	3	1	2	3	1	2	3
Manioc Yield Tercile									
Dried manioc yield (kg/ha)	408	854	1638	257	511	1210	200	478	1016
Dried manioc farmgate price (\$/kg)	\$0.105	\$0.105	\$0.105	\$0.105	\$0.105	\$0.105	\$0.105	\$0.105	\$0.105
Gross revenue (\$/ha)	\$42.73	\$89.48	\$171.62	\$26.90	\$53.54	\$126.79	\$20.91	\$50.09	\$106.50
Purchased inputs excluding labor (\$/ha)	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09
Hired labor (\$/ha)	\$0.00	\$1.16	\$13.05	\$7.44	\$0.00	\$0.16	\$0.00	\$0.00	\$0.00
Family labor (ac days/ha)	89.02	138.53	196.76	52.68	102.88	188.49	51.39	103.15	142.51
Net returns to land (\$/ha)	\$39.75	\$85.42	\$155.85	\$16.46	\$50.57	\$123.80	\$17.91	\$47.10	\$103.59
Net returns to labor (\$/ac day)	\$0.45	\$0.62	\$0.79	\$0.31	\$0.49	\$0.66	\$0.35	\$0.46	\$0.73

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-9 Mean Returns to Labor in Cotton, Maize and Manioc by Cotton Production Category and Zone, 1994/95

	Cotton		Maize		Manioc	
	Labor	Land	Labor	Land	Labor	Land
Zone / Cotton Production Category						
Montepuez	(\$ per a.e. labor day - \$ per hectare)					
High-input block	2.41	102	1.82 ¹	56	0.78	66
High-input dispersed	1.91	105				
Low-input dispersed	0.78	65	0.92	46	0.61	49
No cotton	n.a.	n.a.	0.71	41	0.68	66
Monapo / Meconta						
Low-input block	0.93	93	0.64	27	0.61	93
Low-input dispersed	0.62	70	0.39	22	0.51	63
No cotton	n.a.	n.a.	0.36	21	0.51	56

¹ Includes only those households in high-input block maize.

² Because categorization is done based on cotton category and the desirability of grouping high-input block maize growers together, high-input dispersed cotton growers in the high-input maize block are grouped with high-input block cotton growers. The few remaining households in this cotton category are excluded from the computation of group means for maize. With respect to manioc, where there is no high-input group, all high-input dispersed cotton households are grouped with high-input block cotton growers.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

High-input households hired more non-family labor (valued at \$24.18 to \$32.33 per ha) than low-input cotton growers (valued at \$3.93 to \$10.15 per ha), much of this hired labor being to meet demand during the weeding period.⁵ This suggests that access to herbicide (and tractorization in the block scheme) for high-input cotton households enables expansion of area planted to cotton while limiting household labor requirements, particularly at the time of weeding. Further, Table 3-2 showed that high-input cotton growers cultivated more cotton area (2.10 to 2.30 ha) than low-input households in Montepuez (0.94 ha) and Monapo/Meconta (1.15 ha), with these differences being statistically significant at the .01 level. High-input cotton households' larger area planted in food crops (see Table 3-5) and greater maize yields (see Table 4-1) suggest that these gains in cotton area did not come at the expense of food crop area or productivity. This is consistent with findings from the yield equations that showed cotton under intensification is relatively more profitable than low-input cotton, and also may have a positive effect on food crop area and productivity. At a minimum, counter to the charges of cash-cropping critics in traditional SSA agriculture, the analysis shows no deleterious effect of cash-cropping on food-cropping under intensification of the former.

To this point, this section has limited itself to mean private profitability measures, and shown certain advantages of the high-input schemes. Caution should be exercised in interpreting results, however, given the significant variation in profitability observed between high and

⁵ Given the lack of formal credit institutions available to smallholders with possibility for collateral, the source of the operating capital required to pay non-family laborers is important, though this was not included in the smallholder survey.

low yield terciles in high-input cotton. Consider that returns to labor (\$1.12 per ae labor day) are less than one-third the levels of the high yield tercile (\$3.48 per ae labor day) in the Montepuez block. Possible explanations include access to greater amounts of hired labor and earlier weeding in the high yield terciles. For example, hired labor in the high yield tercile was valued at \$36.24 per ha, compared with \$16.86 per ha in the low yield tercile; family labor was nearly equivalent at 42.07 and 44.37 ae labor days per ha, respectively. A competing explanation is that better farm management employed by those with superior performance explain much of the yield difference; unfortunately, available data does not allow us to measure this effect empirically.

Private profitability in the low yield tercile of both high-input block and dispersed cotton was still relatively attractive (at \$1.12 and \$0.77 per family ae labor day) compared to wage levels paid off-farm (shown in Table 5-1). The more important point, however, is that risk increases with intensification, both on the part of the JVC and the smallholder. In fact, financial losses were experienced by three of the 67 sampled high-input cotton households. With little collateral and highly limited liquidity, the JVC (Lomaco) has reported high default rates among those households with financial losses in a given season in the high-input schemes (for both cotton and maize). (Personal communication, Phil Tonks, 1996) It is possible that in years with generally low yields (due to poor rainfall or other factors), the incidence of losses by smallholders would increase. For successful intensification (from both the smallholder and the JVC perspective) to flourish, appropriate practices must be developed to handle this type of inter-annual risk. We consider this subject again in the concluding chapter.

Limiting the analysis to low-input cotton households, there are three important results. First, in Monapo/Meconta, returns to block farmers, both in terms of family labor (\$0.93 per ae labor day) and land (\$93 per ha) are statistically greater (significant at the .05 level) than dispersed households (\$0.62 per ae labor day and \$70 per ha). Recall from the cotton yield equation, however, that the effect of block land itself was found, somewhat surprisingly, not to be statistically meaningful in predicting yield.⁶ Non-block factors, therefore, must be at the root of the difference between block and dispersed performance in Monapo/Meconta. Comparing second-tercile budget summaries, we observe that block households had greater access to insecticide (3.65 v. 3.19 applications) than dispersed growers, and also hired more non-family labor (valued at \$8.35 vs. \$3.93 per ha). Thus, while block land quality itself may not result in higher yields, it appears that farmers gain access to greater levels of insecticide (which the JVC may find easier to deliver in a concentrated area) and hire somewhat more non-family labor, explaining part of the higher returns for Monapo/Meconta block growers.

Second, we compare high to low yield tercile budgets within low-input categories and consider the relationship between input usage, household labor, and private profitability. For example, among Monapo/Meconta dispersed households, those in the high yield tercile used more insecticide (3.73 vs. 2.62 applications), greater family labor (141.91 vs. 88.33 ae labor days per ha), and modestly more hired labor (valued at \$5.95 vs. \$1.62 per ha). Returns per

⁶ Recall from Table 5-1 that mean 1994/95 Monapo/Meconta block cotton yields were 678 kgs/ha, compared to Monapo/Meconta dispersed yields of 470 kgs/ha. A t-test shows statistical significance at the .01 level.

ae family labor day show high yield tercile farmers' earnings are more than four times greater (\$0.93 vs. \$0.21 per ae labor day). This pattern - improved private profitability associated with greater input and labor use (both family and non-family) - is evident in each low-input group in both zones. The consistency of these results with findings from the yield equations, which also showed the private profitability of insecticide and household labor (at the margin) for low-input cotton producers, is striking.

This analysis suggests that for low-input cotton production, as it is currently defined in the cotton belt to generate attractive returns to smallholders (e.g., those in the high yield tercile levels), a necessary condition is for a household to have access to sufficient and timely insecticide supplies and enough household and/or hired labor at key periods. Without these two conditions, poor performance mirroring the extremely low labor and land returns of first yield tercile growers across low-input categories in both zones is likely to continue.

Third, there is no statistical evidence suggesting a difference in private profitability of low-input dispersed cotton schemes between the two primary study zones. This is consistent with the statistical insignificance of the zone variable in the cotton yield equation. Low-input (dispersed) Montepuez growers earn higher returns to labor (\$0.78 vs. \$0.62 per ae labor day) than Monapo/Meconta dispersed growers, but the reverse is true in terms of returns to land (\$65 vs. \$70 per ha); note that neither difference is statistically significant. Meanwhile, returns to labor in Monapo/Meconta block production (0.93 per ae labor day) is somewhat higher than in Montepuez (\$0.78), but again these differences are not statistically significant.

5.3.2 Analysis of Maize and Manioc Enterprise Budgets

Discussion in this section focuses first on inter-group comparisons for both maize and manioc. To understand the effect of cotton growing on food crop production, enterprise budgets are grouped for these two food crops by the household's cotton production category. To gain insight into the question of cotton intensification on food crops, we focus particular attention on the 21 high-input cotton households who grew maize outside the high-input scheme, and group them as a separate category in the enterprise budgets. This is followed by analysis of intra-group variation based on yield terciles.

5.3.2.1 Inter-Group Comparisons of Maize and Manioc Private Profitability

Returns in high-input block maize in Montepuez average \$1.82 per ae family labor day (see Table 5-5). This level of performance, with associated yields of 1,900 kgs per ha in the second tercile, is from two to five times higher than returns to labor in all low-input maize groups where yields (see Tables 5-5 and 5-6) ranged from 332 to 475 kgs per ha and labor returns were \$0.53 to \$0.73 per ae day.⁷ This is consistent with the strong incremental effect (1,924 kgs/ha) of the high-input block maize scheme on maize yields found in the yield equation.

The high-input block maize scheme is input-intensive and requires little manual labor relative to low-input maize, particularly for weeding given the use of herbicide. Mechanized

⁷ Mean yields in the low-input maize/high-input cotton category are much higher than low-input maize yields for households outside the high-input cotton scheme. This group is discussed separately below.

field preparation and seeding and purchased inputs valued in the scheme range from \$117 to \$121 per ha (including labor); meanwhile, no other maize and manioc tercile groups shows greater than \$13 per ha in purchased inputs. Overall manual labor use is low (19.84 household ae labor days per ha in the second yield tercile), given that it is required for only one to two weedings (which are likely not to be difficult, given the use of herbicide) and at harvest. Low-input maize and manioc are much more labor intensive, requiring from 48.14 to 75.96 family ae labor days per ha in maize and from 62.40 to 138.53 ae labor days per ha in manioc.

Limiting the analysis to traditional maize and manioc producers, we consider the extent to which profitability varies based on whether a household grows cotton. First, in Montepuez, returns to family labor in maize are higher for cotton growers (\$0.92 per ae labor day) than non-growers (\$0.71 per ae labor day), though a t-test shows this difference is not statistically significant. Likewise, the slight difference in favor of cotton growers in mean returns to land between these two groups in Montepuez (\$46 v. \$41 per ha) is not statistically significant. Manioc profitability among non-cotton growers in Montepuez, on the other hand is slightly higher (\$0.68 vs. \$0.61 per ae labor day and \$66 vs. \$49 per ha) than for low-input cotton growers, though again with no statistical significance of differences.

In Monapo/Meconta, returns to family labor in maize is higher for block cotton producers (\$0.64 per ae labor day) than for non-cotton growers (\$0.36 per ae labor day), with this difference being statistically significant at the .10 confidence level; meanwhile, dispersed cotton growers have maize returns of \$0.39 per ae labor day, slightly higher (but not

statistically different) than non-cotton growers. With respect to manioc, the block cotton group demonstrates higher returns to both labor and land (\$0.61 per ae labor day and \$93 per ha) compared to non-cotton farmers (\$0.51 per ae labor day and \$56 per ha); again these differences are statistically indistinguishable.

5.3.2.2 Association of High-Input Cotton on Food Crop Profitability

Recall that the maize yield equation showed a strong positive association between intensification in cotton and maize yield. Specifically, the 21 households who were high-input cotton producers and who grew maize outside the high-input block were identified as having significantly higher maize yields than other traditional maize producers. Table 5-5 also reveals that this group has much higher returns to labor (\$2.44 per ae family labor day) than all other low-input maize categories (\$0.36 to \$0.92 per ae family labor day in Tables 5-5 and 5-6).

Examination of the budgets reveals little which explains the differential performance of this group. These households did not report using any herbicide, fertilizer, nor tractorization. Curiously, however, this group had second tercile yields (1,000 kgs per ha) much higher than their neighbors (434 to 475 kgs per ha). A possible explanation is that some inputs (e.g. herbicide or fertilizer) intended for use on cotton plots were diverted to their maize plots; such diversions are common in similar schemes in Zambia. (Stringfellow, 1996) Similarly, it is possible that, having access to these inputs in cotton enabled these households to obtain additional quantities for use on maize, but that because this was not permitted under the terms of the JVC:smallholder contract, smallholder surveys did not capture this information.

Regardless of the reason, this provides another piece of evidence of a positive interaction between intensification in cotton and productivity in maize.

To summarize, recall that a key question in the food crop:cash crop debate is the effect of cash-cropping on food crop profitability and food security. This analysis has provided two pieces of evidence to inform this question. First, in neither province does low-input cotton production demonstrate any statistically significant positive or negative association with either food crop profitability indicator. This result runs counter to the argument of those who suggest cash-cropping may negatively affect food production. By contrast, when smallholders grow cotton under intensification, facilitated by the JVC, both the maize yield equation and the enterprise budgets provide evidence that this enhances maize profitability and productivity.

5.3.2.3 Within-Group Comparison of Maize and Manioc Private Profitability

In addition to being the scheme with the highest returns to labor in maize, the high-input block scheme also imposes considerable financial risk upon participants. This is analogous to the relative risk levels of high-input cotton discussed above. To gain insight into the nature of this risk, we compare this scheme's low and high yield tercile budgets. In the low yield tercile, the mean yields was 871 kgs while gross revenue was \$76.28 per ha; the \$113.12 cost of purchased inputs resulted in financial losses for this group of \$40.93 per ha. Meanwhile, third tercile households, who used the same input package as those in the first tercile, had mean yields of 3,185 kgs per ha and attractive returns of \$158.31 per ha and \$3.21 per ae family labor day. Partial explanations may be:

- 1) third tercile households applied more family labor (49 v. 27 ae labor days per ha) including during weeding (31 v. 15 ae labor days per ha) in comparison to first tercile households;
- 2) third tercile households hired more labor overall (valued at \$7.62 v. \$4.09 per ha);
- 3) lack of rainfall and poor germination rates cited by several households in the low yield tercile as explanatory factors;
- 4) soil fertility differences; and
- 5) differential management skills though available data does not permit testing this hypothesis.

Regardless of the reasons for poor maize yields among this group, this further confirms the seriousness of the problem highlighted above with respect to the high-input cotton schemes. Intensification increases the potential value of production for operating capital-constrained farmers, but also increases costs. This translates into increased risk that in a given cropping season, farmers may experience losses which liquidity constraints may prohibit them from paying off, exposing the JVC to significant losses and broader social tension.⁸ Potential mechanisms for dealing with risk under intensification on an inter-annual basis will be discussed in the conclusions in Chapter 8.

Among traditional maize and manioc growers, there is a high level of variation in yield which is directly correlated to profitability indicators. For example, among Monapo/Meconta non-cotton growers, first and third tercile maize growers experienced

⁸ Note that in the surveyed village with the most frequent incidence of financial losses in the high-input maize scheme, Marrarange, several farmers refused to pay back maize input costs with cotton profits. The negative social tension from this incident was, in all probability, the key factor that caused Lomaco to discontinue the otherwise successful high-input scheme in cotton in this village in 1995/96.

yields of 162 and 593 kgs per ha and earned returns per labor day of \$0.23 v. \$0.97, respectively. Both these differences are statistically significant at the .01 probability level. What explains this difference in mean yield? Each group applied similar amounts of total family labor per ha (55 v. 59 ae days) including during weeding (23 days each), and hired virtually no labor, but had yields of 162 v. 593 kgs respectively. Natural factors identified in the yield model such as land quality and rainfall may explain part of the difference here, though much of the variation remains difficult to explain with existing data. Notwithstanding the factors behind these extremely poor yields, understanding their causes represents a priority toward improving productivity growth and food security enhancement among this vulnerable population.

5.4 Comparison of Returns to Cotton and Food Crops

In this section, we are still using food prices actually received by farmers to value production. If cotton is found to be more profitable than maize or manioc in some cases, it does not necessarily imply that farmers should abandon food production in favor of cotton. Rather, the analysis in this section is designed to compare the commercial attractiveness of food crops at harvest prices to returns in cotton. In other words, the analysis seeks to identify where farmers would obtain the greatest returns to household resources for that portion of their agricultural production intended for sale.

5.4.1 Comparison within Zone/Cotton Category Groups

Among Montepuez high-input block cotton growers, returns to family labor and land in cotton (\$2.41 per ae labor day and \$102 per ha) are higher than for high-input maize (\$1.82

per ae labor day and \$56 per ha) or manioc (\$0.78 per ae labor day and \$66 per ha). On the other hand, low-input dispersed cotton growers show their highest returns to labor in maize (\$0.92 per ae labor day) and to land in cotton (\$65 per hectare).

Do these returns suggest that non-cotton growing households should begin to grow cotton in Montepuez? Assuming the short-run cotton option for these households is the low-input dispersed category, their 1994/95 returns to labor in maize (\$0.71 per ae labor day) and manioc (\$0.68 per ae labor day) are only slightly lower than mean cotton returns (\$0.78 per ae labor day). These differences lack statistical significance. This would suggest that in Montepuez, low-input cotton-growing does not significantly improve non-cotton growers returns to labor assuming current mean yield and profitability levels, and the valuation method used for retained maize. On the other hand, cotton profitability at the third yield tercile among Montepuez low-input households is much higher (\$1.41 per ae labor day) than mean maize profitability levels. This suggests attention be paid to findings presented here concerning productivity determinants which would allow low-income cotton profitability to be enhanced.

For both block and dispersed cotton growers in Monapo/Meconta, cotton is currently more profitable than maize, both in terms of returns to labor and land with these differences being statistically significant at the .05 level. Switching the comparison to manioc, however, results are altered. For example, low-input dispersed cotton growers earn \$0.51 per ae labor day in manioc, which is somewhat lower than their returns in cotton (\$0.62 per ae labor day), but this difference is not significant statistically. Manioc returns for both Monapo/Meconta

cotton groups (\$93 and \$63 per hectare) are equal to or slightly below those for cotton (\$93 and \$70 per hectare).

Does cotton-growing improve returns to household resources in Monapo/Meconta compared to the set of food crop alternatives analyzed? Consider the case of non-cotton growers in this zone, whose returns in maize are \$0.36 per ae labor day and \$21 per ha and manioc are \$0.51 per ae labor day and \$56 per ha. Meanwhile, their cotton-growing neighbors experience mean returns to cotton of \$0.62 to \$0.93 per ae labor day and \$70 to \$93 per ha. Assuming non-cotton growers could expect returns equal to or greater than the mean of their neighbors, switching family labor and land out of maize, where returns are particularly low, and into cotton may improve returns to household resources. As was pointed out previously, sufficient and timely availability of insecticide and labor would be required for these households to see welfare improvements by growing cotton.

5.5 Sensitivity Analysis

Sensitivity analysis is conducted within this section to consider the implications on returns to family labor of changes in price parameters from the base 1994/95 case. With respect to cotton, government and donor policy toward the sector changed markedly from 1994/95 to 1995/96. KR-II donor insecticide subsidies ended; as a result, JVCs charged \$7.82 per insecticide application per ha, in comparison to \$3.09 (Montepuez) and \$0.21 (Monapo/Meconta) during the study year. Pan-territorial minimum seed cotton prices increased dramatically during the same period, from \$0.155 to \$0.339 per kg. Table 5-10 shows the implications of applying these changes on returns to family labor in cotton and

Table 5-10 Sensitivity Analysis, Returns to Family Labor in Cotton, Scenarios A, B, and C

	Scenario A			Scenario B			Scenario C		
	1994/95 Base Case			1995/96 Seed Cotton Price and 1994/95 Insecticide Price			1995/96 Seed Cotton Price and 1995/96 Insecticide Price		
	Yield Tercile			Yield Tercile			Yield Tercile		
	1	2	3	1	2	3	1	2	3
Montepuez									
High-input block	\$1.12	\$2.60	\$3.48	\$5.46	\$9.05	\$11.35	\$5.22	\$8.79	\$11.10
High-input dispersed	\$0.77	\$2.24	\$2.63	\$2.93	\$7.22	\$10.53	\$2.79	\$7.05	\$10.34
Low-input dispersed	\$0.22	\$0.60	\$1.41	\$0.74	\$1.62	\$3.49	\$0.67	\$1.55	\$3.43
Menapo/Meconta									
Low-input block	\$0.48	\$0.73	\$1.38	\$1.12	\$1.71	\$2.94	\$0.93	\$1.56	\$2.76
Low-input dispersed	\$0.21	\$0.56	\$0.93	\$0.54	\$1.30	\$2.12	\$0.43	\$1.16	\$2.07

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Scenario A: Harvest season maize price for each zone = \$0.087 in Montepuez High-input block, \$0.084 rest of Montepuez, \$0.074 Monapo/Meconta
Scenario B: Hungry season maize purchase price, = \$0.22 in Montepuez, \$0.21 in Monapo/Meconta

Source: 1994/96 MAP/MSU FSP Smallholder Survey

maize. Scenario B assumes the 1995/96 output price while maintaining the low insecticide prices from the 1994/95. Scenario C assumes both 1995/96 seed cotton and insecticide prices. Scenario A represents the base case. Two patterns are apparent. First, as expected, holding input prices constant and increasing the real output price from 1994/95 to 1995/96 levels by 118 percent dramatically increases returns to family labor. More interesting, however, is that as smallholders pay a significantly higher insecticide prices, returns per family labor day are little changed in each category. Second, the dismal returns in both provinces in the first tercile low-input groups remain quite low. Increasing returns to labor among this group requires, in addition to price policy, productivity enhancement through, at a minimum, increased input use in cotton, or their focus on non-cotton alternatives. Note that for many of these households, however, even the small contribution that cotton makes to their cash incomes is meaningful, given the lack of other secure options to obtain cash.

Sensitivity analysis for maize displays returns when production is valued entirely at hungry season mean purchase prices in Monapo/Meconta (\$0.21 per kg) and Montepuez (\$0.22 per kg) in Scenario B and compares them to Scenario A, the base case. Note that Scenario B represents roughly a threefold increase in price from sales prices received in the harvest period. Caution should be exercised in the interpretation of this table in terms of its commercial applicability for maize producing households, as few households were able to sell significant proportions of their maize production at these prices. Rather, its usefulness is limited to representing the significant proportion of smallholders, particularly in Monapo/Meconta, who were net food buyers during the relevant twelve-month period.

Consider second tercile maize returns for Monapo/Meconta block cotton growers in Maize Scenario B (\$1.76), which now exceed cotton Scenario A (\$0.73). Maize becomes relatively more profitable than cotton. This implies that those households who are significant net food buyers do not benefit by growing cotton at the relative prices and yield levels assumed in this comparison until assuring food security through household production (or other methods). If this is the case and assuming perfect information at the time of planting in terms of all relevant parameters and their food market position, what explains so many net maize buyers growing cotton and getting such disappointing returns in Monapo/Meconta?

Consider that under all scenarios, we have assumed prices to value all food production based on those experienced in the sample. This was necessary in order to have a common numeraire with which to compare returns in cash and food crops. However, stable and predictable food prices in rural markets is not characteristic of this zone; in some relatively more isolated villages, few farmers sell any agricultural products outside cotton as market outlets do not exist. Yet, these households desperately need to generate some cash to purchase consumer goods. That these households choose to grow cotton because it is the only agricultural commodity with a certain output market does not indicate that it is an attractive option. For farm level profitability among this population to improve, productivity enhancing technologies must become available.

Assuming the persistence of similar seasonality in cereals prices in this zone, this analysis suggests that three prior conditions for food-deficit cotton-belt households to grow cotton profitably using low-input technologies are 1) to improve cereals productivity, or 2) have

access to lower cost food market alternatives during the hungry season, or 3) enjoy greater cotton profitability than 1994/95 mean levels.

5.6 Financial Analysis of the JVCs in Smallholder Schemes

The preceding analysis of smallholder financial outcomes in JVC cash-cropping schemes has provided strong evidence that cotton, and to a lesser extent maize, are attractive cash crops for a significant proportion of participating smallholders in the study zone. For this success to continue and expand, the JVCs' continued investment and support is vital, given the severe input market failure and their legalized cotton monopsony in the study zone. This requires that the outgrower schemes be profitable to the JVCs. In this section, first we consider the profitability of the major cotton schemes (high-input block, high-input dispersed, and low-input) to the JVCs.⁹ Second, the high-input block maize scheme, the only case where a JVC actively supported smallholder food production in 1994/95, is analyzed from the JVC perspective as well. Yield and input parameters required for this analysis are derived from the enterprise budgets, reflecting the 1994/95 harvest year.

⁹ Much data for this analysis depends on financial records of Lomaco from the 1995/96 cropping year. Parallel financial data was not available from Lomaco for the 1994/95 season in equal detail. Neither was it possible to obtain corporate financial records from the other JVCs in sufficient detail to perform such analyses. It is assumed that the 1995/96 data used herein is largely representative of the revenue and cost structures of the JVCs in the study zone. Fok (1995) discusses the difficulties of conducting such financial analyses of the JVCs, and also presents some revenue and cost parameters based on the 1993/94 cropping season.

5.6.1 Revenue Generated from Smallholder Cotton to the JVCs

Seed cotton produced by and purchased from smallholders in the study zone is transported by the JVCs to their ginneries in Montepuez, Namialo and Monapo. In the ginning process, the cotton fiber is separated from the seed. The primary economic value of seed cotton is for its transformation into cotton fiber. The rate at which seed cotton from the study zone is transformed into fiber, the ginning outturn rate (GOR), is approximately 34 percent.

(CIMSAN (1995), Lomaco (1996)) The fiber is exported, with the JVCs selling typically at an FOB Pemba or Nacala price.¹⁰ Table 5-12 displays mean FOB Pemba cotton fiber sales prices received by Lomaco-Montepuez for its production from 1987-1996.¹¹ The 1994/95 mean price received by Lomaco (\$1,715 per ton) represented a ten year high; rather than using this extreme price, we assume the ten year mean price (\$1,329 per ton) for the base case to be as representative as possible of long term JVC profitability.

The cotton ginning process produces one by-product, cotton seed, which has economic value. It represents 59 percent of pre-ginning weight. Lomaco reports receiving \$80 per ton for its cotton seed, which it sells to the edible oil and soap factories located in Monapo City. Seven percent of seed cotton is considered trash and has no value. (Lomaco (1996)) Table 5-13 summarizes the uses and revenues of seed cotton generated to the JVC.

¹⁰ A small amount of cotton fiber is also consumed by the domestic textile industry. For details, see Fok (1995).

¹¹ Lomaco-Montepuez began operations in 1990. Data from 1987-89 reflects prices received by the Empresa Estatal de Algodao for fiber production from the Montepuez ginnery.

Table 5-12 Mean Lint Cotton Price Received by Lomaco-Montepuez, FOB Pemba, 1987-96

Year¹	Mean Price, FOB Pemba
	(\$/ton)
1987	1189
1988	1060
1989	1610
1990	1693
1991	1275
1992	1035
1993	980
1994	1435
1995	1715
1996	1438
1987-96 mean	1329

¹ Lomaco-Montepuez began operations in 1990. Prices reported in this table prior to 1990 reflect prices received by the Empresa Estatal de Algodao, Montepuez.
Source: Interview with Lomaco staff, December 1996.

Table 5-13 Utilization and Market Value of Seed Cotton Purchased from Smallholders by JVCs

Utilization	Conversion Factor From Seed Cotton	Relevant Market	Price Received by JVC
Cotton fiber	34 percent	FOB, Pemba or Nacala	\$1329 per ton ¹
Cotton seed	59 percent	Oil and soap factories, Monapo	\$80 per ton at factory
Trash	7 percent	n.a.	n.a.

¹ Ten year mean FOB price received for Montepuez smallholder cotton.
Source: Interview with Lomaco staff, December 1996.

Table 5-14 Revenue Received by JVCs per Hectare of Smallholder Cotton Production by Input Category, 1994/95

Product	Production Category		
	High-Input Block	High-Input Dispersed	Low-Input¹
	-- kg/ha --		
Seed cotton yield	1442	1179	569
Cotton fiber yield	493	403	194
Cotton seed yield	851	696	336
Revenue	-- \$/ha --		
Cotton fiber @ \$1,329 / ton	655	535	258
Cotton seed @ \$80 /ton	68	56	27
Total revenue	723	591	285

¹ In the absence of financial data from SODAN and SAMO concerning their revenue and cost structure, the Lomaco low-input scheme is assumed in this section to be representative of the low-input cotton enterprises of the three JVCs.

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Lomaco (1996)

Assuming mean 1994/95 yields from smallholder production in each of the three categories, Table 5-14 shows revenues generated per hectare of smallholder cotton production, ranging from \$723 for the high-input block scheme to \$285 for the typical low-input case.

5.6.2 JVC Costs of Supporting Smallholder Cotton Production and Transformation

To determine profitability of the range of cotton schemes to the JVCs, we now consider their costs incurred. These costs are broken down between on-farm and post-farm costs.

5.6.2.1 JVC On-Farm Costs in Smallholder Cotton

Table 5-15 provides an explanation of the economic costs of variable inputs applicable to all smallholder cotton schemes in the study zone based on 1994/95 conditions. Table 5-16 then divides these costs between the portions paid by the smallholder and by the JVC by scheme showing that net JVC on-farm costs range from \$119.20 per hectare (high-input block) to \$41.16 per hectare (low-input).¹²

5.6.2.2 JVC Post-Farm Costs in Smallholder Cotton

There are three expenditure types which the JVC must pay to transform seed cotton at the farmgate into cotton fiber for sale at the F.O.B. Pemba/Nacala price: 1) trading and collecting costs; 2) ginnery costs; and 3) post-ginning costs. These costs, presented in Table 5-17, are computed on a per fiber ton basis, and are equal across input packages. Costs per

¹² To be as representative as possible of the long-run cost structures faced by the JVCs, it is assumed that for insecticide farmers were charged the 1995/96 rate applied by the three JVCs (\$7.82 per application per hectare), rather than the much lower subsidized rates from 1994/95.

Table 5-15 Cost of Variable Inputs in Smallholder Cotton and High-Input Block Maize Production in the Study Zone, 1994-95

Item	Total Cost
Cotton seed	\$2.40 per ha assuming that the recommended 30 kgs/ha are distributed to the smallholder and that the JVC could have sold this product at \$80 per ton to the edible oil and soap factory.
Maize seed	Entire cost paid by smallholder.
Insecticide	\$10.95 per application; Assuming each application consists of three liters @ \$3.65 per liter CIF Nacala/Pemba.
Insecticide sprayer	\$0.15 per application; Each ULV knapsack sprayer costs \$45.00, CIF Pemba, and has an expected life span of three years; Lomaco has 1 sprayer per 22 ha cotton in family sector.
Fertilizer	\$0.30 per kg, CIF Pemba for 12-24-12 (N-P-K).
Herbicide	\$10.21 per liter, CIF Pemba for cotton herbicide; \$8.75 per liter CIF Pemba for maize herbicide.
Herbicide sprayer	\$5.00 per application; Each sprayer costs \$140.00, CIF Pemba, has an expected life span of three to four years. Lomaco has 1 sprayer per 8 ha in high-input cotton.
Batteries for sprayers	\$0.22 per battery, CIF Pemba, assuming one battery required for each hectare of pesticide application.
Tractor services	Lomaco estimates that the total cost of tractor operation, including depreciation and spare parts is equal to \$1.00 per liter of diesel fuel used per hectare. In 1994/95 and 1995/96, Lomaco charged farmers during the study year charged farmers at the rate of \$0.77 per liter.
Extensionist salary	Based on total cotton fiber production in 1995/96 by Lomaco Montepuez of 2,930 tons, and total extensionist salaries of \$116,354, this results in extension costs of \$39.71 per ton cotton fiber.
Transport of inputs	Lomaco records indicate total expenditures for transport from the Port of Pemba to the farmgate of family sector cotton inputs (or those used in both the low-input and high-input schemes) of \$304,858 (or \$104 per fiber ton). Transport of inputs specifically for the high-input schemes had total costs of \$32,378, or \$11 per fiber ton (based on total production of 280 tons).

Sources: Henriques (1996), Tonks (1996), Carvalho (1996).

Table S-16 Farm-level Cost to JVC of Supporting Smallholder Cotton Production, by Category, 1994/95

Item	Cotton Production Category									
	High-Input Block					High-Input Dispersed				
	Total Cost	Farmer Pays	JVC Pays	Total Cost	Farmer Pays	JVC Pays	Total Cost	Farmer Pays	JVC Pays	Low-Input Farmer Pays
	(\$/ha)									
Seed	2.40	0	2.40	2.40	0	2.40	2.40	0	2.40	0
Insecticide	54.75	39.13	15.62	41.77	29.85	11.92	33.95	24.26	9.69	0
Insecticide sprayer	0.68	0	0.68	0.52	0	0.52	0.42	0	0.42	0
Fertilizer	30.00	26.00	4.00	13.84	12.00	1.84	0	0	0	0
Herbicide	30.63	25.25	5.38	30.63	25.25	5.38	0	0	0	0
Herbicide sprayer	5.00	0	5.00	5.00	0	5.00	0	0	0	0
Tractor services	37.69	29.21	8.48	0	0	0	0	0	0	0
Extensionist salary	19.57	0	19.57	16.00	0	16.00	7.72	0	7.72	0
Transport of inputs	56.72	0	56.72	41.93	0	41.93	20.23	0	20.23	0
Batteries	1.35	0	1.35	1.08	0	1.08	0.70	0	0.70	0
Total cost per hectare	238.79	119.59	119.20	153.17	67.10	86.07	65.24	24.26	41.16	
Seed cotton yield (kg/ha)		1442			1179			569		
Cotton fiber yield (kg/ha) ¹		490			401			193		
Total cost per kg fiber	0.49	0.24	0.25	0.38	0.17	0.21	0.34	0.13	0.21	

¹ Assuming 34 percent ginning outturn rate.

Source: Lomaco (1996), Interviews with SODAN and SAMO staff (1996), 1994/96 MAP/MSU Smallholder Survey.

Table 5-17 Post-farm JVC Costs of Cotton Fiber Production

	Explanation	\$/ton fiber
Trading and collecting costs		
Seed cotton purchase	Farmgate price=1500 Mt/kg and Mt:\$ exchange rate of 9702:1	455
Sacks	Each sack costs \$0.85, CIF Pemba and has a one year lifespan and capacity of 120 kgs seed cotton	21
Staff	1995/96 cost=\$8,802	1
Transport	1995/96 cost=\$217,455	74
Ginnery		
Staff	1995/96 cost=\$49,897	17
Ginning costs	1995/96 cost=\$293,918	100
Depreciation	1995/96 charge=\$34,610	12
Post-ginning		
Insurance	Fixed cost of \$12/ton	12
Transport to port	1995/96 cost=\$18,667	6
Port charges	1995/96 cost=\$20,582	7
IAM tax	3.5 percent, FOB price	47
Export tax	0.5 percent, FOB price	7
Interest on cotton purchase	46 percent interest rate on Mt denominated loan for 150 days	194
Management and overhead	25 percent of Lomaco-Maputo costs=\$123,000 in 1995/96 plus Montepuez costs of \$32,481	21
Total cost per fiber ton		974

Source: Lomaco (1996), 1994/96 MAP/MSU FSP Smallholder Survey

ton of most items are dependent on the scale of throughput relative to capacity at a given gin during a given ginning season. This analysis relies on data from the 1995/96 Lomaco ginning season, where 2,930 tons of fiber was produced (or 39.8 percent of its estimated capacity of 8,500 tons, assuming a 34 percent GOR) and indicates total post-farm costs to the JVC of \$974 per ton of fiber. This low utilization of ginning capacity is assumed to be characteristic of conditions at the SODAN and SAMO facilities also.

5.6.3 JVC Financial Profitability in Smallholder Cotton

Having determined JVC revenues and costs in smallholder cotton, it is possible to determine financial profits. Significantly, Table 5-18 shows that each scheme is financially profitable to the JVCs, when assuming ten year mean world cotton prices, current yields, GOR and smallholder:JVC cost-sharing structure. On a per hectare basis, JVC profits are \$127 (high-input block), \$115 (high-input dispersed), and \$56 (low-input).

Of course, this analysis represents only a first step in establishing JVC profitability in working with smallholder cotton. Sensitivity analysis conducted in Chapter 6 will shed insights concerning the range of world prices, producer prices, yield levels and GORs where the JVCs make profits in smallholder cotton

5.6.4 High-Input Block Maize from the JVC Perspective

In contrast to their enthusiasm for supporting smallholder cotton in the study zone, the JVCs have been reluctant to invest in smallholder food production. Lomaco management's

Table 5-18 JVC Profit Analysis in Smallholder Cotton, by Production Category

	Production Category		
	High-Input Block	High-Input Dispersed	Low-Input
		(\$/ha)	
Revenue	723	591	285
Costs			
On-Farm	119	86	41
Post-Farm (@ \$974/ton)	477	390	188
Total Costs	596	476	229
Profit (Loss)	127	115	56

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Henriques (1996), Tonks (1996), Carvalheira (1996)

original decision to invest in smallholder maize in 1991 was driven largely by emergency demand for domestic maize. Under war-time conditions, donor-driven relief programs elsewhere in Cabo Delgado Province and in the rest of Mozambique forward contracted with the JVC for maize delivery immediately following harvest at fixed and favorable prices (and in all probability above prevailing market rates). Eliminating the maize price risk the firm faced allowed it, in turn, to commit to paying smallholders the government minimum maize price and remain profitable.¹³ With the return to peace and the scaling back of emergency feeding programs, donors have discontinued this arrangement. As such, without a guaranteed contract for its maize and for other reasons (e.g., high transport costs to major urban demand centers, price risk, etc.), Lomaco ended the high-input block maize scheme following the 1994/95 season. In this section we consider the profitability of maize in the high-input block system from Lomaco's perspective assuming that it must sell its production in market conditions, either elsewhere in Mozambique or on the regional/world market from the Port of Pemba.

5.6.4.1 Market Value of Northern Mozambican Maize

The market value of maize within the Southern Africa region is bounded by prices outside the region, with upper limits being related to import parity and lower limits to export parity. In years when the region is in deficit and Mozambique must import from outside the region, such as 1994/95, maize from the north competes with imports arriving in Maputo. Following

¹³ Another advantageous reason from the firm's perspective to support smallholder maize is that it represents an attractive crop to rotate with cotton on the blocks.

5-19 Calculation of Maputo Import Parity Price of White Maize, 1995

Item	(\$/ton)
Yellow maize, FOB Gulf	\$123
Premium for white maize	\$10
Freight and insurance, Gulf to Maputo	\$36
Port charges and bagging	\$14
Transport from port to warehouse	\$3
Maputo import parity price, white maize	\$186

Source: USDA (1996) and Coulter (1995).

Coulter (1995), the Maputo import parity price of white maize is shown to be \$186 per ton in Table 5-19, assuming the 1995 mean monthly FOB Gulf price of \$123 per ton. In regional surplus years for maize, when South Africa and other countries could supply major Mozambican deficit areas (primarily in the South), Coulter shows that Maputo wholesalers would be willing to pay at most \$148 per ton.¹⁴

Another possible scenario for the sale of maize from the north is to export to the world market. For example, following a very good 1995/96 domestic harvest when world grain prices were at historically high levels, private trading firms purchased maize from smallholders in the north and exported it at approximately \$135 per ton, FOB Nacala. Assuming a return to more long run equilibrium conditions in the world grain market, it is unlikely that Mozambican maize could be sold consistently at this price in most years. At any rate, this section analyzes JVC profitability in smallholder high-input block maize using these three price and market scenarios.

5.6.4.2 JVC Costs of Supporting Smallholder High-Input Block Maize

Costs incurred by Lomaco in the high-input block maize scheme are divided here in two parts: on-farm and post-farm. A detailed explanation of on-farm costs is included in Table 5-15 (where JVC on-farm cotton costs are also shown). Table 5-20 shows that, net of the

¹⁴ Note that this price during a regional surplus year represents the most optimistic scenario, according to Coulter, who writes, "Mozambique...could only receive such prices as long as Maputo continued importing part of its needs...Were there to be a glut of local production, prices (for Northern Mozambican production) would be driven lower."

proportion of these costs paid by the smallholder, Lomaco incurred costs of \$58.15 per hectare or \$29.29 per ton assuming the mean yield of 1,985 kgs per hectare.

Table 5-21 shows post-farm costs under two scenarios concerning the location of demand: Maputo and world (where the relevant price would be FOB Pemba). The most significant cost for the firm is the farmgate price, which in 1994/95 was \$88 per ton. Total post-farm costs escalate dramatically, however, when the market is Maputo, reflecting the high-cost of coastal shipping (\$63 per ton from Pemba, following Coulter). At any rate, Table 5-21 shows total farm costs are \$116 per ton for sales to the world market, based on an FOB Pemba price, and \$179 per ton when the buyer is in Maputo.

5.6.4.3 Analysis of JVC Profits in Smallholder Maize

Driven by very high transport costs, a government minimum price of \$88 per ton, and yields well below their potential,¹⁵ Table 5-22 shows that Lomaco would experience financial losses ranging from \$20 to \$119 per hectare in the three market scenarios hypothesized. This result is not surprising in light of Lomaco's decision to end this scheme at the emergency's end. Sensitivity analysis in Chapter 6 will examine under what yield and (world and producer) price scenarios this situation could be reversed. In the short run, it is straightforward to conclude that Lomaco's decision to abandon the high-input block maize

¹⁵ Maize yields in the high-input block scheme were approximately 2.0 tons/ha in Montepuez in 1994/95. By comparison, mean smallholder maize yields from Zambia in on-farm trials of maize using a hybrid variety (MM603/604) and fertilizer range from 3.2 to 3.5 tons/ha. (Howard, 1994). More recently, on-farm trials from Meconta District using a similar technology package to that used in Montepuez generated yields of 4.3 to 5.7 tons/ha. (DNER, 1996)

Table 5-20 On-farm Cost to JVC of Supporting Smallholder High-input Block Maize, 1994/95

Item	Total Cost	Farmer Pays	JVC Pays
		(\$/ha)	
Mechanical field preparation	42.68	32.87	9.81
Mechanical fertilizer application	47.32	36.44	10.88
Mechanical seeding	18.34	18.34	0
Herbicide	26.25	22.37	3.88
Herbicide sprayer and batteries	5.22	0	5.22
Extensionist salary ¹	0	0	0
Transport of inputs ²	28.36	0	28.36
Total cost per hectare	168.17	110.02	58.15
Maize grain yield (kg/ha) ³		1985	
Total cost per ton maize grain	84.72	55.42	29.29

¹ Lomaco staff indicated in interviews that they attribute all extensionist costs to cotton, given its overall dominance in terms of extensionists workload.

² Lomaco staff did not have data available related to transport of inputs for high-input block maize. Assume this cost equals one-half input transport costs for high-input block cotton.

³ Assuming mean yield.

Source: Lomaco (1996), Interviews with SODAN and SAMO staff (1996), 1994/96 MAP/MSU Smallholder Survey.

Table 5-21 Post-farm JVC Costs of High-input Block Maize, 1995

Item	Explanation	Relevant market	
		Maputo	World
		-- (\$/ton grain) --	
Maize grain purchase	Farmgate price=850 Mt/kg and Mt:\$ exchange rate of 9702:1 in 1994/95	88	88
Sacks	Coulter (1995) reports sack cost of \$8 per ton	8	8
Staff	Assume equal to same item for cotton	1	1
Transport Village to Montepuez	Coulter (1995) reports average transport cost from village to market town equal \$6 per ton	6	6
Transport Montepuez to Pemba	Assume same as cotton	6	6
Port charges	Assume same as cotton	7	7
Transport Pemba to Maputo	Based on Coulter (1995)	63	
Total		179	116

Source: Lomaco (1996), 1994/96 MAP/MSU FSP Smallholder Survey

Table 5-22 JVC Profit Analysis in Smallholder High-input Block Maize, by Market

	Maputo (Southern African Deficit Year)	Maputo (Southern Africa Surplus Year)	World (FOB, Pemba, High World Price)
	-- (\$/ha) --		
Revenue	369	294	268
Costs			
On-Farm	58	58	58
Post-Farm	355	355	230
Total Costs	413	413	288
Profit (Loss)	(44)	(119)	(20)

Source: 1994/96 FSP MAP/MSU Smallholder Survey, Henriques (1996), Tonks (1996), Carvalho (1996)

scheme and focus its attention on demonstrably profitable smallholder cotton, and the reluctance of the other JVCs to enter this arena are logical short-run business strategies.

5.7 Summary

This chapter has shown that, on average, both smallholders and the JVCs earn attractive returns in smallholder cotton relative to the alternatives considered. However, a significant group of farmers in both zones experienced extremely poor cotton yields in the low-input schemes; in these cases, returns per labor day and per hectare were very low. This, combined with the results from the cotton yield model, imply that for smallholder low-input cotton to be profitable to producers and the firms, a minimum level of insecticide and household labor must be used to earn reasonable returns. These findings are consistent with those from the cotton yield model, which also highlighted the importance of early seeding date in yield determination. In Monapo/Meconta, smallholder cotton provided greater returns to labor and land than either food crop studied, while maize generated slightly greater returns for Montepuez low-input producers.

Participants in Montepuez high-input cotton and maize schemes generated the highest returns to labor and land, on average, of any cropping activity studied throughout the study zone. In both crops, but particularly in the case of maize, analysis by yield terciles pointed out that the poorest performing farmers often experienced financial losses. Analysis of financial returns from the JVC perspective showed strong evidence that, under current market conditions, supporting high-input smallholder cotton is profitable. On the other hand,

high-input maize is not profitable to the JVCs under current market and yield conditions, where donor-driven emergency-related demand has ended.

The next logical step in the analysis, presented in Chapter 6 is the question: From a social perspective (i.e., accounting for economic costs), under what conditions does Mozambique exhibit a comparative advantage in smallholder cotton and food crops? Does Mozambique's comparative advantage lie in the crops and input packages found most profitable for smallholders and the JVCs?

Chapter 6

Economic Analysis of Cotton, Maize, and Manioc Production and Processing

6.0 Introduction

In this chapter parameters generated in the financial budgets are used to determine under what conditions Mozambique enjoys comparative advantage in the same set of cotton, maize and manioc enterprises analyzed in Chapter 5. Economic prices of inputs and outputs replace market prices from the smallholder and JVC financial analyses, permitting the computation of social profitability indicators of the respective commodities and technology packages under 1994/95 mean yields. This is important, because when market and economic prices differ, for whatever reason, the interests of farmers, the JVCs and the nation may differ. Thus, the complementarity of financial and economic analysis is apparent. For example, two of the most important factors of production in smallholder agriculture, family labor and land, were not valued in the smallholder or JVC financial analyses because they did not represent monetary costs to either. Subsidized farmgate prices for cotton inputs were used in the farm-level budgets, but these prices represented often only a portion of their social opportunity cost. These subsidies improved private returns for the farmer. In the absence of such subsidies, whether these enterprises represent an efficient use of resources for the nation is a question analyzed from a comparative advantage perspective in this chapter.

Important to the JVCs but not relevant to smallholders are the processing, marketing, and transportation costs the JVCs incur in association with the cash-cropping schemes. The

JVC profitability analysis in Chapter 5 incorporated the firms' financial costs and showed the relative attractiveness of the respective cotton and maize schemes. Incorporating all economic costs of production, transformation, and transportation to relevant markets, how do the most attractive production alternatives to the country in terms of its trade balance compare to those most profitable for the farmer and the JVC?

This analysis is sensitive to assumptions concerning world commodity prices, crop yields and other key parameters (e.g., the cotton ginning outturn rate (GOR) and the regional maize situation in a given year). Mean levels of these parameters are used to develop the base case scenario for each package. These parameters are varied through sensitivity analysis in the final section of this chapter to: 1) analyze the robustness of comparative advantage measures; and 2) compare the outcomes of producers, JVCs and the nation under the range of scenarios.

6.1 Measures of Social Profitability

Two measures are used to evaluate the relative economic efficiency of smallholder production alternatives in this chapter: net social profitability (NSP) and the resource cost ratio (RCR).¹ NSP indicates the contribution of each production alternative to national income, measured in terms of returns to land. NSP is calculated on a per hectare basis because, in the absence of a land rental market, it is problematic to determine land's opportunity cost. Therefore, NSP will allow comparison of returns to the national economy for each crop and technology level using land as the numeraire.

¹ This approach follows CIMMYT methodological recommendations. See Morris (1990).

A limitation of the NSP as the sole basis of comparison between competing enterprises is that it provides no explicit information about the use of tradables (and hence foreign exchange) in production. To incorporate the distinction between tradables and non-tradables, the resource cost ratios (RCR) for each enterprise is computed. The RCR's advantage is that it is unitless, and measures the social opportunity cost of generating one unit of foreign exchange. The RCR calculation assumes that the opportunity cost of land in each enterprise is a non-tradable, and is equal to the next best return in competing enterprises, as revealed through the NSP calculations. Interpretation of the RCR is straightforward. An RCR less than one indicates that the value of domestic resources used in production is less than the value of foreign exchange earned (or saved); the production alternative thus demonstrates a comparative advantage. An RCR greater than one indicates that a greater value of domestic resources are used in production than is generated in foreign exchange value through its production.² The RCR is calculated with the following formula:

$$RCR_c = (\sum W_p F_p) / (P_c T_c - \sum P_i T_i)$$

where:

RCR_c	=	resource cost ratio crop c
W_p	=	social price of non-tradable factor
F_p	=	non-tradable factor of production (per ha)
P_c	=	world price equivalent of crop c
T_c	=	quantity produced of crop c (per ha)
P_i	=	world price equivalent of tradable input i
T_i	=	quantity used of tradable production inputs (per ha)

² A negative RCR is also possible, and indicates that the value of tradable inputs is greater than the value of production at world prices.

6.2 Economic Benefits to Mozambique of Cotton, Maize and Manioc

To establish a base case scenario, the cotton fiber price is assumed equal to its ten-year mean value FOB Pemba/Nacala (shown in Table 5-12) of \$1,329 per ton.³ For maize, following Coulter (1995), it is assumed that the relevant market is Maputo during a year in which the Southern African region is a net importer of maize; in this case, the economic value of maize is \$186 per ton at the wholesale level in Maputo (see Table 5-19).

Manioc, on the other hand, is assumed to be a non-tradable whose consumption is assumed to take place near its point of production; thus, its economic value is equal to its mean market price of \$146 per ton in Montepuez and \$105 per ton in Monapo/Meconta (see Tables 5-7 and 5-8).

6.3 Determining the Opportunity Cost of Family and Hired Agricultural Labor

Three potential methods to value the opportunity cost of family labor are:

- 1) the official minimum wage or some proportion thereof;
- 2) the wage rates at which sampled households sold labor off-farm; and
- 3) the wage rates at which non-family labor was hired by households in the sample for employment on their cotton, maize, and manioc fields, by zone and period.

Relying on the minimum wage poses two theoretical disadvantages. First, it does not reflect any true scarcity value within the rural economy, as most market transactions for labor within the study zone are not determined as a function of the minimum wage.

Further, use of the minimum wage would not permit real seasonal or zone differences in

³ The ginning outturn rate and cottonseed transformation rates from seed cotton are the same as those shown in Table 5-13. Cottonseed is assumed to have an economic value of \$80 per ton, equivalent to the price which Lomaco reports receiving recently for this by-product.

labor supply and demand to be incorporated. Method 2 represents a reasonable alternative, in that it would capture for each household the rate at which it actually sold labor off-farm; however, problems with regard to this portion of the household data set argue against its use for this purpose. Therefore, Method 3 is used. It has two advantages. First, it assumes that if sampled households attempted to sell their labor, they would have received approximately the same wage that sampled households actually paid to non-family labor. Second, it allows seasonal and regional factors to be implicitly incorporated. Table 5-1 showed a close correlation between unskilled agricultural labor wage rates in Montepuez and Monapo/Meconta by two-month period and the national minimum wage. This strongly implies that comparative advantage indicators are not sensitive to the minor empirical differences implied between Methods 1 and 3. Meanwhile, the economic value of non-family agricultural labor is assumed equivalent to the value actually paid by sampled households and shown in Table 5-1.

6.4 Other Economic Costs of Production, Transformation and Marketing

To establish the remaining costs necessary to compute NSP, selected data from Chapter 5 are used. Tables 5-15 and 5-20 presented a detailed breakdown of the total (economic) cost of inputs related to smallholder cotton and maize. Table 5-17 showed that the JVC experienced costs of \$974 per fiber ton in total post farm costs. The economic post-farm costs can be derived from Table 5-17 by eliminating the cost of seed cotton purchase and taxes paid by the JVC. This results in a post-farm economic cost of \$465 per fiber ton. Similarly, the marketing, handling and transportation costs of maize from farmgate to

Maputo market were shown in Table 5-21 to equal \$91 per ton (eliminating the cost of purchasing maize grain of \$88 per ton).

6.5 Net Social Profitability

Tables 6-1 and 6-2 present the calculation of net social profitability on a per hectare basis for cotton, maize and manioc by zone and input level. Mean results for each enterprise are displayed, rather than the per yield tercile format from the farm-level analysis in Chapter 5, generating a single representative macroeconomic indicator of social profitability. A further simplification is that low-input maize and manioc budgets are aggregated by zone, instead of being presented as a function of the household's cotton category.

6.5.1 Social Returns to Cotton

NSP calculations highlight that cotton is socially profitable to Mozambique following base case scenario assumptions, in both study zones and in each technology package.

Comparing social profitability to land in cotton between zones and input levels, both Montepuez high-input schemes are more profitable to the nation (\$188 to \$204 per ha) than the low-input schemes (\$42 to \$97 per ha) in either Montepuez or Monapo/Meconta.

Combining this result with findings from Chapters 4 and 5, the high-input cotton schemes offer some significant advantages for farmers, the JVCs and the nation over low-input alternatives. Recall that the cotton yield model showed a statistically significant and positive yield effect from the high-input packages. Cost-benefit calculations derived based

Table 6-1 Net Social Returns to Cotton by Zone and Input Level, 1994/95

	Montepuez			Monapo/Mecenta	
	High-Input Block	High-Input Dispersed	Low-Input Dispersed	Low-Input Block	Low-Input Dispersed
Social Returns	-- \$/ha -- (unless otherwise noted)				
Fiber @ 34 percent ginning outturn	\$651	\$533	\$257	\$313	\$226
Cotton seed @ 59 percent conversion	\$68	\$56	\$27	\$33	\$24
Gross social returns	\$719	\$588	\$284	\$346	\$250
On-farm production costs					
Labor					
Family labor	\$21.09	\$19.99	\$41.51	\$56.20	\$56.83
Non-family labor	\$24.77	\$30.33	\$9.40	\$7.83	\$3.93
Variable costs					
Seed	\$2.40	\$2.40	\$2.40	\$2.40	\$2.40
Insecticide	\$54.75	\$41.77	\$33.95	\$40.23	\$33.13
Fertilizer	\$30.00	\$13.84	\$0.00	\$0.00	\$0.00
Herbicide	\$30.63	\$30.63	\$0.00	\$0.00	\$0.00
Batteries	\$1.35	\$1.08	\$0.70	\$0.82	\$0.68
Extension services	\$19.57	\$16.00	\$7.72	\$7.72	\$7.72
Transport of inputs to farmgate	\$56.72	\$41.93	\$20.23	\$20.23	\$20.23
Capital costs					
Farm implements	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09
Tractor services	\$37.69	\$6.76	\$0.00	\$0.00	\$0.00
Herbicide sprayer	\$5.00	\$5.00	\$0.00	\$0.00	\$0.00
Insecticide sprayer	\$0.68	\$0.52	\$0.42	\$0.50	\$0.41
Total on-farm costs (\$/ha)	\$287.74	\$213.34	\$119.42	\$139.02	\$128.42
Seed cotton yield (kg/ha)	1442	1179	569	693	501
Fiber yield (kg/ha) @ 34 % conversion rate	490	401	193	236	170
Total on-farm costs (\$/ton fiber)	\$587	\$532	\$617	\$590	\$754
Post farm costs					
Trading and collecting (\$/ton fiber)	\$96	\$96	\$96	\$96	\$96
Ginnery (\$/ton fiber)	\$129	\$129	\$129	\$129	\$129
Post-ginnery (\$/ton fiber)	\$240	\$240	\$240	\$240	\$240
Total post farm costs (\$/ton fiber)	\$465	\$465	\$465	\$465	\$465
Total cost FOB Nacala/Pemba (\$/ton fiber)	\$1,052	\$997	\$1,082	\$1,055	\$1,219
Total cost FOB Nacala/Pemba (\$/ha)	\$516	\$400	\$209	\$249	\$208
Net social returns (\$/ha)	\$204	\$188	\$74	\$97	\$42

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Henriques (1996), Tonks (1996), Carvalho (1996)

Table 6-2 Net Social Returns to Maize and Manioc, by Zone and Input Level, 1994/95

	Montepuez			Monapo/Meconta	
	Maize	Maize	Manioc	Maize	Manioc
	High-Input Block	Low-Input	Low-Input	Low-Input	Low-Input
-- \$/ha (unless otherwise noted)					
Gross social returns (\$/ha) relevant market	\$369.21	\$130.94	\$63.94	\$78.68	\$77.70
On-farm production costs					
Family labor	\$11.14	\$27.42	\$41.68	\$32.18	\$61.78
Non-family labor	\$22.05	\$6.88	\$1.05	\$1.41	\$0.55
Variable costs					
Seed	\$11.54	\$3.40	\$3.40	\$3.40	\$3.40
Fungicide	\$6.80	\$0.00	\$0.00	\$0.00	\$0.00
Herbicide	\$26.25	\$0.00	\$0.00	\$0.00	\$0.00
Batteries	\$0.22	\$0.00	\$0.00	\$0.00	\$0.00
Extension services	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Transport of inputs	\$28.36	\$0.00	\$0.00	\$0.00	\$0.00
Capital costs					
Farm implements	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09
Mechanical field preparation	\$42.68	\$0.00	\$0.00	\$0.00	\$0.00
Mechanical fertilizer application	\$47.32	\$0.00	\$0.00	\$0.00	\$0.00
Herbicide sprayer	\$5.00	\$0.00	\$0.00	\$0.00	\$0.00
Total on-farm costs (\$/ha)	\$204.45	\$40.79	\$49.22	\$40.08	\$68.82
Yield (kg/ha)	1985	704	444	423	740
Total on-farm costs (\$/ton)	\$103	\$58	\$111	\$95	\$93
Farmgate to market costs (\$/ton)	\$91	\$91	\$0	\$91	\$0
Total costs (\$/ton)	\$194	\$149	\$111	\$186	\$93
Total domestic costs (\$/ha)	\$385	\$105	\$49	\$79	\$69
Net social returns (\$/ha)	(\$16)	\$26	\$15	\$0	\$9

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Henriques (1996), Tonks (1996), Carvalheira (1996)

on these parameters demonstrated that the increased yield attributable to the high-input packages were privately profitable to participating farmers. Chapter 5 then highlighted that the high-input cotton enterprises generated significantly higher returns to household resources (on a per labor basis) and to the JVCs (on a per hectare basis) than did the low-input cotton schemes. The NSP analysis shows that the high-input schemes create a greater effect on Mozambique's net exports than the low-input alternatives by producing each unit of cotton fiber at lower costs per fiber ton. Finally, comparing Monapo/Meconta block to dispersed cotton, greater social profitability per hectare is generated in the block; the financial analysis also showed block production to be relatively more attractive to smallholders than dispersed production.

6.5.2 Social Returns to Food Crops

Prior to discussing empirical results concerning the NSP of cotton belt producers in maize and manioc production, a limitation of this analysis must be pointed out. That is, even if the region is shown to be economically inefficient in the production of food crops, this does not imply that the production of these crops should be reduced or eliminated by cotton belt households for own consumption. The concern for household and regional food security argue strongly for local food production. The policy interpretation of such a finding would be, rather, that when the cotton belt seeks to trade internationally or with other regions of the country, it is not economically efficient in the production of food crops compared to alternative enterprises. Having stated this caveat, we consider the NSP of maize and manioc.

Table 6-2 reveals that high-input block maize has negative (though close to zero) NSP per hectare. Low-input maize (and manioc) production in both provinces also provides social returns of \$0 to \$26 per ha, much lower than low-input cotton. Why is northern Mozambique not efficient in the production of maize for the Maputo market? Recall from Table 5-19 that the import parity price (IPP) of maize in Maputo under a regional deficit scenario in 1994/95 was \$186 per ton; the total economic costs of shipping maize from farmgate to Maputo are estimated at \$91 per ton (or 49 percent of IPP) in Table 5-21. Thus, regardless of the costs of production, the high level of internal transportation costs relative to IPP is such that the north is not an efficient exporter of maize to the Maputo market under current conditions.⁴ The findings are similar to those of Coulter (1995), who writes:

"...these calculations show that under any reasonable assumptions, for northern Mozambique to produce maize for Maputo is likely to be a very marginal proposition...For farmers in northern Mozambique there may be better opportunities for exporting maize to neighbouring countries such as Zambia, Malawi or Tanzania. The probability of such trade depends upon the degree of correlation between production in neighboring sub-regions..."

The implications of improved trade opportunities with neighboring countries in maize are discussed in the sensitivity analysis section below.

6.6 Computation of Resource Cost Ratios

Two additional steps beyond the NSP calculations are necessary to calculate RCRs. First, it is necessary to determine the opportunity cost of land for each enterprise. Computation

⁴ Infrastructure investment which would either lower coastal shipping rates and/or over-land trucking rates would improve the economic viability for the north to supply Maputo (and other potential markets).

of the opportunity cost of land requires a decision concerning how a particular producer would react in the event that the farmer (or the JVC in the case of high-input block fields) had to choose an alternative cropping enterprise for particular fields. Table 6-3 displays the best alternative land use in each enterprise and the net social returns per hectare taken from the NSP computations.

Second, production costs must be segregated between tradables and non-tradables.

Clearly, all imported inputs are tradables, while agricultural labor and land are non-tradables. Other costs, however, such as extension services, transportation and processing-related items contain both a tradable component (e.g., fuel, machinery, spare parts, etc.) and a non-tradable component (labor). In the absence of more precise data, each of these cost components is assumed as one-half tradable and one-half non-tradable.

6.7 Analysis of Resource Cost Ratios

Resource cost ratio calculations are displayed for Montepuez and Monapo/Meconta in Tables 6-4 and 6-5, respectively. By definition, the relative rankings within zones of the production alternatives do not change from the NSP calculations.⁵ Rather, the RCRs are unitless, and indicate the opportunity cost the nation incurs to generate (or save) one unit of foreign currency. In both zones, all cotton categories are shown to have an RCR < 1, indicating a comparative advantage in cotton. The comparative advantage across cotton

⁵ Because manioc is a non-tradable, its RCR is not a meaningful calculation and is excluded here.

Table 6-3 Opportunity Cost of Land by Zone, Crop and Input Category

Crop / Input Category	Montepuez		Monapo/Meconta	
	Best Production Alternative	Net Social Returns	Best Production Alternative	Net Social Returns
		- \$/ha -		- \$/ha -
High-input block cotton	High-input block maize	\$0		
High-input dispersed cotton	Low-input dispersed cotton	\$74.50		
Low-input block cotton			Manioc	\$8.88
Low-input dispersed cotton	Low-input maize	\$26.09	Manioc	\$8.88
High-input dispersed maize	High-input block cotton	\$203.70		
Low-input maize	Low-input dispersed cotton	\$74.50	Low-input dispersed cotton	\$42.32

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 6-4 Resource Cost Ratio, Cotton and Maize, Montepuez, 1994/95

	<u>Cotton</u>			<u>Maize</u>	
	High-Input Block	High-Input Dispersed	Low-Input Dispersed	High-Input Block	Low-Input Dispersed
	-- \$/ha --				
Tradables					
Outputs (\$/ha)					
Value of Production	\$719.42	\$588.21	\$283.88	\$369.21	\$130.94
On farm costs					
Seed	\$2.40	\$2.40	\$2.40	\$18.34	\$3.40
Insecticide	\$54.75	\$41.77	\$33.95	\$0.00	\$0.00
Insecticide sprayer	\$0.68	\$0.52	\$0.42	\$0.00	\$0.00
Fertilizer	\$30.00	\$13.84	\$0.00	\$47.32	\$0.00
Herbicide	\$30.63	\$30.63	\$0.00	\$26.25	\$0.00
Herbicide sprayer	\$5.00	\$5.00	\$0.00	\$5.00	\$0.00
Batteries	\$1.35	\$1.08	\$0.70	\$0.22	\$0.00
Extension services (50 percent)	\$9.79	\$8.00	\$3.86	\$0.00	\$0.00
Farm implements	\$3.09	\$3.09	\$3.09	\$3.09	\$3.09
Tractor services (50 percent)	\$18.85	\$3.38	\$0.00	\$0.00	\$0.00
Total tradables on farm (\$/ha)	\$156.53	\$109.71	\$44.42	\$100.22	\$6.49
Postfarm tradables (50 percent) (\$/ha)	\$113.99	\$93.20	\$44.98	\$90.32	\$32.03
Total cost - Tradables (\$/ha)	\$270.52	\$202.91	\$89.40	\$190.54	\$38.52
Non-tradables					
Labor					
Family labor (\$/ha)	\$21.09	\$19.99	\$41.51	\$11.14	\$27.42
Non-family labor (\$/ha)	\$24.77	\$30.33	\$9.40	\$22.05	\$6.88
Extension services (50 percent)	\$9.79	\$8.00	\$3.86	\$0.00	\$0.00
Tractor services (50 percent)	\$18.85	\$3.38	\$0.00	\$21.34	\$0.00
Total non-tradables on farm (\$/ha)	\$74.49	\$61.70	\$54.77	\$54.53	\$34.30
Postfarm non-tradables (50 percent) (\$/ha)	\$113.99	\$93.20	\$44.98	\$90.32	\$32.03
Land (\$/ha)	\$0.00	\$74.50	\$26.09	\$203.70	\$74.50
Total cost non-tradables (\$/ha)	\$188.48	\$229.40	\$125.84	\$348.55	\$140.83
Value added tradables (\$/ha)	\$448.90	\$385.30	\$194.48	\$178.67	\$92.42
Resource cost ratio	0.42	0.60	0.65	1.95	1.52

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Henriques (1996), Tonks (1996), Carvalheira (1996)

Table 6-5 Resource Cost Ratio, Cotton and Maize, Monapo/Meconta, 1994/95

	Cotton		Maize
	Low-Input	Low-Input	Low-Input
	Block	Dispersed	Dispersed
	(\$/ha)		
Tradables			
Outputs			
Value of Production	\$345.74	\$249.95	\$78.68
Inputs			
Seed	\$2.40	\$2.40	\$3.40
Insecticide	\$40.23	\$33.13	\$0.00
Insecticide sprayer	\$0.50	\$0.41	\$0.00
Batteries	\$0.82	\$0.68	\$0.00
Extension services (50 percent)	\$3.86	\$3.86	\$0.00
Farm implements	\$3.09	\$3.09	\$3.09
Total tradables on farm	\$50.90	\$43.57	\$6.49
Postfarm tradables (50 percent)	\$54.78	\$39.60	\$19.25
Total cost - Tradables	\$105.68	\$83.18	\$25.74
Non-tradables			
Labor			
Family labor	\$56.20	\$56.83	\$32.18
Non-family labor	\$7.83	\$3.93	\$1.41
Extension services (50 percent)	\$3.86	\$3.86	\$0.00
Total non-tradables on farm	\$67.89	\$64.62	\$33.59
Postfarm non-tradables (50 percent)	\$54.78	\$39.60	\$19.25
Land	\$8.88	\$8.88	\$42.32
Total cost non-tradables	\$131.55	\$113.10	\$95.16
Value added tradables	\$240.06	\$166.78	\$52.94
Resource cost ratio	0.55	0.68	1.80

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Henriques (1996), Tonks (1996), Carvalheira (1996)

schemes is consistent with findings from Dengo (1994) where the author concluded:

"...(comparative advantage calculation) indicates that domestic cotton production is competitive, although the traditional smallholder competitiveness is somewhat questionable if we observe the very low yields obtained and that the corresponding (RCR) is close to one (0.92)." Meanwhile, by construction, maize in both zones has an $RCR > 1$ in both high- and low-input schemes because of the assumption related to the opportunity cost of land based on NSP calculations. For example, the opportunity cost of land in high-input block maize, equal to the net social returns to high-input block cotton is \$203.70, results in a RCR for that scheme of 1.95.

6.8 Sensitivity Analysis: The Interests of Smallholders, JVCs and the Macroeconomy

Earlier analysis of smallholder cropping enterprises has considered the interests of smallholders, the JVCs and the macroeconomy separately. For any JVC-based system to represent a sustainable development choice for the cotton belt, however, it must satisfy minimum conditions with respect to each relevant group. Sensitivity analysis in this section identifies levels of key parameters which simultaneously satisfy the following three conditions:

- 1) Smallholders: must achieve returns at least equal to the opportunity cost of family labor per adult equivalent of \$0.48 per day (assuming a mean annual rate based on data from Table 5-1);
- 2) Macroeconomy: the production system must demonstrate a comparative advantage (or an $RCR < 1$); and
- 3) JVC: must earn a financial profit.⁶

⁶ It is assumed that smallholders and the JVCs share costs of production in the same proportion as was shown in Tables 5-16 and 5-20.

Table 6-6 Low-Input Dispersed and High-Input Block Cotton Sensitivity Analysis Scenarios

Input Level	Assumption on:		Social Cost of Farm-Level Production		Producer, Macroeconomic and JVC Conditions		
	Yield	Ginning Outturn Rate	Purchased Inputs	Family and Hired Labor	Minimum Producer Price for cotton where Smallholder "Benefits" ¹	Minimum FOB N Mozambique Price for cotton where National Economy Benefits	JVC Financial Profit
	- kg/ha -	- percent -	- \$/ha -	- \$/ha -	- \$/kg -	- \$/ton -	
Low-dispersed	569 (Mean)	34	13	51	\$0.15	\$944	See Fig 6-1
Low-dispersed	1010 (Upper Tercile)	34	15	56	\$0.10	\$706	See Fig 6-2
Low-dispersed	1010 (Upper Tercile)	40	15	56	\$0.10	\$613	See Fig 6-3
High-block	1442 (Mean)	34	95	46	\$0.12	\$914	See Fig 6-4
High-block	1796 (Upper Tercile)	34	95	58	\$0.10	\$818	See Fig 6-5
High-block	1796 (Upper Tercile)	40	95	58	\$0.10	\$713	See Fig 6-6

¹ The minimum price JVCs must pay smallholders for smallholders to achieve returns at least equal to the opportunity cost of family labor per adult equivalent of \$0.48 per day.

Source: 1994/96 MAP/MSU FSP Smallholder Survey, Fok (1995), Coulter (1995), Henriques (1996) and Tonks (1996)

The attractiveness of various cropping choices to the three interests depends on levels of the following parameters: input level, the ginning outturn rate (for cotton only), and producer and border prices for each commodity.

6.8.1 Cotton Sensitivity Analysis

Table 6-6 displays key information relating to the six scenarios of smallholder cotton considered in sensitivity analysis. For simplicity, low-input dispersed and high-input block cotton schemes are the two schemes analyzed. In each case the analysis considers the implication of variation in yield and the ginning outturn rate. Initially, mean yield (and input levels) are assumed based on 1994/95 results; the current ginning outturn rate of 34 percent is also assumed.⁷ The second scenario considers the implications of an improvement in yield to the upper tercile mean.⁸ The third scenario for each cotton system assumes an improvement in the ginning outturn rate (GOR) to West African levels (40 percent) and maintains upper tercile yields.

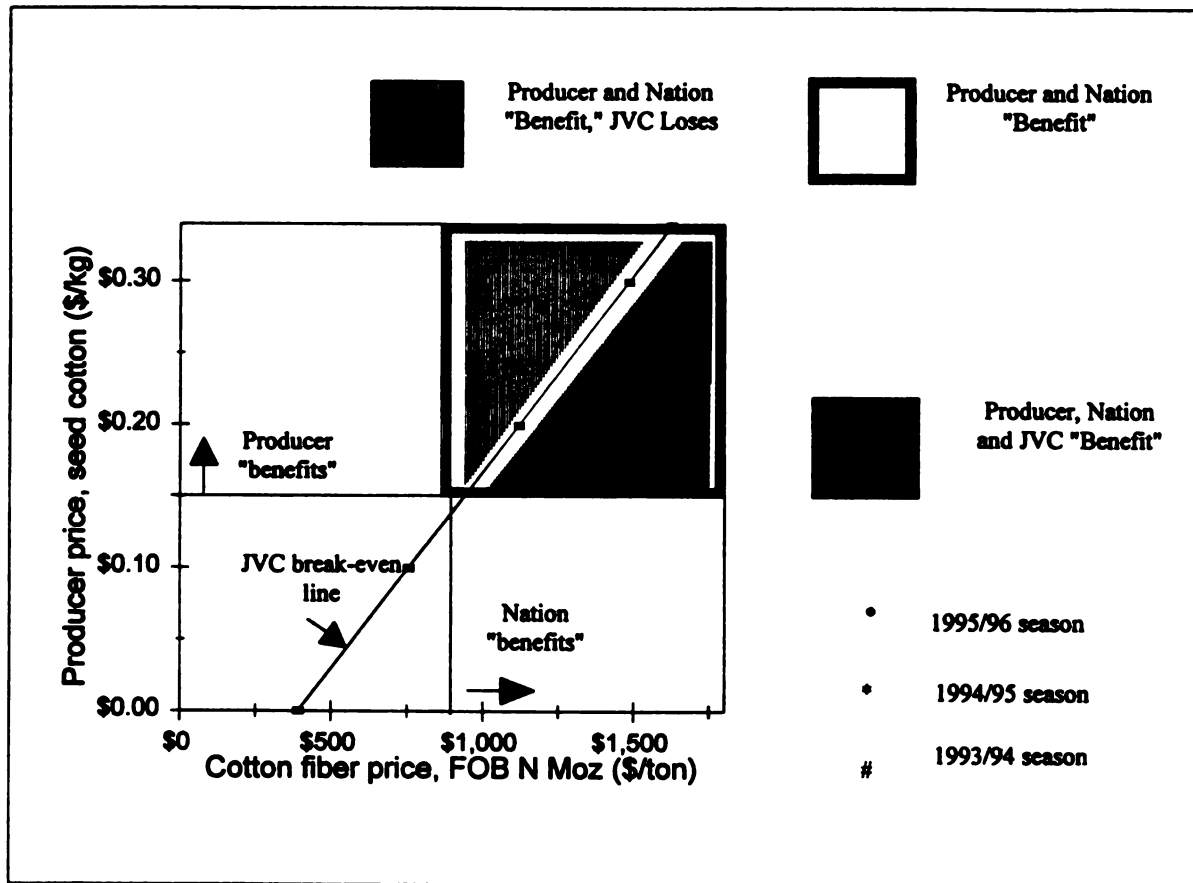
6.8.1.1 Low-Input Cotton

Figure 6-1 depicts the case of low-input cotton under 1994/95 mean yields (of 569 kg/ha) and the current GOR (34 percent) from the smallholder, JVC and social perspective.

⁷ A principle goal of on-going agronomic research in northern Mozambique seeks to develop cotton varieties with ginning outturn rates approaching Francophone African levels. This research is being financed by two donors: the World Bank through its support Instituto Nacional de Investigacao Agraria (INIA) at CIMSAN (Meconta District), and the Caisse Centrale de Cooperation Economique in collaboration with Lomaco in Montepuez.

⁸ To be as realistic as possible in the context of the ending of the KR-2-related subsidies for insecticide in 1995/96, it is assumed that smallholders paid 1995/96 prices for this product.

Figure 6-1 Producer, JVC and Macroeconomic Outcomes, Low-Input Cotton, Current Yield and Current Ginning Outturn Rate



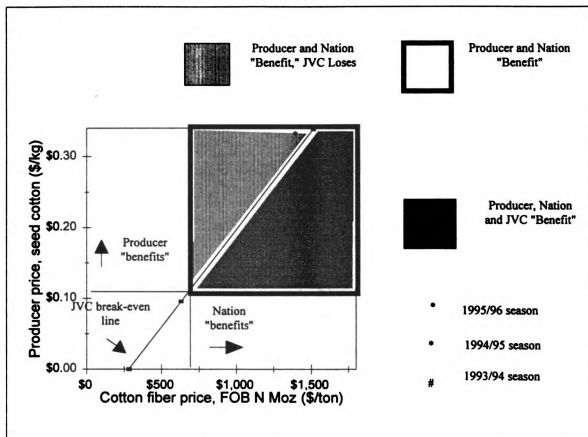
Under this scenario, producers achieve earnings equal to the opportunity cost of labor with a producer price of \$0.15, roughly the 1994/95 official minimum level. Meanwhile, Mozambique demonstrates a comparative advantage at an FOB price of \$944 per ton, well below recent price levels. The region where both producers and the macroeconomy "benefit" is defined by the thick bordered rectangle in Figure 6-1.

Within this rectangle, there are two shaded areas which describe JVC outcomes. In the darkly shaded portion of this region the JVC earns a financial profit; it is easily observed that the combination of producer and world prices in 1993/94 and 1994/95 fell within this favorable region. The lightly shaded portion of the region indicates the conditions where the JVC incurs a financial loss though smallholders and the nation each benefit.

Significantly, at the high producer price level set by Government for the 1995/96 season (\$0.33 per kg), the JVC actually suffered financial losses.

The implications of improving yields from mean to the upper tercile (from 569 to 1,010 kg/ha) are shown in Figure 6-2. Smallholders achieve the opportunity cost of labor at a producer price level of \$0.10, while a comparative advantage is achieved at a minimum of \$706 per ton, both much lower than in the mean yield case. The JVCs' profits improve (i.e., the thick bordered rectangle is much larger) under increased farm-level productivity, earning greater profits at actual 1993/94 and 1994/95 world and producer price levels than in the mean yield case. However, the JVCs still would suffer financial losses at the 1995/96 minimum farmgate cotton price.

Figure 6-2 Producer, JVC and Macroeconomic Outcomes, Low-Input Cotton, Improved Yield and Current Ginning Outturn Rate



With an improvement in the ginning outturn rate from 34 to 40 percent, *ceteris paribus*, as depicted in Figure 6-3, JVC profits are significantly increased. If this improvement could be achieved in the short- to medium-run, the benefits could be shared between producers and the JVCs through government price policy, having a positive impact on smallholder welfare.

6.8.1.2 High-Input Block Cotton

Figures 6-4 to 6-6 present a set of results for high-input block cotton analogous to those presented above for the low-input dispersed system. Overall results are strikingly similar between high-input block cotton and low-input dispersed cotton across the three yield and ginning outturn rate scenarios.⁹ For example, Figure 6-4 shows that producers earn the opportunity cost of labor at a farmgate price of \$0.12 per kg at the mean yield of 1,442 kg/ha. Meanwhile, Mozambique exhibits a comparative advantage at FOB prices of at least \$914 per ton (close to the \$944 per ton level in the low-input case). Again as was the case with low-input dispersed cotton, given prevailing world price levels from the 1993/94 and 1994/95 marketing seasons, the JVC was able to earn financial profits while paying farmers the official minimum price. However, the high 1995/96 price resulted in JVC losses from the high-input block scheme. The implications of improving yields and the ginning outturn rate are shown in Figures 6-5 and 6-6.

⁹ Though not shown in the graphic analysis, a further incentive to intensify cotton production on the part of the JVCs is the current under-utilization of ginning facilities. For example, Lomaco-Montepuez currently utilizes less than 50 percent of its ginning capacity of 25,000 tons of seed cotton. Fok (1995) provides a good discussion of the issue of under-utilization of ginning capacity in Annex 5.

Figure 6-3 Producer, JVC and Macroeconomic Outcomes, Low-Input Cotton, Improved Yield and Improved Ginning Outturn Rate

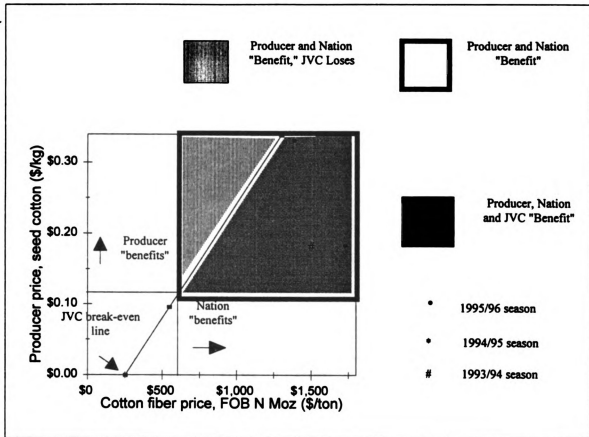


Figure 6-4 Producer, JVC and Macroeconomic Outcomes, High-Input Block Cotton, Current Yield and Current Ginning Outturn Rate

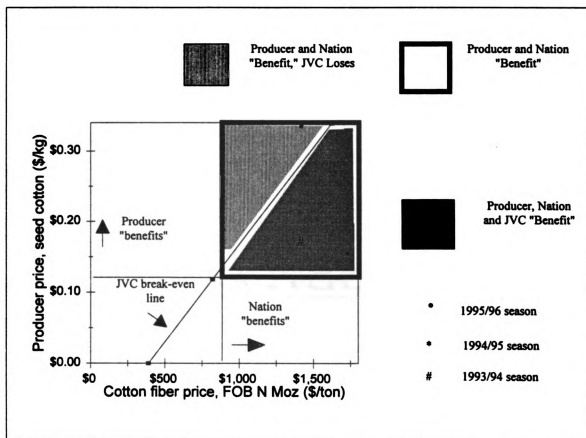


Figure 6-5 Producer, JVC and Macroeconomic Outcomes, High-Input Block Cotton, Improved Yield and Current Ginning Outturn Rate

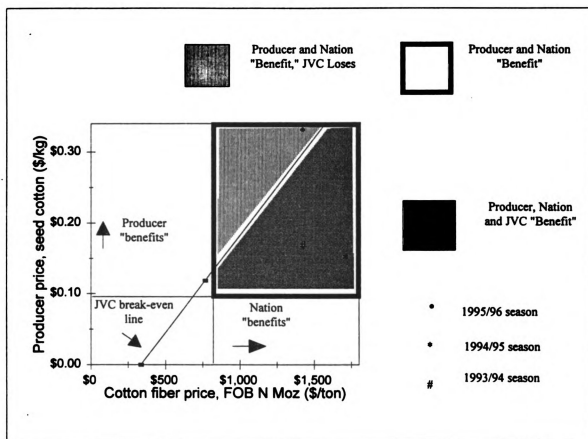
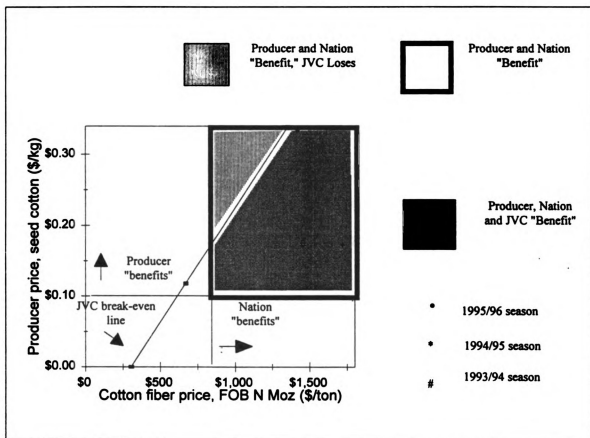


Figure 6-6 Producer, JVC and Macroeconomic Outcomes, High-Input Block Cotton, Improved Yield and Improved Ginning Outturn Rate



6.8.2 High-Input Block Maize Outcomes

High-input block maize outcomes are analyzed in this section under two scenarios - 1994/95 mean and upper tercile yields - depicted in Table 6-7.¹⁰ It is assumed that maize is sold by the JVC at FOB Pemba or Nacala prices. To guide interpretation of results, it is helpful to review the earlier discussion concerning the value of maize in the north under alternative regional and international maize supply situations. FOB/Northern Mozambique prices were assumed at \$125 per ton for a regional deficit year (e.g., 1995); Mozambique commercially exported maize from these northern ports at \$135 per ton during a period of relatively high world maize prices (e.g., 1996); during a regional surplus year, Coulter (1995) estimates the FOB/Northern Mozambique maize value at \$80 per ton (or less).¹¹

For Mozambique to have a comparative advantage in this maize system at mean yield levels, Figure 6-7 shows that FOB Northern Mozambique prices must be at least \$131 per ton. This is a very high level by historical standards, though it was exceeded in 1996. Even at the 1996 world price level, the figure shows that the JVC would not have been able to earn a profit if they were required to pay farmers the government minimum price. This is expected, in light of the findings from Chapter 5 showing financial losses

¹⁰ Analysis is limited here to the high-input block maize case, given that this is the only food crop case with JVC involvement during the study year.

¹¹ The opportunity cost of land in this scheme has been assumed equal to zero in this analysis. Clearly, this opportunity cost depends on world cotton price levels (and the attractiveness of other crops). This assumption is justified in that it accounts for a non-market benefit of this maize scheme: it represents an attractive rotation crop in the farming system with the generally more profitable cotton scheme.

Table 6-7 High-Input Block Maize Sensitivity Analysis Scenarios

Assumption on:		Social Cost of Farm-Level Production		Producer, Macroeconomic and JVC Conditions		
Yield		Purchased Inputs	Family and Hired Labor	Minimum Producer Price for maize where Smallholder "Benefits"¹	Minimum FOB N Mozambique Price for maize where National Economy Benefits	JVC Financial Profit
- kg/ha -	- \$/ha -	- \$/ha -	- \$/ha -	- \$/kg -	- \$/ton -	
1985 (Mean)	242	242	46	\$0.065	\$131	See Fig 6-7
3185 (Upper Tercile)	242	242	56	\$0.045	\$91	See Fig 6-8

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Figure 6-7 Producer, JVC and Macroeconomic Outcomes, High-Input Block Maize, Current Yield

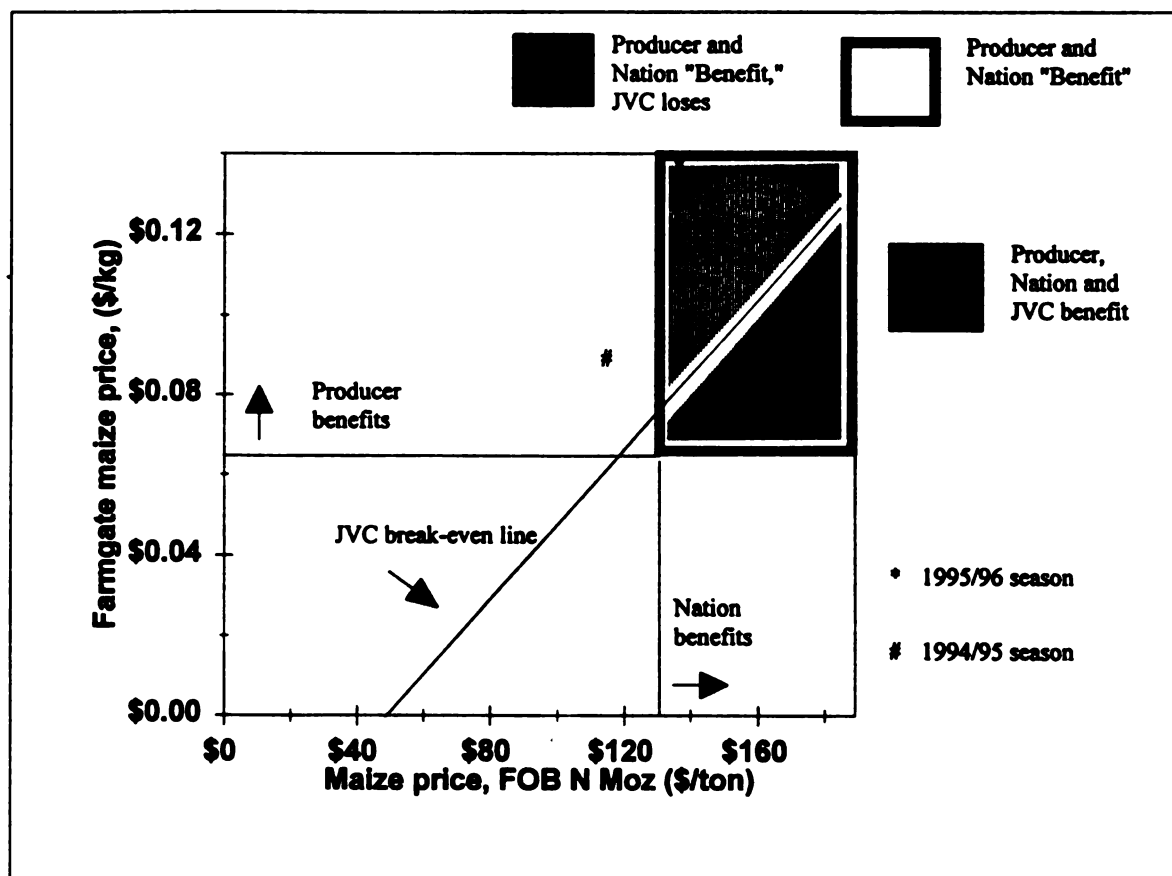
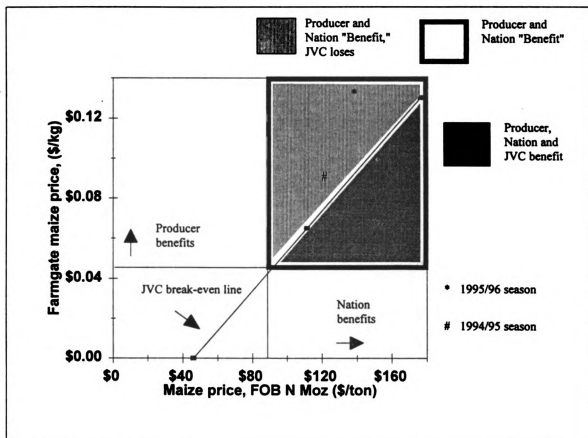


Figure 6-8 Producer, JVC and Macroeconomic Outcomes, High-Input Block Maize, Improved Yield



experienced by Lomaco in this scheme in 1994/95. Meanwhile, a farmgate price of \$0.065 per kg was required for producers to earn returns equal to the opportunity cost of labor, much lower than the \$0.088 per kg price level established by Government in 1994/95. In 1995/96, Lomaco chose to discontinue support for smallholder block maize.

Upper tercile high-input block maize yields were 60 percent greater (3,185 kg/ha) than mean levels. At this yield level, Figure 6-8 shows a Northern Mozambique FOB price of \$91 is required for Mozambique to enjoy comparative advantage. At this world price level the JVC can pay smallholders no greater than \$0.045 per kg to be profitable; the figure shows the considerable losses the JVC actually incurred in 1994/95 among even its best farmers, and how much greater its financial losses would have been in 1995/96 had it continued the scheme. This suggests that if JVCs do again become involved in high-input block maize, much more flexibility must be granted to the JVC in terms of determining its farmgate price in light of regional maize market conditions.

6.8.3 Summary and Conclusions

The base case analysis in this chapter showed clearly that Mozambique enjoys a comparative advantage in smallholder cotton under both high- and low-input levels in both study zones. Likewise, the north was generally shown to not be an efficient exporter of maize under existing agricultural technologies and infrastructure conditions.

The sensitivity analysis discussion highlighted the importance of improving yields and the ginning outturn rate as mechanisms to enhance results for producers, the JVCs and the

macroeconomy. Achieving yield gains from current mean to upper tercile levels may be an obtainable goal with relatively little investment, given that one-third of farmers are already operating at these yields and use little additional inputs compared to farmers operating at mean yields. Improving the ginning outturn rate is already the subject of considerable research attention on the part of CIMSAN and Lomaco. These questions receive further attention in the concluding chapter.

To complete the analysis in this dissertation, Chapter 7 returns exclusively to the household level and takes a more global approach. Rather than simply focusing on a particular cropping enterprise, econometric models are developed which analyze:

- 1) the extent to which household well-being is associated with the JVC cash-cropping schemes; and
- 2) the extent to which participation in the JVC cash-cropping schemes, as opposed to other factors unrelated to these schemes, are responsible for these differences.

Chapter 7

Effects of Cash-Cropping Intensification on Household Income and Hungry Season Cereal Reserves

7.0 Introduction

Many factors interact to determine the level of household well-being¹ in the cotton belt.

Farm-level financial analyses in Chapter 5 showed a positive association between intensification in cotton and returns to household labor. Given this and other earlier findings, it is hypothesized that the nature of a household's cash-cropping activities is also an important factor in explaining overall well-being. Other factors exogenous to the smallholder:JVC relationship, such as household assets, human capital and local infrastructure are also hypothesized to be influential in determining differences in well-being across households. The analytical challenge addressed in this chapter is to estimate the impact of these two sets of factors on household well-being through econometric modelling.

Doing so will allow us to gain insight into a set of policy questions central to this thesis:

- 1) What has been the impact of the JVC cash-cropping schemes on smallholder well-being?
- 2) Is the impact of cash-cropping on smallholder well-being greater with intensification?
- 3) Is there a difference in the impact of cash-cropping on smallholder well-being between the JVC-intensive zones (Montepuez and Monapo/Meconta) and the CARE-OPEN project area, the focus of much less JVC investment?

¹ “Well-being” in this chapter refers to household income and hungry season cereal reserves.

To investigate these issues, the chapter is organized into four sections: 1) a discussion of the two definitions of household well-being used in this analysis; 2) the structure of household income across the study zone; 3) a conceptual framework for modelling household well-being and model results; and 4) a model of the process by which household cotton production category is determined.

7.1 Definitions of Household Well-being

The determinants of two key household well-being indicators are examined in this chapter: 1) net household income and 2) hungry season cereal reserves, a proxy of household food security discussed below. Econometric modelling is conducted using both definitions of well-being based on the sample of 521 households interviewed in Rounds 3, 4 and 5 in the Montepuez, Monapo/Meconta and the CARE-OPEN study zones.

7.1.1 Defining Household Income

Household income is defined as the net value of income earned by resident household members from January to December 1995 (Recall periods from Rounds 3-5). This includes retained production, agricultural sales (including livestock sales), off-farm labor sales and micro-enterprise income, less the cost of purchased agricultural inputs and non-family labor.

Retained production and all other in-kind components of income are valued at relevant market prices.²

7.1.2 Food Security Indicators and 24-Hour Consumption Recall Data

Suppose econometric estimation of household income were to show that cash-cropping contributes meaningfully to household income for some or all households in the study zone. This finding would be important to policy makers who seek strategies to promote income growth in rural Mozambique. On the other hand, another important policy issue is the impact of cash-cropping on food security.

The quantity of cereals stored (per capita) at the height of the 1996 hungry season (Round 5) is used as a proxy for household food security. Recall that household data collection included 24-hour recall of food prepared within the household. The research design had anticipated that this data would be used for modelling smallholder food security in the principal study zones. It is clearly a preferred method over the cereals reserve definition given that it represents actual food prepared within the household and for other reasons discussed below. However, preliminary analysis of the 24-hour recall consumption data demonstrated an unacceptably high number of implausible calorie availability estimates for

² The smallholder survey also gathered data on unearned sources of income, including remittances and gifts as well as donations from governmental and non-governmental organizations. These were small in comparison to total household net income for almost all households. Due to this empirical observation, as well as the analytical goal of estimating the effects of cash-cropping on earned income, these minor income sources are excluded from the definition used. In contrast to southern Mozambique and elsewhere in the Southern Africa region, income from non-resident household members working in urban areas or in South African mines is insignificant.

particular households; these data problems are believed to be largely attributable to enumerator error. In light of this problem, it would be inappropriate to use this data for modelling purposes.³ Given the desire to measure the impact of cash-cropping directly on food security, however, an alternative indicator - the quantity of hungry season cereal reserves (as of Round 5) - is used.

Evidence from elsewhere in Sub-Saharan Africa is mixed concerning the impact of increased income derived from cash-cropping schemes on food consumption. In a review of recent studies, Strauss and Thomas (1995) show estimates of income elasticities of calorie demand are generally positive and frequently, though not always statistically significant. In a comparable study of household income and calorie consumption in a sugar-growing region of Kenya, however, Kennedy (1987) found that "the marginal propensity to consume calories is quite low...for each KSh 100 (or 4 percent) increase in income, household energy intake increases by only 2-3 calories (or 0.1 percent)." In sum, it is not appropriate to conclude that improvements in smallholder income brought about by cash-cropping necessarily generate the same effect on household calorie consumption. Therefore, the two goals of econometric modelling here are: 1) to test the impact of the various cash-cropping schemes on household per capita income; and 2) to test the impact of the same schemes on a proxy for household food security.

³ While the quality of the 24-hour recall data is not appropriate for econometric modelling, it is believed that the descriptive statistics presented in Table 3-8 accurately reflect the proportion of calories attributable to each food group and source.

It is important to stress that using 1996 hungry season cereal reserves as the dependent variable in a model of household food security poses a potential bias. The problem is that the difference in cereal stocks between households may reflect both temporary shocks to household assets and real fundamental well-being differences. Given existing data, it is not possible to separate these two effects.

An additional problem with using 1996 hungry season cereal reserves as a dependent variable to proxy for food availability is that some households may choose to carry low stocks if they have recourse to other ways to access food (e.g., food markets, off-farm labor sales, remittances). In light of food market participation data presented in Chapter 3 showing the relatively small role of cereal purchases in meeting energy requirements, it is believed that this is the case for relatively few households. However, because neither smallholder cash reserves nor planned food purchases in the period between Round 5 and the following cereal harvest were included in smallholder surveys, empirical investigation of this issue is not possible.

In light of the above discussion, two models will be estimated to analyze the determinants of household well-being. Each will have identical explanatory variables and functional form. The first will use net income per capita as the dependent variable, while the second will use 1996 hungry season cereal reserves.

7.2 The Structure of Household Income

From the smallholder perspective, the discussion in Chapters 3 through 6 focused almost exclusively on the role of three crops - maize, manioc and cotton - in the cotton belt household economy. What is the role of earnings from cereals and cotton production in the overall income-generating strategy of households across the study zone? Are there other key income sources for a large number of households?

7.2.1 Income Sources

Tables 7-1 through 7-3 present the share of income attributable to each major on-farm and off-farm source by study zone and cotton production category. Four results merit discussion. First, for all groups outside the two Montepuez high-input cotton production categories, retained staple food production is, by far, the largest income source, representing between 45-60 percent of net household income. Meanwhile, off-farm earnings comprise only 9-21 percent of net household income. These proportions are similar to findings from the 1991 Nampula Smallholder Survey, and suggest that the vast majority of surveyed farmers continue to be heavily reliant on agricultural production from their own fields for their food security. By contrast, cotton earnings for households in the high-input cotton production categories (36 to 45 percent of total income) approximates or exceeds the value of their retained production (29 to 38 percent).

Second, smallholders rely on food sales for a minor part (from two to ten percent) of net income. This is consistent with findings from the 1991 Nampula Study, where food sales

Table 7-1 Net Household Income Shares by Cotton Production Category, Montepuez, 1995

Source	Cotton			No Cotton
	High-Input Block	High-Input Dispersed	Low-Input Dispersed	
-- percent of net household income --				
On-Farm				
Retained staple food production	29	38	54	68
Food sales (net of input costs)	5	10	4	7
Cotton sales (net of input costs)	45	36	23	-
Cashew sales	0	0	0	0
Livestock sales	<1	<1	1	<1
Vegetable and fruit sales	<1	<1	<1	<1
Other	3	1	5	3
Off-Farm				
Labor sales	10	3	4	9
Micro-enterprise	6	10	8	9
-- Mean in \$ --				
Purchased inputs ¹	289 ²	119 ³	4	7
Purchased inputs per capita	86 ²	34 ³	1	2
Net income	669 ³	650 ³	255 ⁴	192
Net income per capita	191 ³	199 ³	82 ⁴	58

¹ Farmgate prices; excludes non-family labor hired.

² Significantly greater than all other groups at .01 level.

³ Significantly greater than low-input dispersed and non-cotton categories at .01 level

⁴ Significantly greater than non-cotton category at .05 level.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 7-2 Net Household Income Shares by Cotton Production Category, Monapo /Meconta, 1995

Source	Cotton Production Category		No Cotton
	Low-Input Block	Low-Input Dispersed	
-- percent of net household income --			
On-Farm			
Retained staple food production	45	45	59
Food sales (net of input costs)	2	3	4
Cotton sales (net of input costs)	31	22	-
Cashew sales	6	6	9
Livestock sales	2	1	2
Vegetable and fruit sales	1	<1	<1
Other	<1	6	4
Off-Farm			
Labor sales	4	8	13
Micro-enterprise	4	8	8
--Mean in \$--			
Purchased inputs ¹	1	1	0
Purchased inputs per capita	<1	<1	0
Net income	371 ²	238 ⁴	151
Net income per capita	101 ³	83 ⁴	61

¹ Farmgate prices; excludes non-family labor hired.

² Significantly greater than both other group means at .01 probability level.

³ Significantly greater than low-input dispersed group mean at .10 probability level and non-cotton group mean at .01 probability level.

⁴ Significantly greater than non-cotton group mean at .05 probability level.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 7-3 Net Household Income Shares by Cotton Production Category, CARE-OPEN Zone, 1995

Source	Cotton Production Category	
	Low-Input Dispersed	No Cotton
-- percent of gross household income --		
On-Farm		
Retained staple food production	57	60
Food sales (net of input costs)	3	9
Cotton sales (net of input costs)	18	-
Cashew sales	5	7
Livestock sales	2	2
Vegetable and fruit sales	<1	2
Other	1	<1
Off-Farm		
Labor sales	4	3
Micro-enterprise	5	7
-- Mean in \$ --		
Purchased inputs ¹	1	3
Purchased inputs per capita ¹	<1	1
Net income	174 ²	216
Net income per capita	68 ²	75

¹ Farmgate prices; excludes non-family labor hired.

² No statistically significant differences between group means.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

accounted for between six and 12 percent of household income in Monapo and Ribaue Districts, respectively. It is noteworthy, however, that despite the fact that nearly all Montepuez high-input block cotton households participated in the high-input block maize scheme, Table 7-1 shows net earnings from this scheme contributed only five percent to mean income in this category. This result is attributable to the high variability in block maize yields and profitability during the study year when many households recorded financial losses (see Chapter 5). For those households in the upper yield tercile of the high-input block maize scheme, net food sales comprised a higher proportion of household income than the category mean.

Third, earnings from cashew sales, an important source of smallholder income in this zone prior to independence, have fallen dramatically in the past twenty years (see Chapter 1). Cashew sales in Monapo/Meconta and in CARE-OPEN contributed between two and nine percent of overall household income (and were insignificant in Montepuez where cashew is of little historical importance). It is likely that these results are attributable to a combination of factors, including the serious damage inflicted on the tree stock by Cyclone Nadia in 1994, the lack of adequate pruning and disease control during wartime conditions, and the aging of the tree stock.

Fourth, while there is a large potential role for livestock development in the smallholder economy, livestock sales (and consumption) constitute a very small part (zero to two percent) of household income and food security strategies. This situation is little changed

from 1991 levels, and is undoubtedly related to the decimation of livestock herds which took place during the war.

7.2.2 Household Income Levels

Mean net income on both a household and per capita basis are displayed in Tables 7-1 to 7-3.

A positive association between input use, cotton production and income is evident.

Montepuez households in both high-input categories show per capita income (\$191 to \$199) two to three times higher than all other zone/production category groups (\$58 to \$101).

These differences are statistically significant, with p-values displayed in the tables. Further, there is a clear association between the value of input use and income; based on farm-gate input prices, high-input households used far more purchased inputs (\$34 to \$86 per capita) than any other groups (zero to \$2 per capita).

Second, in both Montepuez and Monapo/Meconta, areas of relatively intense JVC activity, smallholders producing cotton using low-input packages earned significantly greater incomes than their non-cotton growing neighbors (\$82 to \$101 vs. \$58 to \$61 per capita).

Comparing low-input Monapo/Meconta block cotton households to their neighbors growing cotton on dispersed fields, the former had 23 percent greater annual earnings. This is consistent with findings from Chapter 5 which showed Monapo/Meconta low-input block households earning \$0.93 per labor day in cotton compared to only \$0.62 per day for low-input dispersed households.

7.2.3 Hungry Season Cereals Reserves

The second set of household well-being models defines well-being in terms of hungry season cereal reserves per capita based on stocks reported as of Round Five. Table 7-4 presents mean cereals storage per capita by zone and cotton production category. In Montepuez, the table shows statistically greater reserves for households in each cotton production category compared to their non-cotton growing neighbors. However, in contrast to the analogous comparison with respect to household income, there is no statistically significant difference in cereal reserves between Montepuez high-input and low-input cotton production categories. Meanwhile, in Monapo/Meconta low-input block cotton households had significantly greater cereal reserves than their neighbors though there is no statistical difference in this variable between low-input dispersed cotton and non-cotton producing households. Again, in the CARE-OPEN zone, there is no significant difference between food reserves based on cotton production category. It should be pointed out, however, that reserves in the CARE-OPEN area are decidedly lower, on average, than in the other two zones, reflecting a relatively more vulnerable population in terms of food security.

7.3 The Determinants of Household Well-being

Tabular analysis presented in Tables 7-1 to 7-3 showed a strong positive statistical association between household income, agricultural intensification and cash-cropping activity in cotton in the zones of relatively high JVC investment. With respect to 1996 hungry season cereal reserves, the association was positive though statistically weaker. On the other hand, in the CARE-OPEN zone, with a relatively weak JVC presence, there were no statistically significant differences with respect to household income or food security

Table 7-4 Hungry Season Cereals Reserves by Province and Cotton Production Category, 1996

Zone / Cotton Production Category	Hungry Season Cereals Reserves	
	Mean	Standard Deviation
-- '000s calories per capita --		
Montepuez	78 ⁵	96
High-input block	150 ¹	192
High-input dispersed	121 ¹	141
Low-input dispersed	101 ²	113
No cotton	63	76
Monapo / Meconta	156 ⁵	177
Low-input block	220 ³	188
Low-input dispersed	106	143
No cotton	90	163
CARE-OPEN	42	66
Low-input dispersed	30 ⁴	63
No cotton	48 ⁴	66

¹ Statistically greater than no cotton category within this zone at the .05 level.

² Statistically greater than no cotton category within this zone at the .10 level.

³ Statistically greater than both other categories within this zone at the .01 level.

⁴ No statistical difference between group means.

⁵ No statistical difference between group means, but both group means are greater than the CARE-OPEN mean at the .01 level.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

associated with cotton production. These results are suggestive of a causal relationship between a strong JVC presence, cash-cropping and intensification and well-being. However, it is not appropriate to base conclusions regarding causality only on comparisons of group means. This is because of two issues discussed below: 1) other factors unrelated to the smallholder:JVC cash-cropping relationship may be important in explaining some or all of the observed income differences; and 2) a potential "selection-bias" influencing the process by which household cotton production category must be examined and corrected for.

Related to the first point, consider the case of two hypothetical households in Monapo/Meconta, one of whom is in the low-input dispersed cotton production category and the other is in the non-cotton production category. The cotton-producing household may have greater income than its non-cotton producing neighbor for reasons unrelated to cotton production. Possible explanations could be relatively greater cashew earnings, food crop production or entrepreneurial activity. To the extent that non-program differences are observed, these variables can be incorporated into econometric modelling which can isolate the program participation effects using an ordinary least squares (OLS) specification and dichotomous cotton production category (or program effect) variables.

Second, the selection bias problem in modelling household well-being is analogous to the same problem addressed in the yield models in Chapter 4. To review that argument, suppose that dichotomous variables relating to cotton production categories were included in an OLS model with income per capita as the dependent variable. If unobserved differences between households in terms of management skills and farming practices are significant and are

excluded from the model, the cotton production category dichotomous variables would potentially overestimate the “program effect.” That is, the coefficient would be capturing both the effects of the omitted pre-program differences between groups as well as the program effect.

Given existing data, and with the possibility that the sample reflects a selection bias to a significant extent, what econometric techniques are possible to correct for this problem? In the absence of observations for the same cross-section over multiple years (or panel data), a two-stage least squares (2SLS) might be appropriate. The first stage would model household production category determination, while the second stage would use the estimated values from the first stage and other exogenous variables to predict well-being. The feasibility of a 2SLS solution requires the existence of a plausible instrumental variable(s) satisfying two conditions. First, the instrument must be a predictor of cotton production category; but second, the instrument must not be a predictor of well-being.

In model development, it was not possible to identify a suitable instrumental variable. All plausible factors hypothesized to predict household cotton production category choice could also logically be argued to predict well-being. The process by which households select into and/or are chosen to participate in particular JVC schemes remains difficult to explain. Two steps are taken in the analysis to deal with this problem. First, the well-being models are run using OLS and dichotomous program variables, though an attempt to correct for the selection bias is incorporated by specifying the models both with and without KGSTOR95 - the level of household cereal reserves during the 1995 hungry season. KGSTOR95, the same variable

used in the yield equations, is again designed to proxy for unobserved, productivity-related household factors such as management capacity, farmer ability and capital. Importantly, interpretation of this variable is not conceived as capturing the effect of cereal storage on income, but rather as a proxy for the effect of unobserved variables important to well-being determination. To the extent that KGSTOR95 may be simultaneously determined by the household when cash-cropping production decisions are made, the well-being models are estimated without this variable to test for robustness. Second, and to gain further insights into the process by which households select into and/or are chosen to be in specific cotton production categories, discrete choice models are developed in the following section where the explanatory variables are essentially those used in the well-being models.

7.3.1 Choice-Based Sampling and Statistical Weighting

Because sampling was stratified based on prior knowledge of household cotton production category, it is known as a choice-based sample. Ben-Akiva and Lerman (1986) show that econometric estimation using a choice-based sample with OLS must be weighted to obtain unbiased parameter estimates. The weights are equivalent to the population fraction divided by the sample fraction within each district and cotton production category and are shown in Table 7-5.

Table 7-5 Weighting Factor to Adjust for Choice-Based Sample, by Study Zone

Production Category	Sample Fraction (H_j)	Population Fraction (W_j)	$(W_j)/(H_j)$
Montepuez			
High-Input Block	.19	.03	.16
High-Input Dispersed	.13	.01	.06
Low-Input Dispersed	.39	.31	.81
No Cotton	.28	.65	2.28
Monapo/Meconta			
Low-Input Block	.27	.45	1.68
Low-Input Dispersed	.49	.41	.84
No Cotton	.24	.14	.57
CARE-OPEN	Simple random sample drawn in this zone; therefore all observations treated equally		
Source: 1994/96 MAP/MSU FSP Smallholder Survey and Ben-Akiva and Lerman (1986)			

7.3.2 Conceptual Framework for Modelling Household Income

Given the above discussion the following conceptual framework is hypothesized to characterize the level of household income attained by households in the cotton belt:

$$\text{INCOME PER CAPITA} = f(\text{HOUSEHOLD ASSETS, HOUSEHOLD STRUCTURE, INFRASTRUCTURE, CASH CROPPING CATEGORY})$$

Below we consider the rationale for model specification, and how available data are used to develop explanatory variables in the well-being equations.

7.3.2.1 Household Assets

The main types of assets hypothesized to influence household well-being are land area owned, soil quality, the number of productive cashew trees and cereal reserves at the time of planting field crops (measured as of Round 2 in January 1995). Recall that the 1991 Nampula Household Survey showed, somewhat surprisingly given the conventional wisdom of land abundance in rural Mozambique, that land area cultivated was the principal determinant of household well-being. Based on this and similar findings since that time (MAP/MSU FSP, 1994), it is hypothesized that land holdings continue to be a significant predictor of household well-being. Note that this definition of land holdings includes both cultivated and fallow land, but excludes any land borrowed by the household (e.g., block land essentially loaned by the JVC). Soil quality is also hypothesized to contribute to income; as explained in Chapter 4, for soil quality measurement, we rely on farmer responses concerning soil color, texture and fertility. As such, soil quality is proxied in the model as equal to the percentage of farm size considered currently very fertile.

Because cashew income constitutes an important income source for some households in Nampula Province (see Tables 7-2 and 7-3), the number of productive trees is included as an explanatory variable. Note that cashew trees owned by the household but reported as not producing nuts in the previous season are excluded from the definition.

These asset variables (farm size, soil quality and productive cashew trees) are assumed exogenous or outside the control of the household in the short run. KGSTOR95 - hungry season cereal reserves (KGSTOR95) - may also proxy for important household-productivity related factors, though its inclusion is potentially problematic given the simultaneity issue discussed above. As such, two models are estimated for both definitions of household well-being, one excluding KGSTOR95 as an explanatory variable and the other including it.

In similar settings, livestock holdings would typically be included in a model of well-being determination. Livestock holdings are excluded here because herd size is so small for nearly all households; recall Tables 7-1 to 7-3 showed that livestock sales represented a very small portion of household income, while Table 3-6 showed the generally small herd sizes across sampled households.

7.3.2.2 Household Structure

Four household structure variables are incorporated into the well-being models. The number of individuals aged 10 or over represents the labor force available for both agricultural and non-agricultural income-generating activities. The maximum number of years of formal education of household members in a decision-making position, defined as those age 15 and

above, and the age of the household head both proxy for experience and human capital. Finally, the gender of the household head is incorporated as a dichotomous variable.⁴

7.3.2.3 Village-Level Infrastructure

Village-level dichotomous variables are included in the models to control for variation in infrastructure across villages; key types of infrastructure which may affect household well-being include distance to JVC supply depots, quality of road, market services, water resources and the availability of maize milling services.⁵

7.3.2.4 Testing for the Program Effects of the Cotton and Maize Schemes

Dichotomous variables representing a household's cotton production category are incorporated into the well-being models and are designed to capture the program effect (i.e., the effect of a household being in each respective cotton production category relative to the omitted group (or the non-cotton production category)).

To test for the effect of intensification in maize production on smallholder income, a dichotomous variable is also incorporated into the Montepuez model related to high-input block maize participation. Recall that households in this scheme were unique within

⁴ To prevent near perfect multicollinearity, note that this variable is excluded in Montepuez District estimations, as only one household was female-headed.

⁵ See Table 4-12 for the definitions of each village dichotomous variable. For an inventory of infrastructure in each surveyed village, see MAP/MSU FSP, 1996.

Mozambique in terms of receiving JVC support for food crops, both in terms of inputs for production and a guaranteed output market at the official minimum price.⁶

7.3.2.5 Separate Estimation by Study Zone

The models of household well-being are estimated separately for each study zone. This has the advantage of allowing each independent variable to vary across geographic space.

Pooling observations across districts and including a set of dichotomous district variables would only allow the intercept to vary and assume all other coefficients constant across districts. On the other hand, estimating the models by zone has the disadvantage of reducing sample size, and therefore reducing modelling efficiency.⁷ Given the sample size in each study zone (between 145 and 201) and the potential for structural differences to occur between zones, estimating separate models for each study zone was judged superior. Examples of potential inter-zone structural differences include relatively high population density and proportion of smallholders growing cotton in Monapo/Meconta relative to the other zones (see Table 3-1).

7.3.3 Models of Household Well-Being

Equations 7-1 to 7-4 were estimated using a log-linear functional form typical of income equations. By definition, using a log-linear form implies that coefficients of continuous

⁶ Note that among high-input block cotton households, 23/39 participated in the high-input block maize scheme in 1994/95. Also, 5/27 high-input dispersed cotton households and 1/57 non-cotton growing households participated in the high-input block maize scheme.

⁷ A Chow test failed to accept the null hypothesis of pooling the observations at the .01 probability level, implying that separate models should be estimated for each district.

variables may be interpreted as the percentage change in the dependent variable given a unit change in the independent variable; the percentage change implied in the dependent variable by the coefficient, B , of a dichotomous variable is equal to $\exp^B - 1$.

Equation 7-1:

$$\ln(\text{INC_PC}) = f(\text{NADULT}, \text{AGEHHH}, \text{EDUCMAX}, \text{FEMHHH}, \text{AREAOWN}, \text{SOILQUAL}, \text{NCASHEWP}, \text{HIGH_INB}, \text{HIGH_IND}, \text{LOW_INB}, \text{HIGH_MZB}^8, \text{LOW_IND}, \text{VIL1..n})$$

Equation 7-2:

identical to Equation 7-1 except that it includes KGSTOR95⁹ as an explanatory variable.

Equation 7-3:

$$\ln(\text{CER_PC96}) = f(\text{NADULT}, \text{AGEHHH}, \text{EDUCMAX}, \text{FEMHHH}, \text{AREAOWN}, \text{SOILQUAL}, \text{NCASHEWP}, \text{HIGH_INB}, \text{HIGH_IND}, \text{LOW_INB}, \text{LOW_IND}, \text{HIGH_MZB}^7, \text{VIL1..n})$$

Equation 7-4:

identical to Equation 7-3 except that it includes KGSTOR95 as an explanatory variable.

where:

INC_PC=	household income per capita, 1995 (\$)
CER_PC96=	cereal reserves per capita, 1/96 ('000 calories)
AREAOWN=	Total household area owned ¹⁰ (cultivated plus fallow) in hectares
SOILQUAL=	Percent of AREAOWN considered "very fertile" by household head
NCASHEWP=	Number of productive cashew trees as of 9/95
NADULT=	Number of adult household members (>10 years)
AGEHHH=	Age of head of household
EDUCMAX=	Maximum years of education, any household member > 15 years
FEMHHH=	1 if household is female-headed 0 otherwise

⁸ HIGH_MZB is only relevant in the Montepuez model.

⁹ Neither specification of the well-being models including KGSTOR95 are estimated for the CARE-OPEN zone, as data required for its computation was not collected among households in this zone.

¹⁰ Includes area under cultivation and in fallow; excludes all area which the household cultivated in 1994/95 allocated to it whose use rights are controlled by a JVC or other large landholder.

KGSTOR95=	Cereals reserve per capita, 1/95 (kgs)
VIL1..VILn	see Table 4-12
HIGH_INB=	1 if high-input block cotton participant 0 otherwise
HIGH_IND=	1 if high-input dispersed cotton participant 0 otherwise
LOW_INB=	1 if low-input block cotton participant 0 otherwise
LOW_IND=	1 if low-input dispersed cotton participant 0 otherwise
HIGH_MZB=	1 if high-input block maize participant 0 otherwise

Descriptive statistics of variables used in this model are provided by zone in Table 7-6 and the results of the models are presented in Tables 7-7 (Montepuez), 7-8 (Monapo/Meconta) and 7-9 (CARE-OPEN).

7.3.3.1 Income Model Results and Interpretation

Examination of regression results of both income model specifications shows the models perform well in terms of overall explanatory power. In the two primary study zones, the models explain between 49 and 53 percent of the variation in per capita income based on adjusted R-squared statistics. Holding constant all non-JVC related factors, we address first the three policy-related questions asked in the introduction of this chapter related to the impact of participation in the various cash-cropping schemes on smallholder well-being:

- 1) What has been the impact of the JVC cash-cropping schemes on smallholder well-being?
- 2) Is the impact of cash-cropping on smallholder well-being greater with intensification?
- 3) Is there a difference in the impact of cash-cropping on smallholder well-being between the JVC-intensive zones (Montepuez and Monapo/Meconta) and the CARE-OPEN project area, the focus of much less JVC investment?

Table 7-6 Mean and Standard Deviation of Variables, by District, in Household Income, Cereal Reserves and Discrete Choice Models

Variable	Montepuez		Monapo/ Meconta		CARE	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
INC_PC	71.1	71.2	88.2	60.3	72.5	44.6
CER_PC96	78.1	96.0	155.5	176.8	42.4	65.5
NADULT	3.2	1.3	3.1	1.2	2.8	1.2
FEMHHH	<1 percent=1		5 percent=1		3 percent=1	
AGEHHH	39.3	11.9	40.8	12.9	38.5	12.1
EDUCMAX	3.3	2.3	2.9	2.5	2.7	2.1
AREAOWN	3.5	1.9	4.0	2.0	3.9	1.8
SOILQUAL	30 percent = high quality		60 percent = high quality		36 percent= high quality	
NCASHEWP	0.5	3.0	14.6	31.0	12.2	25.0
KGSTOR95	.074	.1	.018	.034	Not available	
HIGH_INB		¹				
HIGH_IND		¹				
HIGH_MZB	See Footnote 8					
LOW_INB				¹		
LOW_IND		¹		¹		¹
Village dummies	See Appendix 1 for number of households in each village					
Number of observations	201		175		146	

¹ See Table 7-5 for sample and population fractions.

Weighted statistics reported; see Chapter 2 and Appendix 1 for derivation of weights.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 7-7 Income and Hungry Season Cereal Reserve Regression Results, Montepuez

Variable	Household Income Per Capita						Hungry Season Cereal Reserves					
	Equation 7-1			Equation 7-2			Equation 7-3			Equation 7-4		
	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value
HIGH_INB	0.72	0.25	0.01	0.68	0.25	0.01	0.66	0.63	0.30	0.68	0.63	0.29
HIGH_IND	0.89	0.40	0.03	0.87	0.40	0.03	0.18	1.00	0.85	0.19	1.00	0.85
LOW_IND	0.22	0.08	0.01	0.22	0.08	0.01	0.38	0.20	0.06	0.38	0.20	0.06
HIGH_MZB	0.77	0.25	0.00	0.75	0.26	0.00	0.91	0.63	0.15	0.92	0.63	0.15
NADULT	-0.18	0.03	0.00	-0.17	0.03	0.00	-0.37	0.08	0.00	-0.38	0.08	0.00
AGEHHH	0.00	0.00	0.22	0.00	0.00	0.25	0.01	0.01	0.42	0.01	0.01	0.42
EDUCMAX	0.05	0.02	0.00	0.05	0.02	0.00	0.13	0.04	0.00	0.13	0.04	0.00
AREAOWN	0.11	0.02	0.00	0.10	0.02	0.00	0.19	0.05	0.00	0.20	0.06	0.00
SOILQUAL	0.05	0.13	0.72	0.01	0.13	0.91	0.79	0.33	0.02	0.80	0.33	0.01
KGSTOR95	--	--	--	6.3E-04	4.2E-04	0.14	2.6E-04	0.00	0.80	--	--	--
VILMTZ1	0.25	0.13	0.07	0.24	0.13	0.08	0.23	0.33	0.49	0.23	0.33	0.48
VILMTZ2	-0.18	0.14	0.18	-0.17	0.14	0.22	-2.52	0.33	0.00	-2.52	0.34	0.00
VILMTZ3	-0.45	0.15	0.00	-0.44	0.15	0.00	-0.02	0.37	0.96	-0.02	0.37	0.95
VILMTZ4	0.06	0.14	0.68	0.02	0.14	0.87	-1.19	0.33	0.00	-1.17	0.34	0.00
VILMTZ5	-0.28	0.12	0.02	-0.26	0.12	0.04	-0.07	0.31	0.83	-0.07	0.31	0.81
VILMTZ6	-0.42	0.14	0.00	-0.42	0.14	0.00	-0.62	0.34	0.07	-0.62	0.37	0.07
Constant	3.87	0.19	0.00	3.86	0.19	0.00	3.48	0.47	0.00	3.48	0.47	0.00
Adj. R squared	0.53			0.53			0.47			0.47		
F-stat	15.80			15.00			12.80			11.90		

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 7-8 Income and Hungry Season Cereal Reserve Regression Results, Monapo/Meconta

Variable	Household Income Per Capita						Hungry Season Cereal Reserves					
	Equation 7-1			Equation 7-2			Equation 7-3			Equation 7-4		
	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value
LOW_INB	0.33	0.14	0.02	0.31	0.13	0.02	0.26	0.49	0.59	0.24	0.49	0.63
LOW_IND	0.26	0.11	0.02	0.25	0.11	0.02	0.23	0.40	0.56	0.21	0.40	0.59
NADULT	-0.18	0.03	0.00	-0.17	0.03	0.00	-0.02	0.11	0.84	-0.01	0.11	0.91
AGEHHH	0.00	0.00	0.93	0.00	0.00	0.62	0.00	0.01	0.71	0.00	0.01	0.72
FEMHHH	-0.68	0.17	0.00	-0.63	0.17	0.00	-1.07	0.61	0.08	-1.02	0.61	0.10
EDUCMAX	-0.01	0.02	0.73	-0.00	0.02	0.78	-0.04	0.06	0.47	-0.04	0.06	0.49
AREAOWN	0.09	0.02	0.00	0.09	0.02	0.00	0.16	0.06	0.02	0.15	0.06	0.02
SOILQUAL	0.00	0.12	0.98	0.07	0.12	0.62	0.73	0.44	0.10	0.80	0.44	0.07
NCASHEWP	-0.00	0.00	0.60	-0.00	0.00	0.33	-0.00	0.00	0.57	-0.00	0.00	0.49
KGSTOR95	--	--	--	0.00	9.8E-04	0.01	--	--	--	0.00	0.00	0.40
VILMON2	-0.38	0.18	0.04	-0.37	0.18	0.04	-1.95	0.66	0.00	-1.94	0.66	0.00
VILMON3	0.05	0.18	0.80	0.03	0.18	0.88	-1.93	0.64	0.00	-1.95	0.65	0.00
VILMON4	0.29	0.12	0.01	0.23	0.12	0.06	0.99	0.42	0.02	0.92	0.42	0.03
VILMON5	-0.21	0.13	0.12	-0.23	0.13	0.07	1.32	0.47	0.01	1.29	0.47	0.01
VILMON6	-0.34	0.14	0.02	-0.34	0.14	0.02	-1.59	0.51	0.00	-1.59	0.51	0.00
VILMON7	0.50	0.13	0.00	0.50	0.13	0.00	0.02	0.46	0.96	0.02	0.46	0.96
VILMON8	-0.07	0.14	0.63	-0.06	0.14	0.64	-2.14	0.49	0.00	-2.14	0.49	0.00
VILMON9	0.28	0.18	0.12	0.33	0.18	0.07	0.05	0.64	0.94	-0.11	0.65	0.87
Constant	4.28	0.21	0.00	4.21	0.21	0.00	3.15	0.76	0.00	3.08	0.77	0.00
Adj. R squared	0.49			0.51			0.43			0.43		
F-stat	10.70			10.90			8.70			8.20		

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table 7-9 Income and Hungry Season Cereal Reserve Regression Results, CARE-OPEN

Variable	<u>Dependent Variable</u>					
	<u>Household Income Per Capita</u>			<u>Hungry Season Cereal Reserves</u>		
	<u>Equation 7-1</u>			<u>Equation 7-3</u>		
	Coeff.	S.E.	P-value	Coeff.	S.E.	P-value
LOW_IND	-0.25	0.12	0.04	-0.03	0.46	0.94
NADULT	-0.21	0.04	0.00	-0.46	0.15	0.00
AGEHHH	-0.01	0.00	0.26	0.01	0.02	0.58
EDUCMAX	-0.00	0.02	0.91	0.07	0.09	0.46
AREAOWN	0.13	0.03	0.00	0.09	0.10	0.36
SOILQUAL	0.20	0.13	0.13	0.24	0.53	0.65
NCASHEWP	0.004	0.00	0.06	-0.003	0.01	0.73
VILCAR1	-0.01	0.14	0.01	0.21	0.58	0.71
VILCAR2	0.02	0.15	0.87	0.99	0.58	0.09
VILCAR3	0.16	0.17	0.34	-1.72	0.68	0.01
VILCAR4	-0.08	0.14	0.58	0.47	0.55	0.40
Constant	4.36	0.21	0.00	2.47	0.82	0.00
Adj. R squared		0.29			0.17	
F-stat		6.29			3.70	

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Related to 1) and 2), in both JVC-intensive zones, the coefficients of each dichotomous variable for cotton production category are positive and statistically significant. Growing cotton in these zones increases per capita income from 25 to 36 percent in the low-input schemes. As Table 7-10 shows, this translates into an increase in per capita annual income of between \$15 and \$22; given a mean family size of approximately five members (from Table 3-1), this equates to an increase in mean family income of between \$75 and \$110 per year. The effect of the high-input cotton schemes, *ceteris paribus*, is to increase smallholder per capita income by an impressive 97 to 138 percent or \$56 to \$80 per capita (or \$280 to \$400 per household) relative to non-cotton growing households. This provides strong complementary evidence to earlier findings suggesting that the high-input schemes have a markedly greater effect on income than low-input cotton in Montepuez or Monapo/Meconta for participating households.¹¹

¹¹ To enhance the study's internal consistency, it would be interesting to compare the magnitude of income effects from the various schemes generated from the income models with results implied by the yield equations. That is, what is the effect on household income implied by the yield equations of participating in the high-input block cotton scheme assuming mean cotton area for participants? How does it compare with the \$56 estimate generated here. Such a comparison is not valid, however, because the dichotomous variables in the two equations are not measuring precisely the same phenomenon. For example, in the cotton yield equation, the high-input block cotton variable was capturing the effects of inputs unique to that system (herbicide, fertilizer and tractorization) and comparing their effect to the low-input (or omitted) category. The impact of insecticide, significant in magnitude at the margin, was captured through a separate independent variable. By contrast, in the income equation, insecticide was not included as an independent variable, but was rather subsumed within the definitions of each dichotomous cotton production category variable. Thus, the estimates of income effect generated in the income models incorporate both the effect of insecticide and the effect of other program inputs in comparison to the case of the average non-cotton grower income, a category by definition not analyzed in the cotton yield equation.

Table 7-10 Estimated Effect of Cash-Cropping Schemes on Household Income per Capita, Percent and Absolute Amount, by Zone

Production Category and Crop	<u>Montepuez</u>		<u>Monapo/Meconta</u>		<u>CARE-OPEN</u>	
	Percent Impact	Absolute Amount (\$)	Percent Impact	Absolute Value (\$)	Percent Impact	Absolute Value (\$)
High-input block cotton	97	56				
High-input dispersed cotton	138	80				
Low-input block cotton			36	22		
Low-input dispersed cotton	25	15	28	17	-22	-19
High-input block maize	112	65				

Source: 1994/96 MAP/MSU FSP Smallholder Survey

The impact of maize intensification on household income can be analyzed by examining the coefficient on HIGH_MZB (or high-input block maize) in Montepuez, the only study zone with a JVC-supported food crop scheme. Table 7-10 shows that the impact of participating in intensified maize production, on average, is to increase per capita income by 112 percent or \$65. It is noteworthy that the maize scheme had such a dramatic effect on income given that households in the lowest yield tercile in the scheme suffered financial losses (see Chapter 5). While results show clearly that smallholders benefit from participation in this scheme, it is important to note that this is not only due to the effect of agricultural inputs, but also to the guaranteed minimum price for maize that Lomaco paid smallholders in 1994/95. Importantly, coefficient estimates of the dichotomous program variables are robust to the two model specifications (with and without KGSTOR95). Further, comparison of parameter estimates between Equations 7-1 and 7-2 (discussed below) indicate that other results are generally robust to the two specifications. Related to the selection bias issue which KGSTOR95 was intended to alleviate, the robustness of the model here indicates either 1) that KGSTOR95 is a poor proxy for unobserved productivity-related factors; or 2) that these factors and hence the selection bias are not important. As was the case in the yield models, it is not possible through the models to distinguish between these two possibilities.

Related to 3), the coefficient on LOW_IND in CARE-OPEN not only indicates that smallholder cotton production does not have a positive effect on income here, but that cotton production actually reduces income in that zone. While it is not surprising that cotton without ample JVC support does not contribute positively to income, the strong significance of its negative effect is difficult to explain. Given the lack of necessary data to test the

model in CARE-OPEN with KGSTOR95, it is not possible to determine the extent to which there is a negative selection effect in that zone (i.e., that cotton-growers were relatively less productive than their neighbors independent of cotton, or whether cotton production actually reduces per capita income).

As expected based on results concerning smallholder land access from earlier studies discussed above, total farm size (AREAOWN) is a key predictor of per capita income, with the coefficients in each zone statistically significant and positive. The impact of increasing farm size by one hectare results in an average increase in per capita income from 9 to 13 percent across the three districts. While the coefficient of soil quality (SOILQUAL) is also positive in each zone, it is not statistically significant.

The number of productive cashew trees (NCASHEWP) has no statistical impact on income in Monapo/Meconta. Modelling from the 1991 Nampula Smallholder Survey showed that cashew holdings were both positive and significant in determining well-being in Monapo, Ribaué and Angoche. That NCASHEWP is both positive and significant in CARE-OPEN, an adjacent zone unaffected by Cyclone Nadia in 1994 but insignificant in Monapo/Meconta suggests that the cyclone may have done irreparable damage to the cashew tree stock in the latter zone.

The coefficient on household labor size (NADULT) is negative and significant in each zone. That is, holding farm size constant, per capita income does not rise proportionately with

family size. This likely reflects the weakness of the labor market across the cotton belt, and further underscores the importance of land holdings in well-being determination.

In Monapo/Meconta, the models show that the effect of a household being headed by a female (FEMHHH) is quite negative on income, lowering it on average by 47 to 49 percent. FEMHHH is excluded from the Montepuez and CARE-OPEN models because there are only one and three percent of sampled households who are female headed in these zones; excluding FEMHHH thus prevents near-perfect multicollinearity.

In similar settings, one would typically expect greater levels of education to contribute positively toward income through improved management and skill levels. It is not surprising, however, in the context of very low absolute education levels throughout the study zone that EDUCMAX is statistically significant and positive in only one district - Montepuez.

7.3.3.2 Testing Human Capital Interaction Terms

To further test the hypothesis that human capital contributes meaningfully to household well-being, two additional versions of Equation 7-1 are estimated, each using interaction terms related to EDUCMAX. Results of these two equations are found in Appendix Tables 3-1 and 3-2. The equation reported in Table A3-1 tests the interaction of a key household asset, land holdings (AREAOWN) multiplied by EDUCMAX. T-tests comparing the constrained specification (Equation 7-1) with the unconstrained specification indicates that model performance improves in Monapo/Meconta and CARE-OPEN, though it does not improve in

Montepuez. In both Monapo/Meconta and CARE-OPEN, the coefficients on EDUCMAX becomes negative and AREAOWN decreases in magnitude, with both becoming significant. Further, the interaction term of AREAOWN*EDUCMAX is positive and significant. This would suggest that the impact of education on income in these two zones becomes larger as area owned increases and vice versa.

The equation reported in Table A3-2 tests the interaction of EDUCMAX with COTTON, a dichotomous variable equal to one if the household is a cotton producer and zero otherwise. A t-test comparing the constrained specification of this model (Equation 7-1) with the unconstrained specification indicates that model performance does not improve with the interaction term added in any of the three zones. That is, income does not increase on average for cotton-growers if they have more formal education.¹²

7.3.3.3 Cereals Storage Model Results and Interpretation

As discussed earlier, similar studies have shown that cash-cropping schemes have positively influenced household income while not necessarily having the same effect on calorie availability or nutrition. The results from the income equations provide robust evidence of the positive impact cash-cropping has had in Montepuez and Monapo/Meconta. We now consider the results of the model predicting cereals storage, the proxy used for food security.

¹² An additional specification was tested where farm size (AREAOWN) was interacted with the various cotton schemes, and was found to be statistically insignificant in each zone.

Overall model performance as measured by the adjusted R-squared statistics (between 42 and 47 percent in the principal study zones and 17 percent in CARE-OPEN) indicates a slightly reduced explanatory power of these models compared with the income models. Again, the coefficient on farm size (AREAOWN) is positive and significant in the two principal study zones, though not statistically significant in CARE-OPEN. Soil quality (SOILQUAL) in this formulation also has a positive and significant effect on this well-being measure in the principal study zones. The level of education (EDUCMAX) within the household again has a positive effect in Montepuez and is insignificant elsewhere.

What is the effect of whether and how a household grew cotton in 1994/95 on their cereal reserve situation the following hungry season? In Montepuez, the coefficients on both high-input cotton categories, the high-input maize block coefficient and low-input dispersed are positive, though only low-input dispersed cotton is statistically significant. Note that HIGH_MZB is nearly significant with a p-value of 0.15. It is likely that the surprising insignificance of the results on the high-input schemes in Montepuez is a result of multicollinearity between the schemes; for example, the correlation coefficient between HIGH_INB and HIGH_MZB is equal to 0.59. Recall that Table 7-4 showed that both high-input cotton groups had significantly greater mean cereal reserves than their non-cotton growing neighbors at a significance level of 0.05.

These findings are important with respect to the frequent critique of cash-cropping schemes in developing countries - that smallholder cash-cropping compromises food security.

Modelling results indicate that, at best cash-cropping and intensification improves food security, and at worst it has a positive though not statistically significant effect.

7.4 Determination of Smallholder Cotton Production Category

This section develops and tests discrete choice models investigating the determinants of smallholder cotton production category. Prior to discussing model formulation, it is important to consider the rationale for these models. Given the strong and positive effect of cotton shown in modelling household well-being, particularly related to the high-input schemes, a simple policy implication would be that all households should begin to grow cotton in the high-input schemes; for adopting households, per capita incomes would then increase in an amount related to the coefficients from the income equations. Of course, such an inference would be incorrect. Why?

For example, is it feasible or realistic for a non-cotton producing female-headed household in Monapo with relatively little income currently would realize such income gains if it were to bring a hectare of dispersed land into cotton production and apply fertilizer, herbicide and insecticide? Would this household have the necessary management skills, labor and capital to achieve these results? Equally important, would a JVC be likely to provide the sufficient inputs and credit to such a household? The answer to each question, at least in the short run, is decidedly "no." Even though the human capital-related variables did not prove decisive in the well-being models, this and other factors are clearly pre-conditions for cash-cropping and technology adoption to yield attractive results.

The question still remains: Who decides in which cotton production category a household will operate during a given period? What is the role of the household and what is the role of the JVC? Some insights into this question, particularly concerning selection into the high-input categories in the Lomaco area of influence, were gained through interviews with Lomaco management by the author. When the high-input cotton block pilot scheme began, Lomaco management first identified villages with sufficient land of suitable quality and other key infrastructure in order to launch the pilot scheme. Lomaco subsequently identified farmers whom the company considered likely to succeed in the scheme. Traits which the firm sought included relevant cotton-growing experience (during the colonial era and/or the state-farm period), management skills and available labor. Village leaders also played a role in this process, though this process is difficult to understand or incorporate into the model. Early participants who achieved profitable results continued in the scheme while those who were less successful exited or were not invited to return by Lomaco. In subsequent years, this process has been repeated.

In Monapo/Meconta, where over 80 percent of households produced cotton in 1994/95, evidence from the 1993 Rapid Rural Appraisal suggested that non-growers were somewhat more likely to be female-headed, have less available labor and/or be in poor health.

Smallholder access to Monapo/Meconta block land for cotton production was hypothesized to depend on a combination of factors, including a household's relationship with traditional leaders from the local area.

From a policy perspective, the most important point to draw from this discussion is that the attractive impact smallholder cotton production and intensification have had on well-being probably require particular conditions in order to be replicated. Where households have similar levels of human capital, labor and other resources to participating smallholders, technology adoption may result in similar effects as those found in this study. If some of these conditions are not currently present in a given region, relevant education and training programs may represent attractive development policies. (Further discussion of policy implications is reserved for the final chapter.) Of course, successful adoption would also depend on a household's food security situation and a significant investment on the part of a JVC, including appropriate levels of agricultural extension, processing and marketing facilities.

7.4.1 The Discrete Choice Model

As explained in the conceptual framework of the well-being models, it is assumed that all factors hypothesized to influence well-being also influence the process by which household cotton production category is determined. Analogously, no suitable instrumental variable existed to facilitate a two stage least squares specification in the well-being models. As such, the discrete choice models are estimated using essentially the same explanatory variables as the well-being models. Two models, Equations 7-5 and 7-6 are estimated for each study zone. The former excludes KGSTOR95 while the latter includes it. For Montepuez and Monapo/Meconta, a multinomial specification is used because in both cases

there are more than two choices possible.¹³ A logit model is used in the CARE-OPEN zone, where low-input dispersed cotton and non-cotton are the two relevant categories.

Equation 7-5¹⁴:

$$\text{COTTON PRODUCTION CATEGORY} = f(\text{NADULT, AGEHHH, EDUCMAX, FEMHHH}^{15}, \text{AREAOWN, SOILQUAL, NCASHEWP, VIL1..n})$$

Equation 7-6:

identical to Equation 7-5 except that it includes KGSTOR95 as an explanatory variable.

7.4.2 Discrete Choice Model Results and Interpretation

Results of the discrete choice models of smallholder cotton production category are displayed below for Montepuez (Tables 7-11 to 7-13), Monapo/Meconta (Tables 7-14 and 7-15) and CARE-OPEN (Table 7-16). With respect to the multinomial logit results for Montepuez and Monapo/Meconta, note that the multiple tables simply reflect results from a single model estimated for each zone.

¹³ In Montepuez, four cotton production choices are possible: high-input block, high-input dispersed, low-input dispersed and non-cotton growing. In Monapo/Meconta, the dependent variable may take on three values: low-input block, low-input dispersed and non-cotton growing.

¹⁴ According to Ben-Akiva and Lerman (1986), correcting for the choice-based nature of the sample through weighting the regressions by the population fraction / sample fraction (as done in the earlier models in this chapter) only effects estimates of the constant. Given that the constants are of little interest here, and for reasons of analytical simplicity, these equations are estimated using an unweighted model.

¹⁵ FEMHHH is excluded from Montepuez models because there is only one observation of a female-headed household in the sample. It is also excluded from the Monapo/Meconta models because there is only one such observation in the low-input block category.

Table 7-11 Multinomial Logit Model Results of Determinants of Smallholder Cotton Production Category, Montepuez High-Input Block

Category	Equation 7-5	Equation 7-6
High-Input Block		
NADULT	.02 (.89)	.03 (.89)
AGEHHH	.02 (.34)	.02 (.53)
EDUCMAX	.10 (.43)	.11 (.39)
AREAOWN	-.14 (.41)	-.38 (.05)
SOILQUAL	-.18 (.81)	-.71 (.40)
VILMTZ1	21.96 (.00)	22.56 (.00)
VILMTZ2	21.18 (.00)	23.27 (.00)
VILMTZ3	21.18 (.00)	21.97 (.00)
KGSTOR95	--	.003 (.00)
CONSTANT	-22.09	-22.89

N=201

Chi-squared statistic = 148.75; Significance = 0.00

Pseudo R-squared = 0.28

Figures in parentheses are p-values

Table 7-12 Multinomial Logit Model Results of Determinants of Smallholder Cotton Production Category, Montepuez High-Input Dispersed

Category	Equation 7-5	Equation 7-6
High-Input Dispersed		
NADULT	-.43 (.09)	-.45 (.08)
AGEHHH	-.04 (.23)	-.05 (.19)
EDUCMAX	-.16 (.28)	-.18 (.24)
AREAOWN	.74 (.00)	.63 (.00)
SOILQUAL	.50 (.63)	.48 (.66)
VILMTZ1	22.21 (.00)	22.07 (.00)
VILMTZ2	23.98 (.00)	23.99 (.00)
VILMTZ3	20.57 (.00)	20.39 (.00)
KGSTOR95	--	.001 (.30)
CONSTANT	-22.06	-21.67

N=201

Chi-squared statistic = 148.75; Significance = 0.00

Pseudo R-squared = 0.28

Figures in parentheses are p-values

Table 7-13 Multinomial Logit Model Results of Determinants of Smallholder Cotton Production Category, Montepuez Low-Input Dispersed

Category	Equation 7-5	Equation 7-6
Low-Input Dispersed		
NADULT	-.31 (.05)	-.33 (.04)
AGEHHH	.03 (.09)	.03 (.09)
EDUCMAX	.00 (.99)	.00 (.99)
AREAOWN	.41 (.00)	.43 (.00)
SOILQUAL	.09 (.88)	.12 (.86)
VILMTZ1	.77 (.21)	.80 (.19)
VILMTZ2	1.16 (.08)	1.06 (.10)
VILMTZ3	.74 (.11)	.77 (.10)
KGSTOR95	--	-.00 (.84)
CONSTANT	-1.90	-1.92

N=201

Chi-squared statistic = 148.75; Significance = 0.00

Pseudo R-squared = 0.28

Figures in parentheses are p-values

Table 7-14 Multinomial Logit Model Results of Determinants of Smallholder Cotton Production Category, Monapo/Meconta Low-Input Block

Category	Equation 7-5	Equation 7-6
Low-Input Block		
NADULT	.86 (.00)	.85 (.00)
AGEHHH	-.04 (.08)	-.05 (.07)
EDUCMAX	.26 (.09)	.26 (.10)
AREAOWN	.31 (.08)	.26 (.13)
SOILQUAL	-1.13 (.24)	-1.03 (.28)
NCASHEWP	.003 (.82)	.002 (.88)
VILMON1	24.24 (.00)	24.29 (.00)
VILMON4	26.53 (.00)	26.49 (.00)
VILMON5	24.62 (.00)	24.68 (.00)
VILMON7	22.74 (.00)	22.73 (.00)
VILMON9	21.05 (.00)	21.11 (.00)
KGSTOR95	--	.004 (.23)
CONSTANT	-23.88	-23.86

N=175

Chi-squared statistic = 126.12; Significance = 0.00

Pseudo R-squared = 0.35

Figures in parentheses are p-values

Table 7-15 Multinomial Logit Model Results of Determinants of Smallholder Cotton Production Category, Monapo/Meconta Low-Input Dispersed

Category	Equation 7-5	Equation 7-6
Low-Input Dispersed		
NADULT	.37 (.08)	.37 (.08)
AGEHHH	-.06 (.00)	-.06 (.00)
EDUCMAX	.26 (.03)	.25 (.04)
AREAOWN	.30 (.03)	.27 (.05)
SOILQUAL	-.12 (.84)	-.09 (.88)
NCASHEWP	-.00 (.87)	-.00 (.67)
VILMON1	.70 (.45)	.69 (.46)
VILMON4	2.84 (.06)	2.81 (.06)
VILMON5	2.03 (.03)	1.87 (.05)
VILMON7	.99 (.18)	.93 (.21)
VILMON9	.08 (.90)	.04 (.96)
KGSTOR95	--	.003 (.30)
CONSTANT	-23.88	-23.86

N=175

Chi-squared statistic = 126.12; Significance = 0.00

Pseudo R-squared = 0.35

Figures in parentheses are p-values

Table 7-16 Logit Model Results of Determinants of Smallholder Cotton Production Category, CARE-OPEN Low-Input Dispersed

Category	Equation 7-5
Low-Input Dispersed	
NADULT	.25 (.36)
AGEHHH	-.03 (.38)
EDUCMAX	-.25 (.13)
FEMHHH	-12.7 (.86)
AREAOWN	-.14 (.47)
SOILQUAL	-.67 (.42)
NCASHEWP	.02 (.15)
VILCAR1	1.39 (.14)
VILCAR2	1.97 (.03)
VILCAR3	5.74 (.00)
VILCAR4	-8.60 (.76)
CONSTANT	-.69

N=145

Chi-squared statistic = 90.03; Significance = 0.00

Figures in parentheses are p-values

Analysis of these results indicates that the production category selection process varies across the three study zones. First, in Montepuez, farm size (AREAOWN) does not have a significant effect on entry into the high-input block when KGSTOR95 is excluded, and is negative and significant when KGSTOR95 is included; KGSTOR95 is positive and significant in the latter case. This is not surprising in the sense that, by definition, the Lomaco high-input block scheme provides the necessary land to smallholders. The inference is that having greater access to food reserves to meet household hungry season needs and hire weeding labor improves the probability of participating in this scheme. Likewise, because of the potential simultaneity between KGSTOR95 and the household decision, it is likely that past participation in this scheme improves the probability of having greater access to hungry season food reserves. By contrast, AREAOWN is positive and significant in the other two Montepuez cotton production categories where, in both cases smallholders grow cotton (and other crops) on their own land. None of the household structure/human capital-related variables (AGEHHH, EDUCMAX or NADULT) are significant in predicting high-input participation. This is somewhat surprising in light of the screening process reportedly used by Lomaco officials.

Second, in Monapo/Meconta, results suggest similar underlying processes in terms of selecting into both cotton production categories. Household labor (NADULT), human capital (EDUCMAX) and farm size (AREAOWN) each positively and significantly influence the probability of producing cotton. It is noteworthy that formal education is important here, though it was insignificant in Monapo/Meconta in the well-being models.

On the other hand, AGEHHH is negative and significant in each case, indicating that households with (relatively) younger heads are more likely to produce cotton.

Finally, in the CARE-OPEN model, no independent variable is statistically significant in predicting household cotton production (with the exception of one village dummy variable); little distinguishes households who produce cotton from those who do not.

7.5 Summary and Conclusions

A comparison of mean per capita income levels in this chapter provided strong evidence that high-input cotton producing households were substantially better off than all other groups throughout the study zone. Households in the low-input cotton categories in the JVC-intensive areas of Montepuez and Monapo/Meconta were shown to enjoy greater income than their non-cotton growing neighbors. Meanwhile, analogous results from the CARE-OPEN zone suggested that cotton production without a significant JVC presence did not contribute meaningfully to smallholder income. The positive relationship between cotton production and intensification with household hungry season cereal reserves was positive and significant in one of the three relevant categories in Montepuez, and positive though statistically insignificant in Monapo/Meconta.

Accounting for factors exogenous to the smallholder-JVC relationship, econometric models of income determination provided strong evidence of a causal relationship between smallholder cotton production and household income. Related to household food security,

model results indicated that, at best cash-cropping and intensification improves food security, and at worst it has a positive but not statistically significant effect.

Finally, in the model predicting household cotton production category, it was observed that replicating the results of the various JVC cotton schemes found to benefit participating smallholders requires a combination of factors to be present. Provision of sufficient agricultural inputs is only one such factor. On the part of the smallholder, these conditions include human capital, land resources, available labor and a reasonable food security situation.

Chapter 8

Summary, Conclusions and Policy Implications

8.0 Research Problem, Dissertation Objectives and Data Collection

As Mozambique recovers from war and undergoes economic reform, given its favorable agro-ecological endowment and its highly rural population, improved agricultural performance is essential to three key Government of Mozambique (GOM) policy objectives: 1) smallholder income growth; 2) improved food security; and 3) reducing the balance of payments deficit. In the context of near complete input and credit market failure in rural areas, policy-makers are faced with the challenge of how to achieve these micro- and macroeconomic goals. In the north, the GOM formed Joint Venture Companies (JVCs) with three multi-national agro-industrial firms to rehabilitate cotton infrastructure in 1990 with the hope that this would contribute toward achieving these goals. In return for monopsony cotton-buying rights in their respective areas of influence, the JVCs agreed to provide participating smallholders with reliable input supplies and extension services for cotton and food crops and to purchase seed cotton from farmers at official price levels. The firms also invested in the rehabilitation of cotton ginneries and rural road networks in their areas of influence. The desire to understand the effects of smallholder:JVC cash-cropping with respect to GOM policy goals is the motivation of this dissertation.

There is a controversy over whether cash-cropping improves smallholder welfare in Sub-Saharan Africa (SSA). This is despite results from a range of SSA experience showing

that cash-cropping typically has a positive effect on smallholder incomes and a smaller but still positive effect on food consumption. A key finding from much of the SSA cash-cropping literature is that the effects on participating families depend critically on the organizational details of the scheme. The three JVCs that have operated in the cotton belt since 1990 have provided smallholders with a variety of cash- and food-cropping packages. In the area of influence of the two JVCs in Monapo and Meconta Districts, the smallholder:JVC relationship has been limited to "low-input cotton," where insecticide and improved seed are the only modern inputs used. Here farmers cultivate cotton either on their own "dispersed" fields or on "block" fields established during the colonial era. Approximately 80 percent of smallholders in this zone grew low-input cotton during the 1994/95 season. These JVCs provided no support to smallholders for food crops.

In Montepuez, where 27 percent of rural households grew cotton in 1994/95, "high-" and "low-" input packages were available from the third JVC. Most cotton-growing households used a low-input package similar to that in Monapo/Meconta. A pilot group of farmers used an innovative "high-input" package that included herbicide, fertilizer and insecticide (and in some cases tractorization) for cotton. A subset of these high-input cotton growers also participated in the JVC's high-input maize scheme. This high-input group was unique in rural Mozambique for two reasons. These were the only smallholders 1) using either herbicide or fertilizer or receiving tractorization services; and 2) receiving JVC support to produce and market maize. In a nearby region (CARE-OPEN), one-third of rural households grew cotton in 1994/95, though with insignificant JVC support.

The considerable variation found in smallholder:JVC relationships represented an attractive quasi-experimental design upon which this study was based. The dissertation addresses the following objectives:

- 1) Describe the food security strategies of smallholders in the cotton belt;
- 2) Analyze the determinants of agricultural productivity in cotton and maize;
- 3) Compare the financial profitability of cotton, maize and manioc from the smallholder and JVC perspectives at varying levels of agricultural intensification;
- 4) Determine the extent to which the region enjoys a comparative advantage in smallholder cotton, maize and manioc based on the range of existing technologies;
- 5) Determine the extent to which households enjoy differential levels of income and food security based on their cotton production category, and the role of the JVC-schemes in causing this differential; and
- 6) Recommend key policy changes, investments, project initiatives and additional research necessary to improve the contribution of cash-cropping to smallholder food security, income and macroeconomic goals.

To address these research questions, 521 rural households across the cotton belt were surveyed at four month intervals between June 1994 and February 1996. A stratified random sample within the areas of influence of the three principal JVCs was drawn in order to include households involved in the range of cotton production categories (high-input block, high-input dispersed, low-input block, low-input dispersed) present in each zone (see Table 2-6). In the CARE-OPEN zone, a region of insignificant JVC activity, a sample of cotton growers was drawn allowing a comparison of the effects of growing cotton with much less JVC support than in Montepuez or Monapo/Meconta. Also, non-cotton growers were sampled in each zone to represent a control group as part of the quasi-experimental design. For each survey round, questionnaires were devised with the

objective of computing annual estimates of agricultural production and sales, income, labor use and food consumption for each sampled household.

While the smallholder survey represents the centerpiece of the overall research design, key informant interviews were also conducted with officials from the JVCs, agricultural research institutions, the Ministry of Agriculture and Fisheries and non-governmental organizations. Information from these interviews was useful toward understanding the broader economic environment in which cotton belt households operate.

8.1 Analytical Methods Used

To address the research objectives outlined above, several analytical methods were used. Plot-level regression models of the determinants of cotton and maize yields were estimated in Chapter 4. This allowed us to quantify the effects of key inputs and practices on productivity in the two crops. Financial profitability of cotton, maize and manioc to farmers was analyzed in Chapter 5 through the use of enterprise budgets. Budgets were computed for high-input cotton and maize schemes in Montepuez, low-input cotton schemes in both Montepuez and Monapo/Meconta and traditional low-input maize and manioc enterprises in both zones. Further, in the context of a high degree of variation in yield and input use within groups, budgets were broken out by yield tercile. Given the importance of JVC profitability for the smallholder schemes to be sustainable, Chapter 5 also analyzed the financial outcomes of the various schemes from the JVC perspective.

Parameters generated in the financial budgets were used in Chapter 6 to investigate under what conditions Mozambique enjoys comparative advantage in the same set of cropping enterprises analyzed in Chapter 5. Two measures of comparative advantage - resource cost ratios and net social profitability - were computed. Thus, incorporating all economic costs of production, transformation and marketing, Chapter 6 compared the production alternatives most attractive to the country in terms of its trade balance to those found most financially profitable in Chapter 5 to smallholders and the JVCs. The attractiveness of the various cropping choices to smallholders, the JVCs and the macroeconomy depend on assumptions regarding key parameters (e.g., input level, the ginning outturn rate for cotton and producer and world prices); sensitivity analysis was conducted in Chapter 6 to analyze how variation in these parameters affect each group.

Econometric models of annual household income and food security in Chapter 7 were developed to estimate the overall effect of the various JVC cash-cropping schemes while holding other factors constant. Discrete choice models were estimated to analyze the factors associated with a household being in a particular cotton production category.

8.2 Conclusions

■ **Cotton belt households depend on retained production to meet more than 80 percent of their calorie consumption, though the role of food markets has increased from war-time levels.** (Tables 3-7 and 3-8) Households that must buy food in the hungry season face cereal prices two to three times greater than harvest season levels (Table 5-11), suggesting that food markets still represent an unreliable option for many food

insecure households with limited effective demand. With the vast majority of smallholders using unimproved local varieties of maize and other cereals, determining how to increase smallholder access to improved varieties and other modern inputs for food production represents a priority for improving rural food security.

■ **In both principal study zones, cotton producers grew greater quantities of maize than households with no cotton production.** (Tables 3-4 and 3-5) Empirical evidence thus contradicts the claim that cash-cropping has a negative effect on food production in this case. Further, households who grew cotton with the high-input package but who grew low-input maize had significantly **greater maize yields per hectare** than their neighbors in low-input cotton schemes (Table 5-5).

■ **Within the two principal study zones and across cotton production categories, cotton and maize yields varied significantly.** Yield equations were estimated to investigate the source of these productivity differences. With respect to cotton, key productivity-related factors included early seeding, sufficient weeding labor, and adequate insecticide applications (Table 4-13). A benefit:cost ratio of 1.8:1 indicated the profitability of increasing the number of insecticide applications above current mean levels. For those households in low-input cotton schemes in the bottom yield tercile, returns to family labor were very low compared to wage rates paid for unskilled agricultural labor. Poor results were associated with late planting, insufficient insecticide and inadequate weeding labor.

■ **The highest returns to labor were in high-input cotton and maize schemes in Montepuez.** (Table 5-9) An attractive benefit:cost ratio (of 1.5 to 2.5:1) of the high input cotton package suggests the private profitability of herbicide and fertilizer. The high-input maize scheme had a private benefit:cost ratio of 1.3:1 on average. However, the riskiness of these schemes, from both the smallholder and JVC perspectives was highlighted by extreme yield variation in the maize scheme, where nearly one-third of participants suffered financial losses (Table 5-5). An attractive attribute of high-input cotton production, from both the smallholder and JVC perspectives, is that it is generally less risky than high-input maize due to two reasons. First, cotton is relatively more drought resistant than maize. Second, Mozambique produces a small amount of cotton relative to the world market - it is a price taker. On the other hand, domestic and regional maize market conditions are more volatile. For both crops, however, intensification increases the potential value of production for credit-constrained farmers but it also raises costs and risk. This increased risk for Lomaco in high-input maize has translated into significant financial losses due to lack of credit repayment. Mechanisms for dealing with intra-annual risk that simultaneously promote intensification are discussed in the policy implications below.

■ **Low-input cotton raised smallholder per capita income by between 25 and 36 percent in the zones of significant JVC investment, ceteris paribus.** (Table 7-10) Cotton's effect on hungry season cereal reserves was positive and significant among low-input growers in Montepuez, and positive but statistically insignificant among households in other cotton production categories in Montepuez and Monapo/Meconta. In CARE-OPEN, with very minor private sector investment in input distribution and extension

services, low-input cotton had a negative effect on income and little effect on hungry season cereal reserves. The finding that, holding constant other factors, low-input cotton contributes positively to smallholder income in areas of significant JVC investment, though less so to food availability is a key result. Contrasting this finding with the results in CARE-OPEN suggests the importance of a significant JVC investment in a given zone for smallholder cotton to deliver these benefits in the current policy environment.

■ **High-input cotton increased per capita income by between 97 and 138 percent relative to non-cotton growers, *ceteris paribus*.** (Table 7-10) Households in this category also enjoyed relatively greater hungry season cereal reserves. It is likely that the process of determining who participates in the high-input category reflects a "selection-bias" for which econometric modelling attempted to correct. That is, those households with relatively greater management and farming skills were somewhat more likely to be chosen to participate in the high-input schemes than their neighbors. Nonetheless, controlling for these pre-program differences between high-input cotton households and the rest of the sample, it is striking that intensification more than doubled smallholder incomes.

■ **For smallholder:JVC relationships to be sustainable, the JVCs must be financially profitable enterprises.** In both principal study zones, low-input and high-input cotton were profitable to the JVCs, generating returns from \$56 to \$127 per hectare under current yield and world market conditions (Table 5-18).

■ Sensitivity analysis showed that increasing the cotton ginning outturn rate from its current 34 percent to 40 percent or greater through varietal improvements such as those which have occurred in Francophone West Africa would significantly contribute toward achieving macroeconomic goals as well as JVC profits. (Figures 6-1 to 6-6) The development of suitable cotton varieties with improved ginning outturn ratios is the subject of on-going research both by CIMSAN in Namialo and Lomaco with support from the French *Caisse Centrale de Cooperation Economique* in Montepuez. The GOM should consider this a priority area for research attention and may wish to allocate a significant portion of the 3.5 percent cotton export tax it collects for this purpose. Note that this tax was established for the support of investments to improve cotton performance in Mozambique. At a seminar involving key officials from the JVCs and other subsector participants in April, 1997, there was criticism by the JVCs that the funds generated through this tax are not providing any tangible benefits to the firms. (Personal communication, David Tschirley) It is important for policy makers to recognize that improving the ginning outturn rate would benefit smallholders through greater producer prices. An important longer term issue is developing a mechanism for allocating these funds which incorporates the perspectives of key cotton subsector participants, including farmers, in a meaningful way.

■ JVC involvement in smallholder food production in Mozambique was limited to the Montepuez high-input block maize scheme when this study began. Lomaco ended this program in 1995/96, coinciding with the end of donor-driven emergency-related maize demand from elsewhere in the country. Financial analysis showed that if Lomaco had

to operate under market conditions, it would suffer financial losses in high-input block maize (Table 5-22), attributable largely to high costs of shipping grain to major markets.

■ Cotton resource cost ratios ranged from 0.42 to 0.65, indicating a comparative advantage for the cotton belt in both low-input and high-input packages. (Table 6-3) Sensitivity analysis showed that these estimates were robust to variation in world cotton prices experienced over the past ten years.

■ The cotton belt is currently an inefficient producer of maize for markets outside the region such as Maputo. (Table 6-4) Even assuming improved yields and lower per unit production costs, the high costs of coastal shipping, inefficient port operations and a poor domestic highway network result in the north currently having a comparative disadvantage in maize. However, the fact that the north's rainfall patterns are not correlated with those in the rest of the Southern Africa region and the potential, with appropriate investments, to develop its strategic position vis-a-vis ports and rail lines suggests that it could become an important supplier of maize (and other food crops) to the region.

8.3 Implications of Conclusions for Formulating Strategies to Promote Economic Growth and Food Security

This study shows clearly that cotton production can benefit northern Mozambican smallholders and the national economy. Smallholders in the areas of influence of the three

principal JVCs operating in the cotton belt have substantially higher incomes than their non-cotton growing neighbors **because** they choose to produce this cash crop. Income gains accrue to smallholders who grow cotton without compromising, and sometimes improving their food security. These findings are significant, given the frequent criticism that smallholder cash-cropping schemes in Sub-Saharan Africa jeopardize food security.

Mozambique urgently needs strategies to increase the export of products in which it has a comparative advantage. This study shows that Mozambique has a comparative advantage in smallholder cotton using effectively the range of input packages currently promoted by the JVCs.

Prior to the agreements between the Government of Mozambique (GOM) and Lonrho, Joao Ferreira dos Santos and Grupo Entrepasto, a much smaller proportion of rural households in the cotton belt were growing cotton than at present. Those who were producing cotton had little access to agricultural inputs or credit because market mechanisms were not available and there were no private firms to fill this role. Cotton yields were very low, its effect on household income was negligible and its impact at the macroeconomic level was insignificant. In recent years, this poor performance has been reversed in the regions which have been the focus of GOM and private investment. In regions without this level of investment but with similar agro-ecological conditions and colonial histories (e.g., CARE-OPEN), relatively small proportions of farmers grow cotton and those who do so show no higher incomes than non-cotton growers. **Key factors instrumental in cotton's resurgence as an important cash crop are the revitalization**

of input distribution and extension networks and improvements in rural roads. The region's three JVCs have been important players in this process.

The benefits to smallholders, the country and private sector firms supporting smallholder cotton increase dramatically where smallholders grow cotton with fertilizer and herbicide. Among households who produced cotton with the "high-input" package, some used a similar "high-input" package for maize while others used a "low-input" approach to maize. It is noteworthy that both groups obtained significantly greater maize yields than households who did not intensify cotton production. This suggests that **cotton intensification can have a substantial effect on improving smallholder maize productivity and improving household and regional food security.** It is likely that a portion of the differences in maize yield between high-input cotton/low-input maize households compared to low-input cotton/low-input maize households is related to residual fertilizer and rotation effects from cotton to maize. Given the reluctance of private sector firms to support maize intensification directly due to its relatively high level of risk (for both smallholders and private sector firms) compared to cotton, cotton intensification may represent a useful indirect mechanism to intensify maize production and increase yields. The intersection of smallholder and JVC interests here is important to point out. As smallholder productivity in food crops increases, farmers are able to devote more resources to producing cotton. The increased cotton production is attractive to the JVCs, given that existing cotton gins are operating well below capacity.

In short, investments made by private firms in providing inputs, credit and extension services to smallholders, as well as investing in rural road development have represented important contributions to the cotton belt's economic recovery. Given the potential for improving smallholder incomes and food security in the north through cash-cropping, the GOM needs to give priority to determining an appropriate policy environment for such development to move forward. In so doing, the GOM needs to address three questions:

- 1) Does the fact that benefits from smallholder cotton have occurred in the areas of significant JVC investment imply that the "JVC model" has been successful and should be replicated elsewhere?**
- 2) What alternative models are possible and would they provide greater benefits for smallholders?**
- 3) What more can be done by government and the private sector to improve smallholder cash-cropping performance?**

In the next sections, we will consider what the results from this study and other Sub-Saharan Africa experience imply about the steps that the GOM, donors, private sector actors and smallholders should take to answer these questions and ensure that cash-cropping continues to contribute to rural development in Mozambique.

8.3.1 Questions About The JVC Model: Its Rationale, Advantages and Disadvantages

The JVCs have had legal geographic monopsonies with respect to smallholder cotton since their inception. This model, which assumes that effective vertical coordination of the subsector will occur by granting monopsony buying rights to the a single firm, is an unusual policy in the Southern Africa region today. The trend is clearly toward not

providing monopsony protection to companies involved in promoting smallholder cash-cropping.

Major donors including both USAID and the World Bank have voiced criticism of the legal monopsony model for promoting smallholder cotton in Sub-Saharan Africa. The two principal arguments against this model is that it retards development of private input markets and limits price competition for smallholder outputs. Yet there were solid reasons why the GOM chose this model.

The standard economic argument - though only part of the GOM rationale - for granting a JVC exclusive cotton buying rights is that the economics of transport and processing cotton in a given zone give rise to a natural monopsony. That is, given the economies of scale in the ginning process, the quantity of cotton produced in each zone is insufficient to achieve efficiency in ginning costs. If this were the case, economic theory would imply that the state has a role in limiting the number of gins operating in a region. The extent to which natural monopsony conditions are present in specific regions of the cotton belt is a complex empirical question and is an area beyond the scope of this study. However, this issue was only one, albeit important factor in motivating the GOM to grant JVCs geographic monopsonies. Of equal or greater importance to the GOM was developing a private sector-based policy mechanism to spark a resurgence in smallholder cotton by facilitating vertical coordination in the subsector. To generate growth in production, it was necessary to develop an input distribution and extension network. Another important barrier with respect to economic growth in this region was the investment needed to repair

and maintain the rural road network after much neglect. The GOM lacked the capital to make such investments and was faced with the dilemma of how to attract private capital to this region.

To any private firm, an investment in roads and cotton ginning infrastructure to develop smallholder cotton represented a long-term endeavor. Such a firm would naturally seek assurances concerning throughput for its cotton gin. Aware of the region's input market failure and the need for increased smallholder input access to jumpstart cotton production, the vertically-integrated approach built around JVCs represented an attractive option. As this model has functioned since its inception, each cropping season the JVCs distribute inputs to smallholders on credit. The financing costs and risk of repayment have been largely borne by the JVCs (though the KR-II pesticide subsidy lowered JVC exposure substantially until its recent termination). In this context, it was natural for the JVCs to seek protection from other buyers who neither bear the production and credit risks during the growing season, nor the upstream investments in rural infrastructure. As such, the JVCs filled an important void from the GOM perspective, and in return received monopsony rights, the source of much criticism of the JVC model. Would competition for smallholder production improve smallholder welfare and the system's performance more broadly? Insights from an analogous situation in Zambia where Lonrho is supporting smallholder cotton points out the limitations of competition and the importance of effective contract enforcement for cash-cropping schemes to be sustainable:

"From the farmer's perspective, competition among buyers is positive. But where this competition undermines existing contracts between buyers and producers, outgrower type arrangements which involve pre-financing are likely to disappear...For commodities with minimal extension and input requirements, the

impact on the producer may be limited if he/she is able to finance and manage his/her own production. But where these requirements are considerable (e.g., cotton), the smallholder is likely to find that he/she can no longer...(effectively) produce the commodity (due to the lack of input availability and financing)." (Stringfellow, 1996)

This suggests that as the GOM approaches policy issues related to the cotton subsector, it is important to implement arrangements which will lead to effective vertical coordination among key actors. Applying the lessons from Zambia to the Mozambican case, the GOM may observe that encouraging competition by eliminating the JVCs geographic monopsonies, in isolation from other key steps, is not likely to result in effective vertical coordination in the face of input and credit market failure. While it may be useful to promote competition for smallholder cotton, more system-wide types of investments (e.g., input distribution, extension, human capital and rural infrastructure) will be required to promote meaningful development of smallholder cash-cropping opportunities.

8.3.2 Questions About How to Improve Government Regulation

When the state grants monopsony rights to a firm, it must regulate the firm's behavior to guard against potentially abusive behavior. In the context of the cotton belt and the JVCs, examples of potentially abusive behavior include failure of the JVCs to provide inputs, credit or extension services to smallholders in a timely manner or offering an unreasonably low producer price for cotton. The GOM uses two regulatory mechanisms for this purpose. First, and most importantly, the GOM establishes a minimum producer price each year. Recent experience suggests that the use of price policy has been unsuccessful at fixing the farmgate price at levels which represent the intersection of JVC and smallholder interests given world market conditions. For example, in 1994/95 when world

price levels were historically high (\$1,715 per ton, FOB N. Mozambique), the official producer price was quite low (\$0.155 per kg seed cotton). To compensate smallholders for this disparity in the following year, the GOM fixed the official price very high (\$0.339 per kg seed cotton) even though world cotton prices had fallen to \$1,438 per ton, FOB N. Mozambique.

The second mechanism by which the GOM attempts to protect smallholders is through the Mozambique Cotton Institute. A central purpose of the Institute is to ensure that all smallholders within a given JVC's area of influence receive reasonable access to inputs and extension services. For example, it may be more profitable from the JVC's perspective to concentrate its input distribution on smallholders whose fields are relatively close to a road. However, the JVC is also required to support production for smallholders in more remote locations within its area of influence, even if this is more costly. Without such support, smallholders in relatively remote locations have no other option to obtain inputs and market their cotton, given the monopsony granted to the JVC and the lack of private sector firms to provide these services. What has been the experience of the Institute in regulating JVC performance in this regard?

To gain insight into this question, we draw an important distinction between two empirical results from the study: 1) that cotton, on average, has benefited smallholders in the JVC-intensive zones; and 2) that a significant group of smallholders in each JVC zone had very low cotton yields and hence very low returns to labor in cotton. For example, seed cotton yields among the lowest tercile of producers was only 200 kg/ha (Montepuez) and 155

(Monapo/Meconta), compared to mean yields well above 500 kg/ha in both zones.

Returns to family labor for households in the lowest yield tercile were at or below \$0.22 per day, compared to mean levels greater than \$0.60 per day and local wage labor rates of \$0.48 per day.

The most important factors associated with cotton's relatively poor performance among households in the lowest cotton yield tercile were the lack of insecticide, late planting and a shortage of labor for weeding. With regard to insecticide, whereas the recommended application rate is approximately four sprays per season, households in the lowest yield tercile typically sprayed two times or less. This suggests that the JVC model of input distribution has essentially not corrected the market failure for this significant group of households. The Mozambique Cotton Institute, to date, has lacked the capacity to monitor and encourage JVC compliance with their agreements with the GOM. Given both the need for effective GOM involvement in the subsector and the problems with the Institute as it is structured today, how should the GOM approach this issue?

According to Fok's analysis, the Institute as it is currently structured, is largely a bureaucratic and administrative body. The GOM should consider how to transform the Institute into a body which acts as a catalyst to promote the interests of key subsector actors, including smallholders as well as other private sector firms (e.g., input suppliers and gin operators). Further, the GOM should consider how its representatives could become active participants in the leadership of the JVCs to represent smallholder interests, given that Government is part owner in each JVC.

The Institute could also encourage regular meetings of key subsector actors at the national, regional and local levels to develop a meaningful and ongoing dialogue about how to improve system-wide performance. Improving the Institute's data collection and analysis capacity could be strategic in this regard. For example, regular published reports about performance at various levels of the subsector could serve an important role as a source of information at such periodic meetings.

8.3.3 What Can Be Done to Increase JVC Support to Smallholder Food Crops?

The JVCs' contracts call for extension systems to be developed for both cotton and food crops. Study results found that the JVC extension systems, with few exceptions, have been singularly focused on cotton. The only significant JVC entry into supporting smallholder food production was the now defunct high-input block maize scheme in Montepuez. Results from this study suggest that both smallholders and the JVCs may benefit from JVC support of smallholder food-cropping. Recall that late planting and a shortage of labor for weeding were two key factors in holding down cotton yields. The study also found a positive relationship between household hungry season cereal reserves and household ability to allocate labor to cotton, thus improving cotton yields. The implication from the JVC perspective is that cotton production may increase substantially as smallholder food security improves; there is the potential for private sector firms to be important actors in this process (e.g., recent experiments by Lomaco in intensified smallholder groundnut and cowpea production). It is important to recognize again the mutuality of interests here between smallholders and the JVCs. Improved food security

for smallholders may result in increased smallholder cotton production which could generate a higher ginning capacity utilization rate and profits for the JVCs.

To date, the GOM has not taken significant pro-active steps to encourage JVC activity in food crop intensification. In fact, its minimum price policy with respect to maize has been counter-productive, in the sense that it has established unreasonable price levels which Lomaco could not pay smallholders and earn a financial profit within the current maize market environment. Smallholder food crop schemes could be profitable to the JVCs and generate attractive returns to smallholder labor if current upper tercile yields could be achieved and if the JVCs were allowed to pay a price significantly below current minimum prices to farmers. In sum, it is important for the GOM to develop a policy environment designed to increase food production (and improve regional food security) through productivity-enhancing technology packages with an attractive set of incentives for both producers and private sector firms. In the current policy environment, JVCs clearly have an important stake in improving rural food security and the GOM should actively encourage their participation in intensifying food crops in this region.

8.3.4 Lessons from Experience in Zambia, Zimbabwe and Mali

Alternative approaches to smallholder cotton were mentioned above from Zambia, Zimbabwe and Mali. The GOM needs to consider the experience from these three cases and what lessons they may offer Mozambique.

In Zambia, Lonrho's outgrower scheme now incorporates 65,000 growers with no legal monopsony. Despite its success in managing the scheme, Lonrho is gradually withdrawing from direct managerial involvement, hoping to pass this responsibility to smaller intermediary companies which it will finance and from which it will purchase seed cotton. The company believes that its comparative advantage lies not in managing smallholders but in research and development, financing and trading. It seeks smaller operators with greater familiarity with local growing conditions to manage smallholders. This is a recent policy change by Lonrho, and to date only a few firms have established such a relationship with the firm. How is the freedom of choice in selecting a buyer for their cotton likely to affect prices smallholders receive for their output and vertical coordination more broadly? Stringfellow's analysis suggests that while no legal monopsony is in place, the dominance of Lonrho in Southern and Central Zambia:

"...sets the prevailing into mill (seed cotton) price...A South African firm purchased a ginnery in Chipata, but the distance between this and the Lonrho ginneries (and the producing area) is likely to eliminate any incentive for traders to take advantage of price differentials. This will limit the degree to which traders at the farmgate can adjust their prices to compete for purchases."

The Zambia case has an important implication for the question of the effect of a legal monopsony. Although there is a *de jure* freedom for smallholders in marketing their cotton, the economics of transporting this bulky product and the scale economies of ginning result essentially in a *de facto* monopsony. The effect of eliminating the monopsony in isolation from other actions to promote vertical coordination has done little to improve smallholder welfare.

In Zimbabwe, liberalization of smallholder cotton marketing has also occurred recently. Cotco, the newly commercialized former Cotton Marketing Board provides credit for cotton production to groups of smallholders. The capital for mounting this credit system was secured through government funding (though there is significant pressure to end the subsidies implicit in its operation), a key difference between this system and the JVC model in Mozambique. While smallholders who receive credit from Cotco are supposed to market all their cotton through Cotco, this is not occurring. Rather, producers only repay their credit obligations with Cotco and sell the larger portion of their production to other buyers that pay a higher price. Cargill, which now leases two ginning facilities in Zimbabwe, feels that smallholders will require increased access to credit if they are to further expand their cotton production and that without government subsidies Cotco may not represent a viable solution. The problem of how to extend credit in a free market environment and make sure that smallholders repay these obligations, particularly in a year of poor production results and financial losses is critically important. A possible solution suggested by Cargill management is for Cargill to act as a facilitator of loan repayment by deducting input costs from cotton payments made to smallholders and transferring these funds to the creditor. (Personal communication, Julie Howard) The critical problem with such an approach is that it begs the question of who will bear the risk of financing smallholder production when no government-backed credit scheme is available. In brief, the Zimbabwe experience points again to the need for policy mechanisms to provide for vertical coordination of the cotton subsector for smallholder production and intensification to be sustainable. Simply ending the JVCs' geographic monopsonies where private input

and credit markets continue to fail has little probability of solving the system's more fundamental problems.

8.3.5 Mali and the Empowerment of Farmers through Village Associations

Smallholder cotton production in the *Compagnie Malienne pour le Développement des Textiles* (CMDT) zone of Mali is characterized by a highly vertically-integrated system whereby CMDT has responsibility for supporting smallholder production through input distribution and tied credit and purchasing output in a manner similar to the design of the JVC model in Mozambique. In the past twenty years, intensification of input use and dramatically improved smallholder cotton yields have improved the profitability of cotton to producers in Mali. The model has proven successful from a macroeconomic perspective as well, as cotton now accounts for almost one-half of Mali's export earnings. Bingen (1997) shows that the role of farmer organizations (or *associations villageoises* (AVs)) has been fundamental in this process. Bingen traces the history of the emergence of the AVs to 1974 when a CMDT extensionist:

"...helped villagers organize a protest against dishonest cotton grading and weighing practices. Responding to the villagers' demands, the CMDT gradually transferred responsibility for cotton grading and weighing, equipment and supply orders and credit management to designated village groups. After several years of fairly informal agreements with these groups, the CMDT formalized the relationship by setting out a series of criteria for establish of AVs. In collaboration with the government, the CMDT also secured World Bank financing to support the development of management skills within the AVs, especially through a functional literacy program to ensure the level of literacy and numeracy skills required to fulfill credit and marketing tasks and the preparation of account books in the Bambara language." (Bingen, 1997)

Farmer associations have the potential to represent smallholder concerns effectively vis-a-vis large firms operating in the cotton subsector in Mozambique as well. In addition to

having benefitted smallholder incomes, smallholder cotton has played a key role in promoting food security in Mali. Consider the analysis offered by Dione:

"...the success of CMDT in promoting foodgrain production was achieved through a strategy centered on a vertically coordinated set of activities (research, extension, input and credit distribution, and output processing and marketing) for the long-term growth of cotton production and income. This income served as an engine to support gradually the development of food crop production and non-crop activities...(The promotion of cotton represents) a strategic approach to rural development and significantly diverges from the approach followed by most rural development agencies and the traditional food crop - cash crop dichotomy, which is almost irrelevant in the CMDT case where there was growth in cereals production mainly **because of the growth in farmers' income from cotton production.**" (emphasis added) (Dione, 1989)

Further, Bingen argues that cotton-led agricultural growth in the CMDT zone has had important indirect benefits such as improving rural literacy and stimulating broader democratization.

With respect to Mozambique, it is important to recall the mutual interest that the JVCs and smallholders have in cooperation. The JVC approach, as it has been implemented, attempts to control the outgrower and/or limit the risk facing the JVC. Stringfellow suggests a more "consensual" approach would be for the firm to build up a good relationship with producers in which both parties recognize the mutual benefits of cooperation. If experience from Mali and elsewhere concerning the positive force of farmer associations in giving farmers voice is a guide to the Mozambican case, encouraging the growth of such organizational structures among smallholder cotton producers may be important. It may represent an important part of the policy solution for cotton to increase its already important role in Mozambique's rural development.

8.4 Policy Recommendations and Priorities for Future Research

- Smallholder cotton can have important micro- and macroeconomic benefits if it is promoted with a sufficient level of inputs, extension and marketing infrastructure.

Intensification of cotton has even greater benefits for each of the actors in the system.

The GOM should promote smallholder cotton production in the cotton belt through strategies which effectively balance smallholder and private sector interests in pursuing vertical coordination of the subsector.

- Improving smallholder capacity to represent their own interests vis-a-vis private sector firms in the cotton subsector can be an important mechanism to improve the effect of cash-cropping on smallholder welfare. In Mali, farmer associations have represented an important way for farmers to achieve greater power and gain access to fertilizers and other key inputs. Village associations have the potential to play a similar role in Mozambique. NGOs such as the Cooperative League of the USA (CLUSA) have been active recently in Nampula in encouraging the formation and training of village associations. CLUSA-supported associations have begun to deal with the JVCs and other private sector firms to improve input availability and access to tractor services. (Personal communication, Alexandre Serrano) Note that the current "Regulamento" of the GOM provides for economic agents with greater than 20 ha of cotton production to sell their cotton freely. To the extent that associations could organize farmers with at least this area of cotton production, this could not only circumvent the problem of monopsony but provide other benefits to participating smallholders as well. **The GOM and donors should promote the formation of farmer associations to promote smallholder's bargaining power with**

private sector firms. Donor support in this area may help build a bridge between the farmer organizations, the JVCs and formal sector financial institutions in the design of financing systems which promote intensification and spread the risk associated with smallholder cotton and food crop production.

■ **The process by which the GOM determines minimum producer prices for cotton should be reviewed.** Yearly changes in the GOM cotton price have not reflected changes in world market conditions. For example, the official price jumped from \$0.155 to \$0.339 per kg from 1994/95 to 1995/96 while FOB Northern Mozambique prices for cotton fiber dropped from \$1,715 to \$1,438. Such erratic price policies make long range investment planning by the JVCs and other private sector firms difficult and create unsustainable price expectations and uncertainty for smallholders. A two-stage process whereby a minimum producer price is announced at the beginning of the agricultural season (September 1) with the possibility for upward revisions based on prevailing world market conditions at the time of export is one alternative which should be considered.

■ **The Mozambique Cotton Institute lacks the institutional capacity and resources to represent smallholder interests effectively.** However, governmental oversight to encourage JVC behavior to benefit smallholders throughout their areas of influence is important. **The GOM should seek new and innovative mechanisms to bring this about such as having Institute representation in the decision-making structure of the JVCs, given that the Government is in fact a partner in these schemes.**

■ If the GOM wishes to encourage JVC involvement in smallholder food crop intensification, establishing a minimum producer price at recently observed levels may be counter-productive. High-input block maize schemes could be profitable to JVCs and generate attractive returns to smallholder labor if current upper tercile yields could be achieved and a lower price paid to farmers than the GOM minimum. **The GOM should seek policies designed to increase rural incomes through productivity enhancing technology packages (e.g. the high-input block maize scheme or other food crop opportunities) rather than through unsustainable minimum price policy.** JVCs have an important stake in improving rural food security and innovative mechanisms should be sought to encourage their participation.

■ **Development of cotton varieties with enhanced ginning outturn ratios is the subject of research attention by the national agricultural research system. The Government and donors should place renewed focus on this effort.** Improving ginning outturn ratios from their current levels of approximately 34 percent to levels achieved in West Africa of 40 to 43 percent could dramatically increase the cotton's impact on smallholder income, the attractiveness of smallholder cotton to private sector firms and Mozambican export earnings. Recall that exporters pay a 3.5 percent tax on cotton fiber exports. This tax was established by the GOM for the purpose of supporting activities to promote the cotton subsector including varietal research though the JVCs contend that they receive no tangible benefits related to this tax. The GOM should consider using a substantial portion of the revenue collected from this tax to support varietal research in collaboration with the national agricultural research system and the JVCs. **An important longer term issue is**

developing a mechanism for allocating these funds which incorporates the perspectives of key cotton subsector participants, including farmers, in a meaningful way. The Mozambique Cotton Institute could play an important role in developing this process.

Appendix 1

Sampling of Smallholders

Figure A1-1

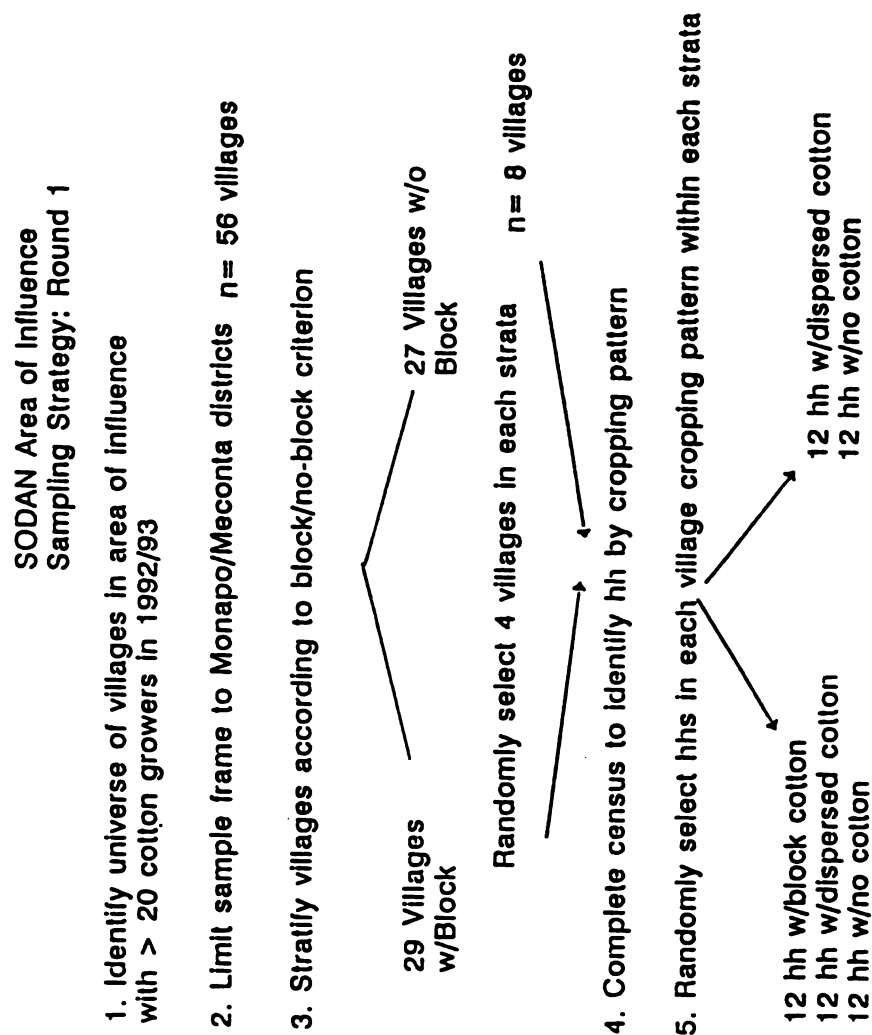


Figure A1-2

**SAMO Area of Influence
Sampling Strategy: Round 1**

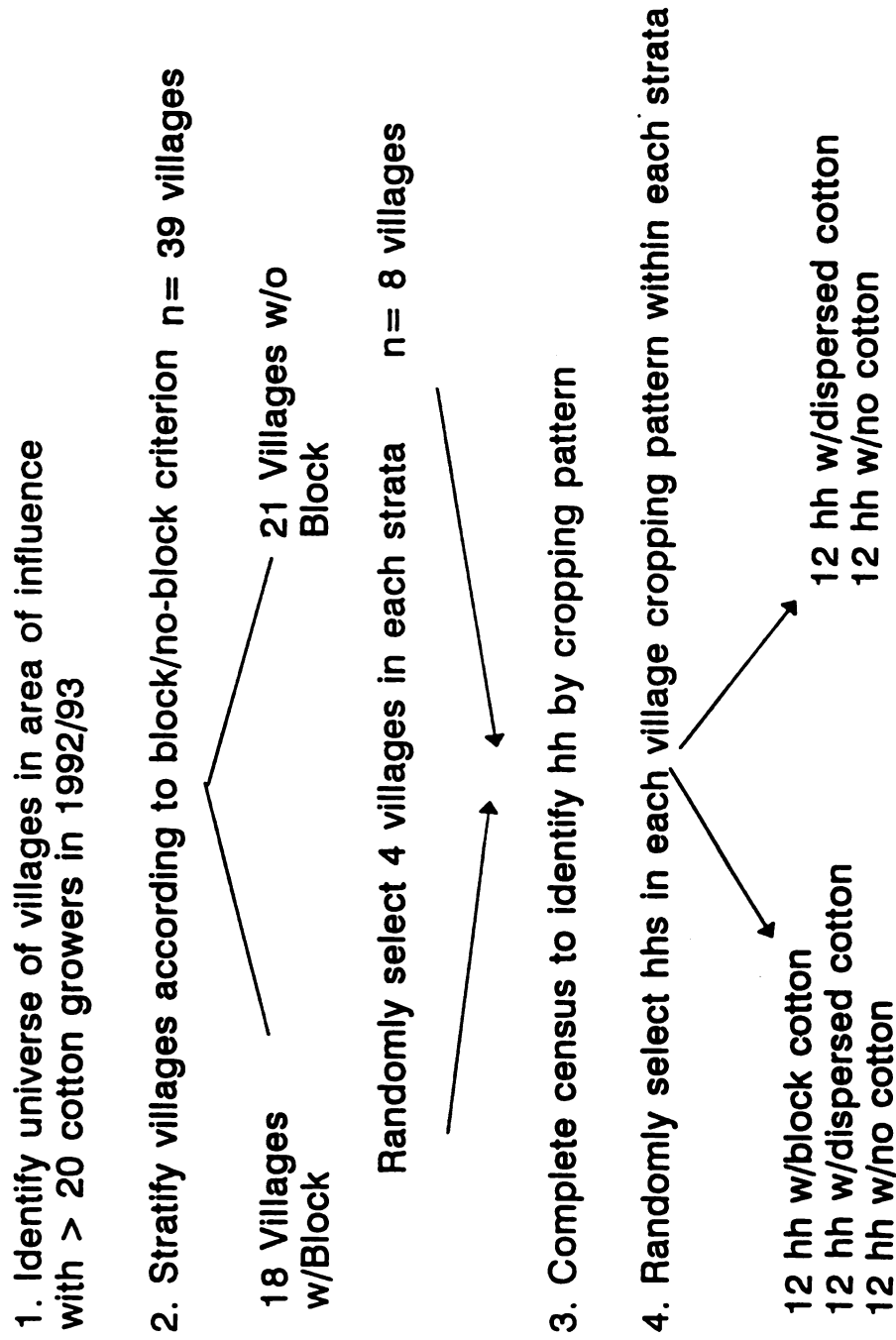


Figure A1-3

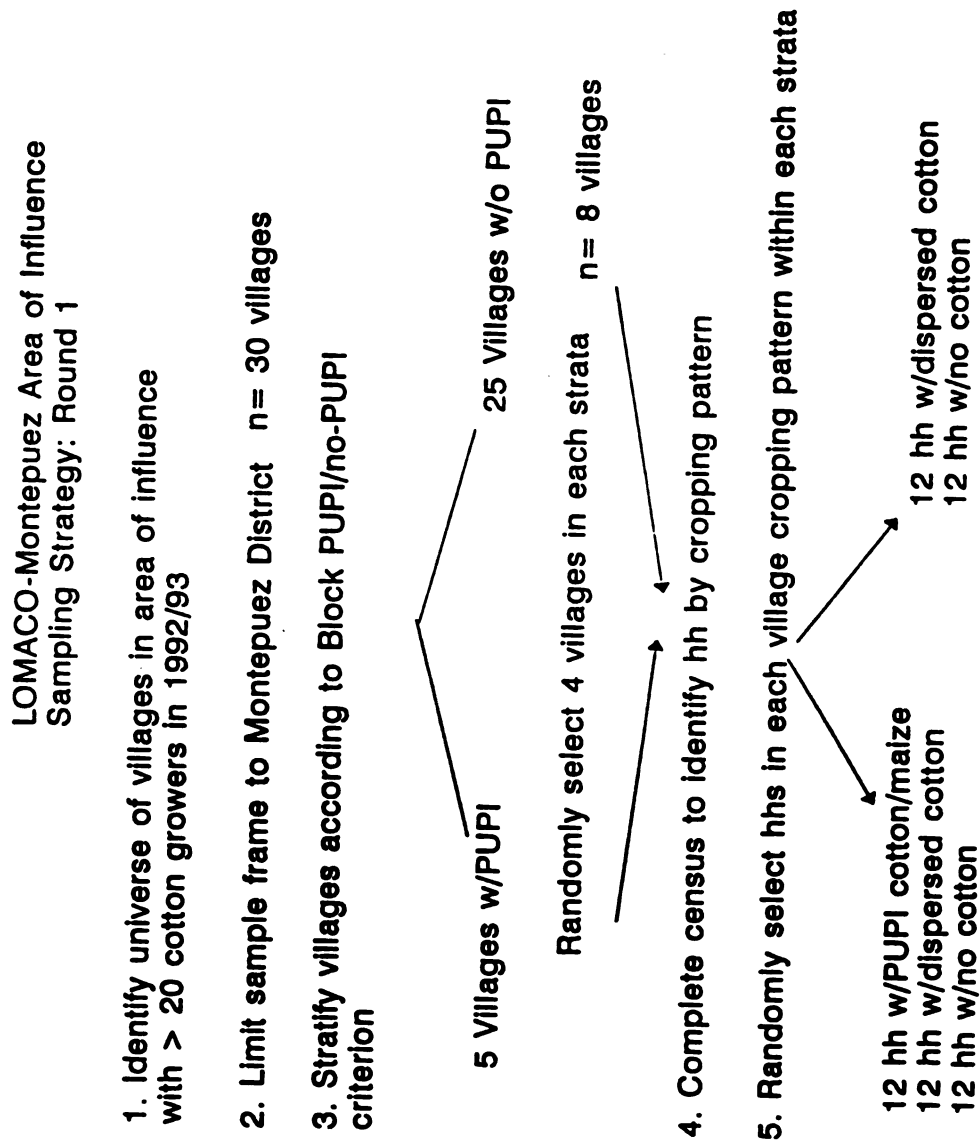


Figure A1-4

**CARE OPEN Project Areas
Sampling Selection for
FSP Study**

1. Identify universe of villages where OPEN operates 1994/95
n=15 villages in 4 districts
n= 5 villages
2. Randomly select villages for baseline
(Round 1)
3. Complete census to identify OPEN participant/non-participant
hhs
4. Randomly select in each village:
26 hh OPEN participants
13 hh OPEN non-participants

Figure A1-5

**SODAN/SAMO
Areas of Influence
Modifications to Sample
Rounds 2-5**

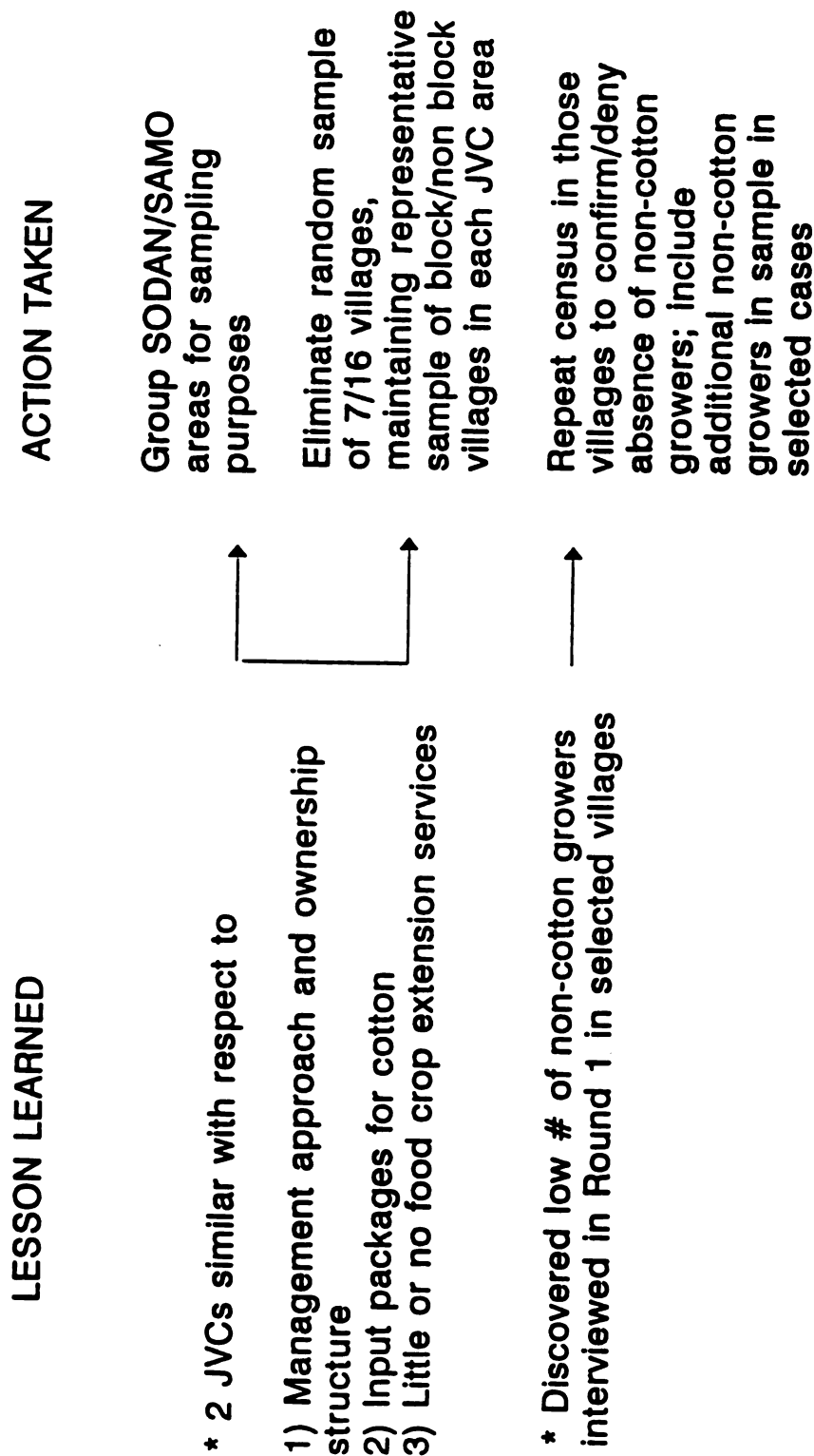


Figure A1-6

**Lomaco-Montepuez
Area of Influence
Modifications to Sample
Rounds 2-5**

LESSON LEARNED

ACTION TAKEN

- * Identified new category of PUPI grower (in dispersed fields) → Random selection of Dispersed PUPI hhs in 3 villages sampled in Round 1
- * Discovered PUPI was discontinued by LOMACO in 1 village → Eliminate 1 non-PUPI village
- * 10/12 non-cotton growers from 93/94 found to not produce cotton 94/95 → Randomly select 10 additional 94/95 cotton growers in that village

Appendix 2

Yield Models

A2.0 Cotton Yield Model

Chapter 4 presented the final cotton yield model. However, four variables initially hypothesized to be important in determining yield were omitted from the final specification. These four variables, all of which were dichotomous were: whether the field was in a block, land quality, unusual rainfall patterns, and JVC input delivery timing. Earlier modelling efforts showed that these variables did not perform well, and were not according to the t-statistics of their parameter estimates shown to be statistically significant. An F-test was used to determine if the parameters of these four variables were simultaneously statistically equal to zero. This test was accepted, and thus the more parsimonious model was presented in the text. The more complete model appears below, again using the Cobb-Douglas functional form. Descriptive statistics of all variables used in the model are presented in Table A2-1. Regression results follow in Table A2-2.

$$\ln(\text{YIELD}) = f(\text{HIGH_INB}, \text{HIGH_IND}, \ln(\text{INSECT}), \ln(\text{TOTWAE}), \ln(\text{SEEDWEEK}), \text{INSESTS}, \text{ZONE}, \text{BLOCK}, \text{LANDQUAL}, \text{RAINPROB}, \text{INPULATE})$$

where:

YIELD=	kgs seed cotton production per hectare
HIGH_INB=	1 if high-input block package 0 otherwise
HIGH_IND=	1 if high-input dispersed field 0 otherwise
INSECT=	number of insecticide applications
TOTWAE=	total adult-equivalent weeding days per hectare, family and non-family included
SEEDWEEK=	seeding week, 1=earliest seeding week (2nd week, November), 2=

INSPESTS= 3rd week, November...
1 if excessive insect infestation reported on field during growing season
0 otherwise

ZONE= 1 if Nampula
0 Montepuez

BLOCK= 1 if block in Nampula
0 otherwise

LANDQUAL= 1 if farmer considered the field "fertile" for cotton
0 otherwise

RAINPROB= 1 if abnormal rain patterns reported
0 otherwise

INPULATE= 1 if any key input were delivered "late" by JVC according to smallholder
0 otherwise

Table A2-1 Mean and Standard Deviation of Variables in Cotton Yield Model

Variable	Montepuez		Nampula	
	Mean	S.D.	Mean	S.D
YIELD	880	580	550	388
HIGH_INB	27 percent=1		0 percent=1	
HIGH_IND	18 percent=1		0 percent=1	
INSECT	3.61	1.30	3.13	1.30
TOTWAE	36.13	17.39	60.61	27.14
SEEDWEEK	4.68	1.80	6.61	1.91
INSPESTS	10 percent=1		7 percent=1	
BLOCK	0 percent=1		36 percent=1	
LANDQUAL	49 percent=1		53 percent=1	
RAINPROB	18 percent=1		13 percent=1	
INPULATE	25 percent=1		44 percent=1	
ZONE	100 percent=0		100 percent=1	

Note: Arithmetic means and standard deviations are presented for all continuous variables, though natural log are taken of these variables in running the model.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table A2-2 Cotton Yield Equation Results

Variable	Coefficient	Standard Error	Significance
HIGH_INB	0.68	0.25	0.01
HIGH_IND	0.81	0.25	0.00
ln(INSECT)	0.91	0.07	0.00
ln(TOTWAE)	0.19	0.12	0.11
ln(SEEDWEEK)	-0.68	0.21	0.00
INSPESTS	-0.38	0.22	0.09
JVC	0.26	0.17	0.12
BLOCK	0.24	0.19	0.21
LANDQUAL	-0.04	0.13	0.77
RAINPROB	0.23	0.18	0.19
INPULATE	-0.07	0.14	0.59
Constant	5.21	0.55	0.00
N=279			
Adjusted R-square = 0.64			
F-stat = 45, Significance = 0.00			

Source: 1994/96 MAP/MSU FSP Smallholder Survey

A2.1 Maize Yield Model

Chapter 4 presented the final maize yield model, but omitted two variables initially hypothesized to be important determinants of productivity, seeding week and level of pest infestation, both instrumented as dichotomous variables. Earlier modelling efforts showed that these variables were not statistically significant. An F-test was used to determine if the parameters of these two variables were simultaneously statistically equal to zero. This test was accepted, and thus the more parsimonious model was presented in the text. The more complete model appears below, again estimated using the Cobb-Douglas functional form. Table A2-3 displays descriptive statistics of all variables included in the model. Table A2-4 provides the regression results, the interpretation of which is little changed from the more parsimonious model presented in Chapter 4.

$$\ln(\text{YIELD}) = f(\text{HIGH_INB}, \text{HIGH_LOW}, \text{LANDQUAL}, \ln(\text{TOTWAE}), \text{RAINPROB}, \text{ZONE}, \ln(\text{SWEEK}), \text{INSPESTS})$$

where:

YIELD=	kgs maize grain production per hectare
HIGH_INB=	1 if high-input block package 0 otherwise
HIGH_LOW=	1 if high-input cotton participant 0 otherwise
LANDQUAL=	1 if farmer considered the field "fertile" for maize 0 otherwise
TOTWAE=	total adult-equivalent weeding days per hectare, family and non-family included
RAINPROB=	1 if abnormal rain patterns reported 0 otherwise
ZONE=	1 if Nampula 0 Montepuez
SWEEK=	seeding week, 1=earliest seeding week (4th week, November), 2=first week, December...8
INSPESTS=	1 if excessive insect infestation reported during growing season 0 otherwise

Table A2-3 Mean and Standard Deviation of Variables in Maize Yield Model

Variable	Montepuez		Nampula	
	Mean	S.D.	Mean	S.D
YIELD	994	851	422	273
HIGH_INB	24 percent=1		0 percent=1	
HIGH_IND	41 percent=1		0 percent=1	
LANDQUAL	44 percent=1		64 percent=1	
TOTWAE	34.31	16.30	39.23	17.67
RAINPROB	58 percent=1		26 percent=1	
SWEEK	2.32	1.29	3.97	1.91
INSPESTS	6 percent=1		11 percent=1	
ZONE	100 percent=0		100 percent=1	

Note: Arithmetic means and standard deviations are presented for all continuous variables, though natural log are taken of these variables in running the model.

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Table A2-4 Maize Yield Equation Results

Variable	Coefficient	Standard Error	Significance
HIGH_INB	0.62	0.22	0.01
HIGH_LOW	0.53	0.17	0.00
LANDQUAL	0.21	0.10	0.04
ln(TOTWAE)	0.16	0.08	0.06
RAINPROB	-0.25	0.10	0.01
ZONE	-0.39	0.12	0.00
SWEEK	-0.10	0.10	0.32
INSPESTS	0.01	0.18	0.96
Constant	6.06	0.35	0.00
N=196			
Adjusted R-square = 0.38			
F-stat = 21, Significance = 0.00			

Source: 1994/96 MAP/MSU FSP Smallholder Survey

Appendix 3

Models of Household Well-Being

Results of econometric estimation of variants of Equation 7-1 are reported in this Appendix. Table A3-1 reports results of Equation 7-1 with the interaction term, AREAOWN*EDUCMAX, while Table A3-2 reports results of the same equation with an interaction term COTTON*EDUCMAX. COTTON is a dichotomous variable equal to one if the household produced cotton in 1994/95, zero otherwise. See Chapter 7 for further discussion of these models and their interpretation.

Table A3-1. Determinants of Log of Household Income per Capita by Zone

Independent Variable	Zone		
	Montepuez	Monapo/Meconta	CARE-OPEN
NADULT	-.182 (.00)	-.188 (.00)	-.241 (.00)
AGEHHH	.005 (.11)	.000 (.93)	-.003 (.59)
EDUCMAX	.048 (.15)	-.071 (.02)	-.079 (.05)
FEMHHH	---	-.765 (.00)	-.136 (.72)
AREAOWN	.107 (.00)	.044 (.09)	.040 (.39)
SOILQUAL	.026 (.85)	-.016 (.89)	.192 (.15)
NCASHEWP	---	-.001 (.30)	.003 (.05)
HIGH_INB	1.14 (.00)	---	---
HIGH_IND	1.02 (.01)	---	---
LOW_INB	---	.328 (.02)	---
LOW_IND	.195 (.02)	.285 (.01)	-.236 (.05)
AREAOWN*EDUCMAX	.001 (.89)	.015 (.02)	.020 (.02)
VIL1	.279 (.04)	-.371 (.04)	-.038 (.79)
VIL2	-.211 (.14)	.051 (.78)	-.033 (.82)
VIL3	-.455 (.00)	.273 (.02)	.146 (.39)
VIL4	.115 (.41)	-.194 (.14)	-.115 (.41)
VIL5	-.278 (.03)	-.335 (.02)	---
VIL6	-.424 (.00)	.519 (.00)	---
VIL7	---	-.101 (.46)	---
VIL8	---	.276 (.12)	---
Constant	3.83 (.00)	4.49 (.00)	4.71 (.00)
Adjusted R-Squared	.503	.503	.305
F-Statistic	13.6 (.00)	10.8 (.00)	5.9 (.00)

Table A3-2 Determinants of Log of Household Income per Capita by Zone

Independent Variable	Zone		
	Montepuez	Monapo/Meconta	CARE-OPEN
NADULT	-.181 (.00)	-.182 (.00)	-.209 (.00)
AGEHHH	.004 (.23)	.000 (.85)	-.005 (.26)
EDUCMAX	.071 (.00)	.035 (.45)	-.004 (.89)
FEMHHH	---	-.657 (.00)	.013 (.96)
AREAOWN	.114 (.00)	.088 (.00)	.128 (.00)
SOILQUAL	.034 (.89)	-.011 (.93)	.203 (.13)
NCASHEWP	---	-.000 (.62)	.004 (.06)
HIGH_INB	1.30 (.00)	---	---
HIGH_IND	1.15 (.00)	---	---
LOW_INB	---	.418 (.00)	---
LOW_IND	.345 (.00)	.351 (.02)	-.257 (.13)
COTTON*EDUCMAX	-.042 (.23)	-.044 (.37)	.004 (.92)
VIL1	.300 (.03)	-.391 (.03)	-.015 (.92)
VIL2	-.192 (.18)	.024 (.89)	-.023 (.88)
VIL3	-.428 (.01)	.290 (.01)	.160 (.36)
VIL4	.110 (.42)	-.216 (.11)	-.078 (.59)
VIL5	-.271 (.03)	-.332 (.02)	---
VIL6	-.405 (.00)	.498 (.00)	---
VIL7	---	-.063 (.64)	---
VIL8	---	.290 (.11)	---
Constant	3.80 (.00)	4.19 (.00)	4.36 (.00)
Adjusted R-Squared	.507	.487	.277
F-Statistic	13.8 (.00)	10.2 (.00)	5.3 (.00)

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