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An Economic Analysis of Smallholder Cashew Development Opportunities and Linkages to Food Security in Mozambique's Northern Province of Nampula

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AN ECONOMIC ANALYSIS OF SMALLHOLDER CASHEW DEVELOPMENT OPPORTUNITIES AND LINKAGES TO FOOD SECURITY IN MOZAMBIQUE'S NORTHERN PROVINCE OF NAMPULA

By

Paulo Nicua Mole

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ABSTRACT

AN ECONOMIC ANALYSIS OF SMALLHOLDER CASHEW DEVELOPMENT OPPORTUNITIES AND LINKAGES TO FOOD SECURITY IN MOZAMBIQUE'S NORTHERN PROVINCE OF NAMPULA

By

Paulo Nicua Mole

Cashew is among the leading export crops in Mozambique. However, very little is known about the costs and returns to cashew production for the millions of smallholders who produce it and depend upon it as a source of income and food security. In addition, there is a cashew productivity decline at the farm level that cannot continue to be ignored. This study gathered detailed input/output data through multiple visits to 40 smallholder cashew households in three different regions of Nampula, currently the most cashew producing province of Mozambique. Additional data was drawn from secondary sources to construct crop budgets which fed into a smallholder linear programing model to examine strategies to improve cashew productivity and management practices in a context of a whole-farm system.

The findings highlight a number of issues. First, smallholders as a group who grow cashew need to be subdivided into more homogeneous target groups: 1) those who have a relatively small number of cashew trees, have less land in total and on a per hectare labor adult equivalent basis, but who are relatively labor abundant; and 2) in contrast, there is another group who seem to own relatively larger land holdings, have relatively more trees, but lack labor (or resources) to engage in more labor intensive and profitable cashew technologies. Second, high tree density and relatively small amounts

of labor allocated to cashew (and not all at the right time of the growing cycle) seemed to be critical factors associated with low cashew productivity. The conflict between the use of labor for cashew tree management and disease control, and for activities needed on food crops suggests that the lack of reliability of rural food markets, cash earning opportunities, and the low economic incentives for cashew producers are forcing farmers to set priority on food cropping activities, thereby shifting labor for cashew activities to later in the agricultural season. Third, the relative profitability of marketable food crops and the importance of food security concerns have an impact on smallholder choices. Results indicate that labor constrained farmers required much higher incentives for the adoption of more integrated approaches to cashew improvement than less labor constrained farmers. Finally, profitability and efficiency of improved technologies and management practices could increase, if farmers were able to identify better and with less risk, which of their existing trees should get a given technology package. Specific research in this regard will help farmers to reduce the risk of investing in uneconomic trees or in an incorrect technology package.

It is concluded that improved technologies and management practices examined have a potential to raise on-farm cashew productivity. However, this needs to be accompanied by a stronger institutional and market reform investment program to improve incentives to cashew growers, and make investments in rural infrastructure, research and extension services in order to bring about the expected increases in cashew productivity to raise smallholder income, improve food security conditions and reduce poverty.

To my late
Father *Augusto Manuel Mole*,
Grandmothers *Arinakina* and *Mocaporia*
Grandfathers *Nicua* e *Martinho,*
and Sister-in-law *Sónia Paula* (*Nhonha*),
who were there from the beginning,
but left to see the fruits of their inspiring energy,

and to my
Wife *Flora*,
Son *Reinaldo (Naldinho)*,
and Daughter *Arinakina (Arina)*,
for our enduring partnership.

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At MSU, I would like to thank to Dr. Eric Crawford and Dr. John Strauss for their critical roles on both guidance and dissertation committees. Reading and commenting the drafts were precious, particularly towards the end. To Dr. Steve Harsh, thanks for those enlightening LP tutorials. I extend also this gratitude to Dr. John Staatz from whose AEC 841 class I drafted my first cashew production improvement ideas. My great friends Dr. Takashi Yamano, and David Mather thanks for your companion. Dr. Stepanek, thanks for been there reading my papers and helping me with my '*portu-English*'. My buddy

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At some point friends and family members have wondered about my endless road at school. I would like to thank all the friends who understood what a graduate student with a family is all about. My younger brothers José Lucas and Pedro Manuel Mole have been exceptionally understanding in that regard. Thanks for making up while I was not there for Mom Rosa and the rest of our team at home. I am also grateful to my friends and colleagues Artur Gobe and Peter Coughlin at the Faculty of Economics-UEM in Maputo, for their help and encouragement, particularly when I, and my wife Flora and son Reinaldo were miles away from each other during 1994-95.

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List of Acronyms

ae	adult equivalent
ACIANA	Associação Comercial, Industrial e Agrícola de Nampula
AMIS II	Agricultural Marketing and Information Systems project II
BPS	Black Panicle Syndrome
CRP	Cashew Rehabilitation Project
CWG	Cashew Working Group
CCPMD	Chemical Control of Powder Mildew Disease
DEA	Direcção de Economia Agrária
DE	Direcção de Estatística
DNER	Direcção Nacional de Extensão Rural
DPA&P	Direcção Provincial de Agricultura
FOB	Free on-board
FSP	Food Security Project
GOM	Government of Mozambique
GLS	Generalized Least Square
GPS	Geographical Positioning System
GTC	Grupo de Trabalho do Cajú
ha	hectare
HH	household
ICM	Integrated Cashew Management
INCAJU	Instituto de Fomento do Cajú
LAE	Labor Adult Equivalent
L-AE	Land per adult equivalent
LP	Linear Programming
MAP/MSU	Ministério de Agricultura e Pesca / Michigan State University
NCD	Nampula Consumption Data set
NGO	Non-Governmental Organization
RPM	República Popular de Mocambique
TIA	Trabalho de Inquérito Agrícola
TWCPMD	Top-working and Chemical Control of Powder Mildew Disease
USAID	United States Agency for International Development
WV	World Vision

CHAPTER 1

INTRODUCTION

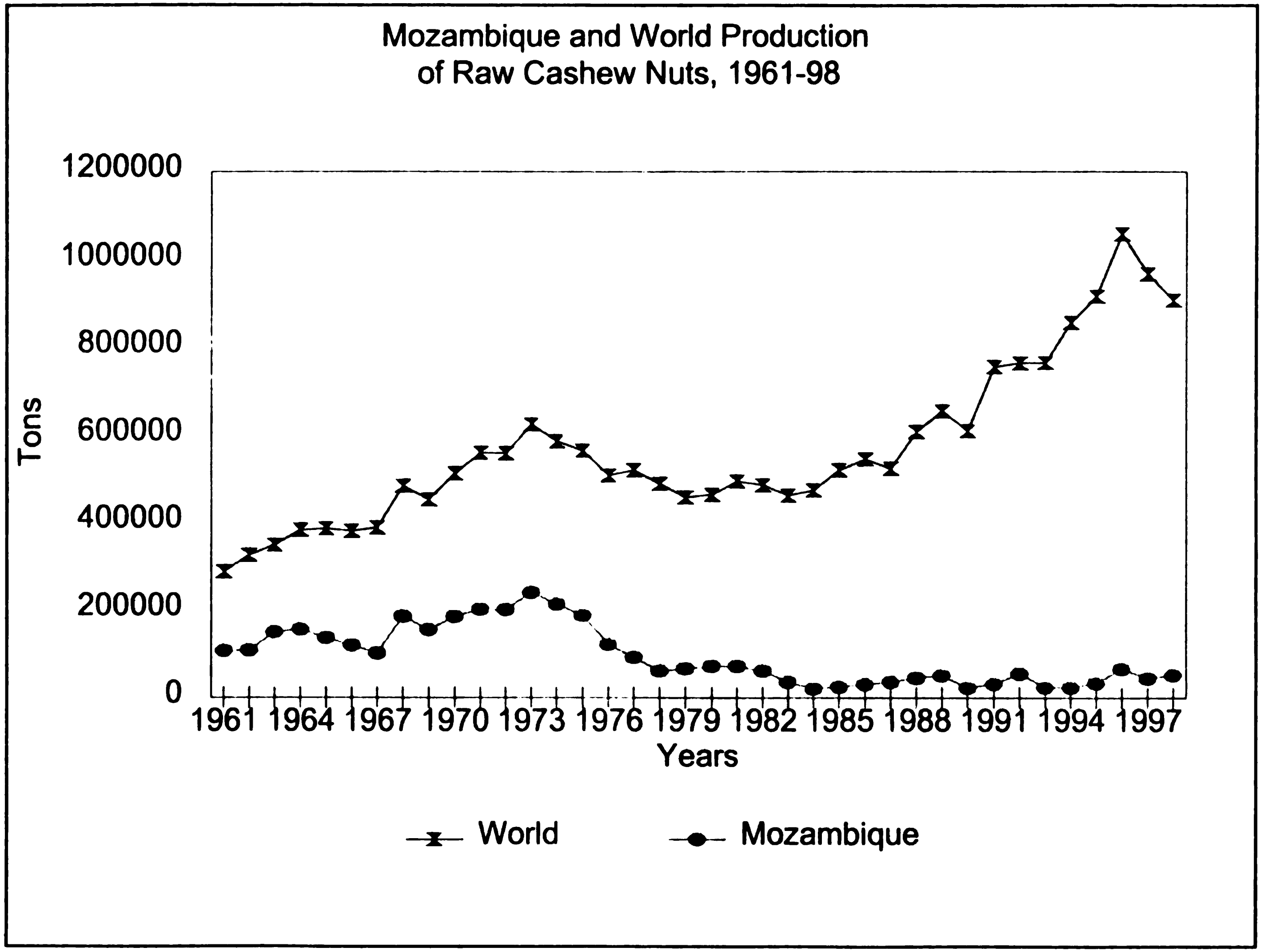
1.0 Introduction

Mozambique has a long history of cashew nut production. Since the arrival of the Portuguese in East Africa, cashew has spread for over 500 years either naturally or through smallholder's cultivation along the coast in a belt of about 2,000 km North and 200-300 km inland on sandy soils. As a smallholder crop, cashew is both grown monocropped and inter-cropped with food crops such as cassava, peanuts, and beans and other tree crops.

Cashew, exported both in raw and processed forms, is among the leading export crops in Mozambique. For years, cashew has also facilitated a growing processing industry that generates employment, particularly in the provinces of Nampula and Zambézia in the North, and Gaza and Inhambane in the South. However, war and economic crisis in the last two decades had an adverse impact on Mozambique's cashew production, and particularly high quality cashew output (see Figure 1-1). As a result, Mozambique's competitive position in the world market for processed kernels has weakened in favor of India and Brazil, other major producers and exporters. On other hand, Mozambique continues to be an important source of supply of unprocessed cashew for Indian processors, and very recently for Vietnam (CWG statistical report, 1999).

Given the continued declining trend in cashew production, since 1995 there has been a long policy debate in the sub-sector, focusing primarily on processing and

Figure 1-1 Mozambique and World Production of Raw Cashew Nuts, 1961-98



advantages/disadvantages of export taxation of raw nuts as part of a package of economic measures in the current economic recovery program. The World Bank and International Monetary Fund have pressured for liberalization of domestic agricultural prices including cashew. In 1988, first liberalization steps were taken, although the government continued setting cashew reference prices at the producer level which were most often not effective due to the high cost of cashew marketing. However, since then increased demand for raw cashew nuts both for domestic processing and exports, have increasingly put pressure on Mozambique's limited supply, particularly in years of bad weather as it happened in the 1998-9 crop year. With increasing concerns about government policies and the continued declining trend in the cashew sector, in 1995 a cashew working group (CWG) involving the government, donors and the private sector was created to discuss the sector's constraints and prospects. In the meantime, institutional efforts were undertaken in 1997 to create an institutional framework for the cashew industry (INCAJU) which in 1998 took a crucial step towards the formulation of a cashew production master plan.[1] Yet, INCAJU's important challenge remains as, figuring out the factors responsible for the productivity decline at the farm level, and finding ways to solve these problems and facilitate economic development of the cashew industry as a whole.

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[1] The government's goal for the cashew industry is its development to improve smallholder's income and food security condition, as well as fostering international competitiveness of cashew nuts and by-products through the rehabilitation and expansion of the current cashew orchard, industry and marketing system. Towards that goal, INCAJU objectives are to achieve a sustainable increase of smallholder's raw cashew nut's output and quality which contribute to the growth of their income and to the country's trade balance of payment (INCAJU, 1998).

Furthermore, for INCAJU and the sector as a whole, the fundamental and complex policy challenge is how to structure technology options (available particularly to smallholders), market rules and industry coordination arrangements to provide the type of policy induced incentives and improve capabilities for smallholder cashew producers to improve both quantity and quality produced from either existing or newly planted cashew trees. These challenges extend equally to the cashew processing industry which needs to adjust and restructure itself to improve its productivity and management in order to be able to compete internationally. Understanding these challenges at the smallholder production level requires obtaining comprehensive farm level insights, evaluating returns to smallholders' resources, particularly labor time allocated to different competing enterprises, under alternative crop production technologies and institutional arrangements.

1.1 Problem Statement

A competitive cashew industry with improved domestic processing requires not only cost effective processing technologies, but most importantly reliance on domestic sources of supply of raw cashew nuts at prices that allow competitive processing for the world market. Otherwise, the domestic processors must have sufficient purchasing power to afford imports of raw cashew nuts from other producing countries.

Efforts by the government of Mozambique to liberalize agricultural prices and to alter policy on exports of raw cashew nuts is part of an overall strategy of seeking to provide incentives to smallholder producers, and restructure the domestic processing industry. The measures were expected to gradually improve competitiveness among actors in the cashew industry toward what it once had been --- one of the world leaders in production and exports of processed cashew nuts. However, in attempting to pursue these goals, policy makers have been focusing primary attention to (1) pricing policy and export taxation, and (2) measures to increase domestic processing capacity and improve its competitiveness. This policy orientation is basically driven by two assumptions:

(1) given the current structure of production, marketing, processing and exports, there would be ***an effective price transmission*** from the external trade of raw cashew nuts down to the smallholder cashew producers as a result of reduced distortions (taxes) on exports and the increased demand from both domestic and foreign cashew processors;

(2) under the current marketing structure, smallholders could ***respond*** to improved prices, and thus increase cashew output and quality, as well as improve their welfare as their share of the export price increases.

This perspective of smallholder cashew production and marketing is reliant on the view that "getting the price right" will change relative prices for smallholders leading them to reallocate resources in favor of cashew production, and thereby increase cashew production and improve quality. Yet, these assumptions lack empirical support. In fact, evidence suggests that output has not responded in spite of an upward trend in producer prices in the last three cashew marketing seasons (1996-99). The farmer's share of the export price has been fluctuating between 44 to 52 percent (MAP/MSU Flash 9P, June 1997; and Mole and Weber, 1999), but whether cashew output and quality levels are beginning to follow the same trend is not yet clear.

As Reardon and Vosti (1987) pointed out, when agriculture is profitable it does not mean that household's choices on investments/practices occur automatically, particularly in the presence of constraints such as credit and lack of information. Economic policies, whether sectoral or macro are necessary, but not sufficient, and "getting prices right" in particular does not provide answers to all policy issues. This includes questions such as whether farmers want or can adopt and maintain new technology for given investments and practices, and which appropriate price policy can promote such investments/practices.

While research work with respect to the real effects of cashew export policy changes on cashew producer prices is underway, consistent empirical evidence and analytical insight to inform smallholder adoption of new technologies and improved management practices to increase cashew production and quality under the current sub-sector setting is scanty and it is hard to generalize over all possible smallholder cashew production areas. As Figure 1-1 above has shown, and economic agents' observation suggests, raw cashew nut output in Mozambique has, in fact, declined over the years. Among other factors, the decline is related to abandonment of many cashew trees, war, economic crisis and the lack of agronomic research and effective extension efforts (ACIANA, 1995; and MAP, 1995).

1.2 Research Questions and Objectives

There is a general lack of micro data on costs and returns to smallholder resources in Mozambique. Analysis of the effects of alternative policies and production technologies are hard, if not impossible, under this setting. As a result, this study will utilize existing and generate additional micro data on smallholder cashew production to answer the following research questions: is it financially attractive for Mozambican smallholder farmers to expand production and improve quality of cashew nuts? If so, what are the investment decisions and available alternative technological options smallholders need to consider in order to achieve the expected cashew production increases and quality improvements? What incentives and institutional support will be required for smallholders to adopt these alternative and new technologies in an environment where cashews are not the main crop?

Given the dynamic changes in the economy of Mozambique and taking into account the potential contribution of the cashew industry to export earnings, studying the economics of smallholder cashew production is a crucial factor in establishing a strategic cashew industry development plan that has the potential to improve income and food security of about a million of smallholder cashew producers.

There are gaps in knowledge on smallholder cashew producer's behavior in Mozambique, and on the extent of smallholder's potential response and capability to respond to changes in policy incentives. Thus the overall objective of this dissertation is to evaluate cashew production profitability relative to other smallholder cropping activities competing for the same scarce resources. An estimate of farm level cashew production costs and returns to smallholder's resources under alternative production technologies and policy incentives will: 1) shed light on the potential trade-offs farmers face and synergies possible when choosing among cashew and other competing enterprises for resources; and 2) inform implications for potential output and quality improvement and overall income generation. Specific objectives of this dissertation include:

1. characterize typical smallholder cashew producers in terms of size, composition, gender, production systems, agricultural practices, relative labor, land and capital requirements and the relative importance of cashew in the household's income. This should help in creating a typology of cashew farmers in the study areas;

2. Identify the problems and constraints to smallholder cashew production;

3. Identify and measure the determinants of financial and economic profitability of smallholder cashew production vis-a-vis other crops in the farming system. Profitability assessment should consider relative input and output prices and relative yield estimates in the calculation of returns and economic cost of labor and land for different enterprises.

Evidence from the profitability assessment should take into account the current smallholder multi-cropping system in Mozambique and be able to inform questions about potential cashew supply response or the lack thereof, and about the opportunity cost of labor time and land allocated between food and cash cropping activities, particularly for households which are already labor and land constrained.

4. Evaluate cropping mixes in a context of a typology of cashew farmers. This evaluation will be conducted through a linear programing model considering alternative combinations of resource levels and use, resource requirements and goals, as they are affected by alternative policies and technological options; and

5. discuss policy implications resulting from a sensitivity analysis of the impacts of alternative policy and technological options on production of cashew vis-a-vis other crops.

It is hypothesized that for Mozambique to meet the increased demand for raw cashew nuts to satisfy demand both from domestic processing and exports will require considerable increased productivity from smallholders. Productivity increases in turn, will require incentives and possibly new inputs including new cashew varieties and different practices and investments in new technologies to shift current production functions upwards. Moreover, as Ali and Byerlee (1991) have pointed out, if with current or new technologies, more productive use of farmer's available resources and inputs provide significant opportunity to improve productivity, then a case can be made for stronger institutional support through investments in input delivery, infrastructure, extension and management services, and education that promote efficient use of resources at the farm level (p.2).

1.3 Historical Background on Cashew Production Structure and Exports in Mozambique

Cashew production is mainly dominated by dispersed smallholders along the coastal areas of Mozambique and in a few areas in the country's interior. Some commercial companies hold a few plantations, but mostly and very recently as on-station trial fields to support smallholder cashew production in concessions areas for other cash crops such as cotton. The next section explains the historical setting of the current smallholder cashew sector as well as Mozambique's cashew production and exports.

1.3.1 The Smallholder Cashew Sector

The historical success of Mozambique's cashew production and exports has been largely attributed to replanting. Production levels reached in the early 1970s are reported as having been the result of new plantings that occurred between 1950s and 1960s which are believed to have stopped after 1965. Given the lack of replanting, the existing stock of cashew trees has aged over the years and its productivity declined (Nomisma, 1987, and Prasad et al., 1997). Total cashew production declined from over 200,000 tons/year in the early 1970s to about 45,000 tons in 1998 (Figure 1-1).

Mozambique was a pioneer in establishing the first African cashew nut processing factory on an industrial scale in 1960. To guarantee planting and sufficient supply of raw cashew nuts to the emergent processing sector and to facilitate consequent export earnings from the value added kernels, from 1920s throughout 1960s colonial authorities efforts were concentrated in high density populated regions. In these regions, a network which often involved traditional authorities (*mwenes* and *régulos*), rural shop owners and colonial policy makers was established under the later known policy as "*medida cem-por-cem*"[2] (*Régulo* Milapa, 1998, personal communication).

Under this policy, smallholders were given 5 to 7 hectares of land and it was mandatory to plant cashew trees (*mandatory planting*) on one hectare at a given spacing. Traditional chiefs had the responsibility to oversee the planting and maintenance of the trees, and report to the colonial authorities observance of the policy. In this process, coercion and violence were used. The strategy was later extended to include cashew planting on any fallow land which did not have cashew trees at a given point in time.

In addition, traders willing to open shops in rural areas received economic incentives such as tax breaks, and were required to grow cashew trees around their shops (DPA & P, 1995). Further expansion of cashew trees was, and still is, a result of spontaneous trees growing out of fallen nuts (Nomisma, 1987).

In addition to the above strategy, traders/wholesalers supplied food stuffs and manufactured goods that were often used in cashew transactions, as much as in other crop marketing. These consumer goods, mainly cloth and footwear, sugar and illumination oil were imported directly by colonial cashew authorities and distributed to wholesalers, then to rural traders who sold to farmers. It is widely believed that this collapse of the rural

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[2] *Medida cem-por-cem* refers to the system used to allocate the mandatory one hectare (100 x 100) determined by the colonial authorities by which trees cashew should be planted by a given smallholder (field group interviews, 1999).

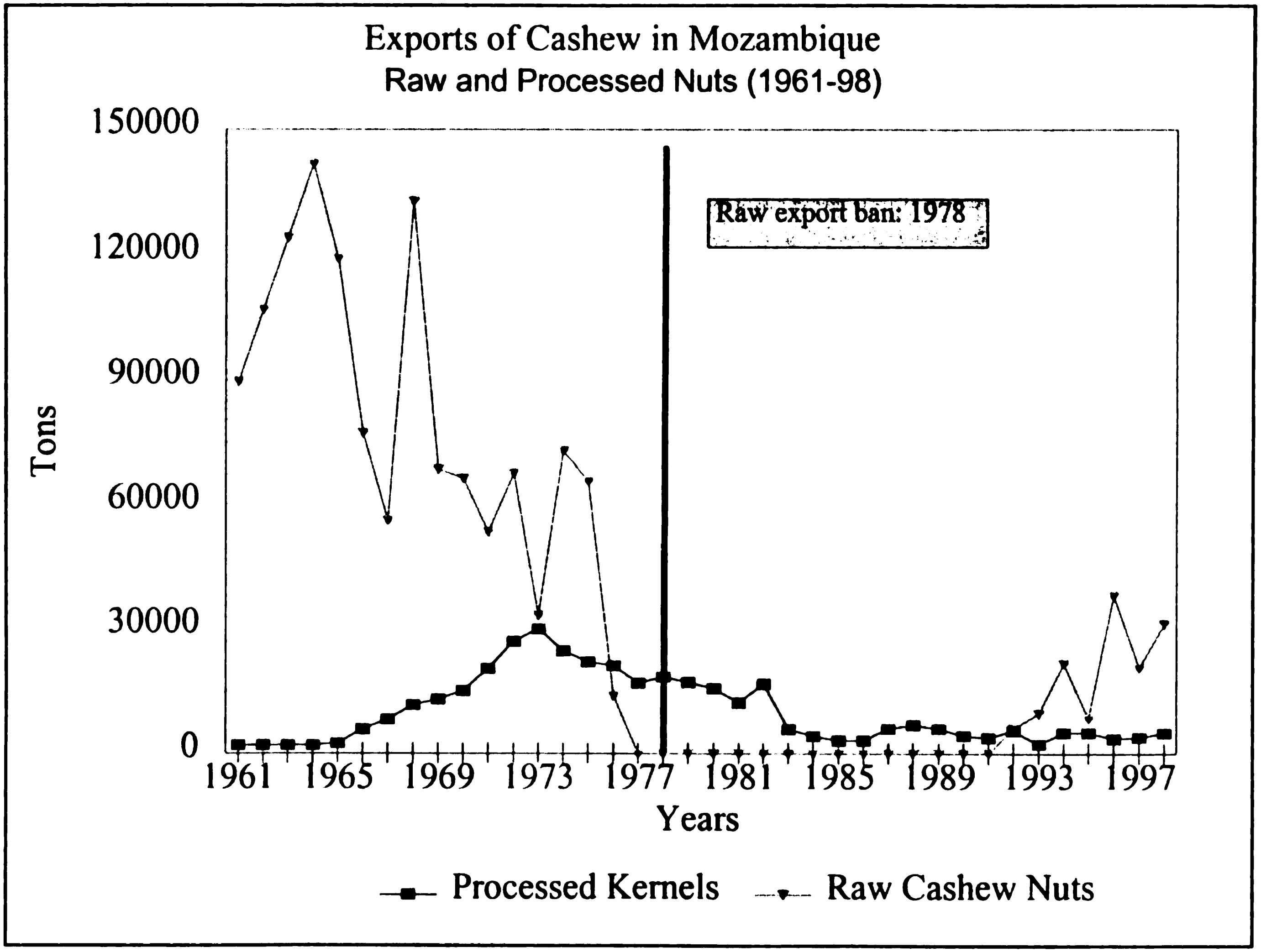
marketing system due to the fight for independence and later civil war is one of the principal cause of the current low level of marketed surplus (Hilmmarson, 1995; DAP&P, 1995, and Deloitte and Touch, 1997). It is also believed that smallholders lost confidence in the marketing system as a source of supply of other goods for which cashew income was spent. However, government officials at the provincial level also suggest that the after independence replanting failure resulted from the complete exclusion of traditional authorities in cashew development strategies. Efforts at developing projects to promote cashew tree planting did not succeed because smallholders became suspicious and fearful that the government would later nationalize the trees (DPA & P, 1995).

1.3.2 Mozambique's Cashew Production and Exports

In the early 1970s Mozambique exported about 140,000 tons of raw cashews, that is about 37 percent of world production and also exported about 30,000 tons of processed kernels, a 41 percent share of world processed cashew nuts' exports (see Figure 1-2, below). Its most direct competitor, India, produced about 87,000 tons of raw nuts. During that period, India was less of competitor in the world cashew market. With increased supply of raw nuts and limited processing capacity worldwide, prices of raw cashew nuts at that time declined.

In the seventies, however, increased processing capacity in major cashew producing countries such as Brazil, India, Mozambique and Tanzania shifted demand for raw cashew nuts upward, resulting in higher raw nut prices. In the late seventies and earlier eighties, production of raw nuts and exports of processed cashew nuts declined

Figure 1-2 Exports of Raw and Processed Cashew Nuts in Mozambique, 19961-98



rapidly in Mozambique due to the war and economic crisis which led to a widespread lack of incentives to take care of the ageing and diseased stock of cashew trees. This led to a decline in total cashew production, and particularly high quality cashew output in Mozambique. In the meantime, faced with structural constraints, the domestic processing technology became obsolete and unable to compete in the world market. In 1992 with liberalization of agricultural prices, export of raw cashew nuts were again allowed. This has increased the pressure on the domestic processing sector, who faced with liquidity constraint could not compete with exporters for raw material. In the world market, the expansion of processing capacity increased demand for raw nuts worldwide. This scenario has not changed substantially yet, even with new entries such as Vietnam into cashew production. For instance, given the limited domestic supply of raw cashew nuts for its growing domestic processing industry, India ---the current world largest raw nut importer --- continues to import substantial quantities of raw nuts from Mozambique and Tanzania.

1.4 Organization of the Dissertation

This dissertation is organized in eight chapters. The first chapter introduces the dissertation with highlights of trends in the cashew industry. In addition, it presents the research problem statement on smallholder cashew production in Mozambique, research questions and objectives of the study. Historical background is also provided for the current smallholder cashew sector and the trends of both exports of raw and processed kernels in Mozambique from 1961-1998. The chapter concludes with the dissertation organization. Chapter Two provides details of the research methodology, including geographical area of the study and the sample selection method, a brief description of the survey instrument used, and an overview of cooperation efforts with partners in cashew research in the study area, and in Mozambique in general. In Chapter Three a decision tree is presented, and smallholder challenges and investment strategies in different alternatives available to increase cashew production and quality are explored. A summary of perceived feasible alternatives is provided. Chapter Four describes the characteristics of the sampled smallholder households, and develops a typology of cashew farms as a framework of analysis in forthcoming chapters. An econometric model was used in Chapter Five to explore the determinants of cashew tree productivity in the study area. Insights from this model help to understand the crop enterprises budget summaries of smallholder resource use in various crops, and the returns to land and labor presented in Chapter Six. Chapter Seven develops a smallholder cashew household linear programming model to explore an alternative technology and management practices to current practices under resource and food security constraints. Finally, the dissertation ends with a summary of findings and policy, research and extension implications of the findings in Chapter Eight.

CHAPTER 2

RESEARCH METHODOLOGY

2.0 Introduction

In the Northern province of Nampula, agriculture is predominantly smallholder although some commercial farms can be found, particularly in cotton production areas. The province of Nampula produces and markets more than 50 percent of total national cashew output (Table 2-1), and holds about 39.8 percent of the total national cashew orchard (Strasberg, Mole and Weber, 1999).

The following sections describe the geographical coverage of the study, the sample selection methodology, and the survey instrument used to gather primary smallholder data. Cooperation with other cashew researchers in Mozambique is briefly outlined.

2.1 Geographic Coverage

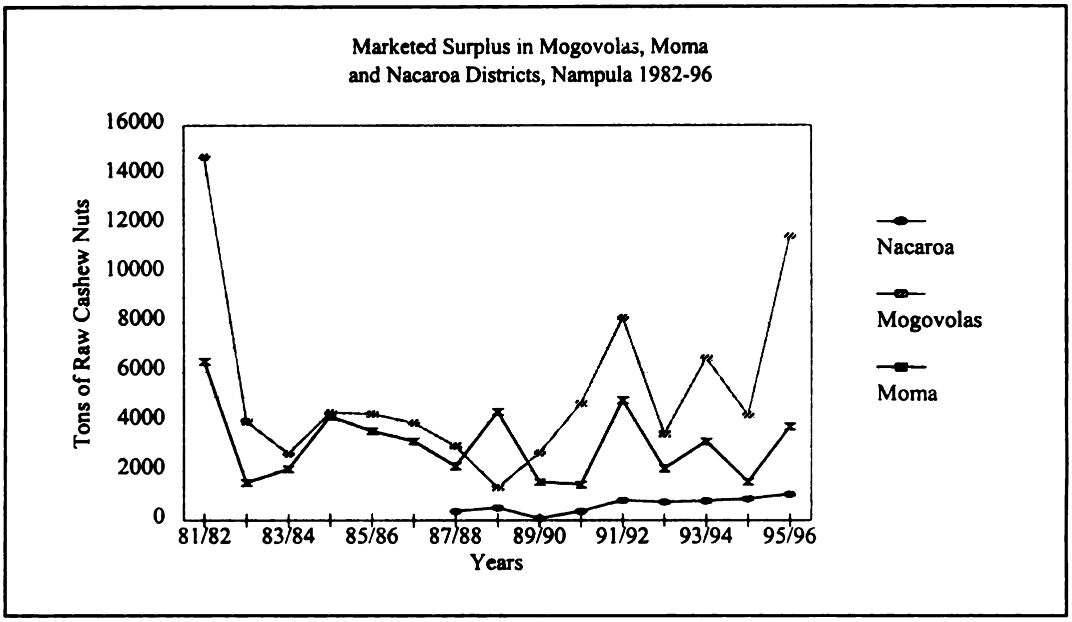
The cashew belt in the Northern province of Nampula has a great agro-ecological variation and offers a diverse agricultural potential. The study area includes two main agro-ecological zones within the cashew belt: the inland medium altitude and the coastal low-altitude areas. In these two areas, the selected districts and villages represent three cashew producing areas in Nampula province with different cashew production potential and agro-ecological characteristics. Despite the variations in cashew production potential one can argue that these districts represent well the distribution of cashew production within the province ranging from the Mogovolas the number one producing district of

Table 2-1 Proportion of National Cashew Marketed Surplus in Three Most Important Cashew Producing Provinces, 1987-97.

Province	1987-8	1988-9	1989-0	1990-1	1991-2	1992-3	1993-4	1994-5	1995-6	1996-7
	(percent)									
Nampula	55	78	68	55	63	75	90	52	55	78
Inhambane	18	6	9	10	6	4	-	18	13	8
Gaza	20	8	14	23	13	8	-	24	15	6
The 3 Provinces	93	92	91	87	81	88	90	94	84	92
Total ('000 tons)	44	50	22	31	54	24	30	33	67	36

Source: Deloitte and Touche (1997).

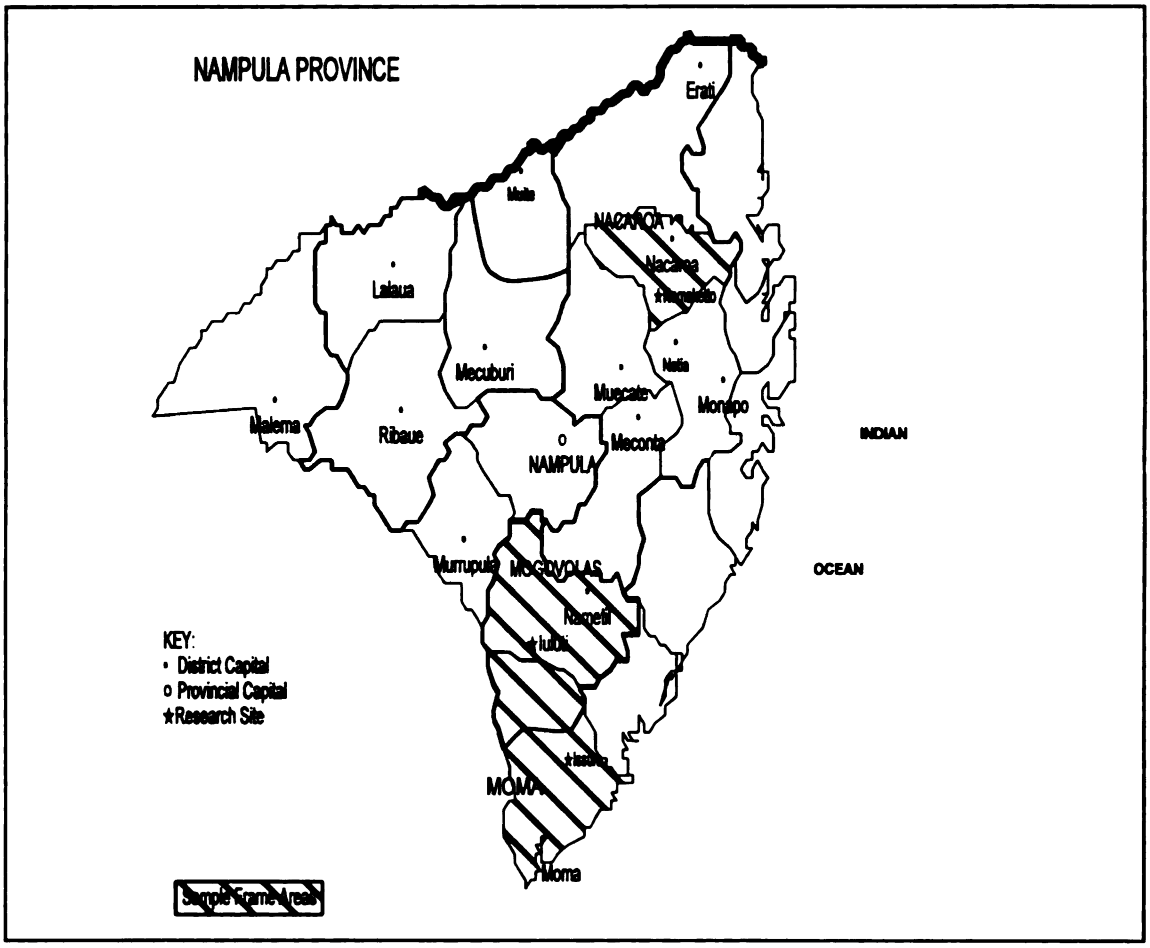
Figure 2-1 Marketed Cashew Surplus from the Study Area, 1981-96



Nampula (and in Mozambique as well) in terms of the volume of marketed cashew surplus, the district of Moma, the third most important in Nampula and Nacaroa at the bottom in the Province (Figure 2-1).

The coastal area is a strip of land with varying width extending from the district of Moma in the South to the far northern district of Memba (Figure 2-2). In this area, the study covers the districts of Moma and Mogovolas. In Moma, a medium potential zone for cashew production, the study includes the village of Issura to represent the low altitude and medium potential cashew area. In the district of Mogovolas the sampled areas include the villages of Milapa and Nivine and are representative of high potential

Figure 2-2. Sampled Areas in Surveyed Cashew Areas in Nampula, Mozambique, 1998.



areas for cashew production. Note that the district of Mogovolas produces currently most of the cashew in Nampula, a province that produces most of the cashew nuts in the country. For most of the agricultural calendar year average temperature in the coastal area is above 25 degrees centigrade with evapo-transpiration rates reaching 1,400 to 1,600 millimeters (Table 2-2). Rainfall levels vary from eight to 1,200 millimeters, and

Table 2-2 Mean Characteristics of Agro-ecological Zones in Surveyed Areas of Nampula Province, 1998

District/Village	Medium Altitude Area Nametho and Nampaco villages (Nacaroa District)	Coastal Littoral Area Issura village (Moma District), Milapa and Nivine villages Mogovolas District)
Altitude	200-1000 m	< 200 m
Rainfall	1000-1400 mm	800-1200 mm
Evapo-transpiration	1000-1400 mm	1400-1600 mm
Temperature	20-25^0 C or above	> 25^0 C
Soil type	Sandy to Clays	Sandy and heavy

Source: Cashew Technologies in the Smallholder sector in Nampula, 1998, and MAP 1996.

soils are mostly of a sandy type, but heavier in the low altitude areas. However, last year's rainfall levels and distribution were not favorable for a good agricultural season, mainly for cashew production and harvest. The farming system in the area is dominated by cultivation of manioc, beans and peanuts with rainfed rice as an important complement in food production in the low-lying areas. Maize is also grown by some farmers, but grows poorly. Cashew and cotton are the main cash crops in the province, and contribute the most to farmer's income. Alternative activities include fishing, cattle grazing, and some employment opportunities among NGO's, and in cashew and cotton processing plants.

The medium altitude area is mostly planaltic with about 200-1,000 meters of altitude extending from the Southwestern district of Murrupula to the Northwestern district of Erati, including the study district of Nacaroa. The villages of Nametho and Nampaco in the district of Nacaroa were covered in the study and considered to be representative of low potential areas for cashew production in the Northwestern inland part of Nampula province. Annual rainfall and evapo-transpiration rates in this area vary between 1,000-1,400 millimeters with moderately warm areas of an average temperature between 20-25 degrees centigrade and more warm areas with greater than 25 degrees centigrade.[1] Soils in the area vary from sandy loams to clays. However, manioc is widely intercropped mainly with beans and groundnuts. Cashew is an important cash crop for farmers, and cotton has a high potential for incrementing farmer's income in the area.

2.2 Sample Selection

The analytical results in the following sections are based on data of a sample of forty smallholder cashew households in the two agro-ecological areas as described above. The data were collect in multiple rounds for a twelve month period thereby following a complete cashew fruit bearing period for the 1998/99 agricultural season. The districts and respective villages were purposively selected in order to capture the diversity of

[1] Northwood (1962) found that although higher altitude may appear to not affect cashew yields this factor puts back the main harvesting period by 1-2 weeks. That means that early rains can spoil unharvested nuts from earlier flowering. The implication of this finding to research is, earlier maturing varieties should be the goal for production researchers.

farmers characteristics and differences in agricultural production potential as they are located in different key agro-ecological zones for cashew production.

The sample includes :

- 16 households from the villages of Nametho and Nampaco in Nacaroa district drawn randomly from a list of six villages in the Posto Administrativo of Namaketto,

- eight households from the village of Issura in the Posto Administrativo of Chalaua, in Moma district, and

- 16 households from the villages of Nivine and Milapa in the Posto Administrativo of Iúluti, in Mogovolas district.

Unless said otherwise, all the statistics presented in the forthcoming analysis are based on the full sample size of the 40 households interviewed during the study period.

2.3 The Survey Instrument

Data and information on households characteristics and resources presented in statistical summaries were obtained using farmer recall and interviewer measurement. Enumerators implemented questionnaires and wrote down responses from interviews of heads of households in May 1998 on demographics, resources availability and cropping systems for the 1997/8 food crop and 1998/9 cashew seasons. In January 1999 a final interview was conducted with the same heads of households obtaining information on the most recent cashew harvest. Between May 1998 and January 1999, enumerators were involved in field measurement, cashew tree and nut counting for yield estimates. Fields and cashew trees were positioned using GPS instruments to facilitate identification and better matching of labor allocation data to measured fields and counted trees. Enumerators were trained both for the interviews as well as on the use of GPS instruments. Before use in final sampled villages, the survey instruments were tested with households in the district of Muecate outside the sampled area.

Collected information was cross checked with available data on smallholders at the Ministry of Agriculture and Fisheries both for internal and external consistency. The databases used for cross checking are the National Agricultural Survey done in 1996 (TIA 96) and the Cashew Survey undertaken in 1997 (CAJU 97) in the four principal cashew producing provinces of the country.

2.4 Research Cooperation with NGOs and Other Institutions

Prior to field work discussions were held with several interested parties in the cashew industry policy debate. Among those were USAID and the Cashew Working Group in Maputo, World Vision (WV) and the Cashew Rehabilitation Project (CRP) in Nampula. For the study period WV and CRP were going to participate in a series of cashew research trials both on-station and on-farmer's fields including the cultural control (known as *sanitation* [2]) of PMD, one of the technology experiments subject of this study. As a result, we had agreed with WV and CRP to cooperate by working in the same districts and with a smaller group of farmers in order to collect more detailed data with better quality due to closer supervision.

Starting in January 1998, extensive planning and visits to the research sites took place with WV and CRP personnel. This allowed us to add the socio-economic perspective to the technical requirements of the research program of the cashew protection scientists leading the WV and CRP trials. By February 1998, farmers had attended sanitation demonstration sessions in three sites in Chalaua, Moma district, Nametil in the district of Mogovolas and Namaketto in the district of Nacaroa.

However, given that sanitation must take place at a given period of the year, and at a given timing, the experiment was later technically called off due low and late participation of farmers. By the end of April we had to make a decision on how to proceed with the socio-economic side of the study. Since the WV and CRP studies were designed as control-treatment experiments and these had not been done, a decision was made to remain in the same districts, but work with a different group of farmers in different villages in order to avoid the bias that could have resulted if the initial group of farmers were to participate. The final sample selection method used is as explained in section 2.3. Cooperation with WV and CRP continued with their valuable technical

[2] Sanitation is one of the smallholder options to treat the current stock of trees which is severely attacked by the most common cashew disease in cashew producing areas, *Oidium Anacardium*. It includes severe pruning of the tree canopy, three times per season, two months apart each.

advice to our enumerators and providing to us with data for cross checking purposes. Furthermore, given that the majority of the technologies evaluated in this study are still being tested on-station, the cooperation with scientist from both agencies helped to generated a great deal of knowledge which helped to develop the synthetic crop budgets which went into the LP models.

CHAPTER 3

CHOICES OF ALTERNATIVE TECHNOLOGIES AND MANAGEMENT PRACTICES IN SMALLHOLDER CASHEW PRODUCTION

3.0 Introduction

The cashew industry is an important economic component of Mozambique's economy. Cashew is the second, after prawns, in export earnings, and benefits about a million households in the family sector to whom depend upon it for part of their food security. In addition, up to 1997, the processing sector had been a source for employment for about ten thousand workers (GTC, 1999). However, these benefits have been decreasing over the years with the decline of production and nut quality. Rehabilitation of the national cashew tree orchard has been slow due to: (1) the incidence and degree of Odium Anacardium disease and the lack of a mechanism to solve it;[1] (2) poor economic incentives, particularly low cashew producer prices; (3) unclear cashew property rights associated with land property rights;[2] (4) widespread use of slash and burn agriculture

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[1] Although many of these informants value the use of agro-chemical inputs such as sulphur to solve the problem, they have shown concerns over the use of this product in Mozambique. However, in Tanzania sulphur-using farmers have shown a higher average harvested production than non-sulphur users. Since 1986 that total imports of sulphur have been increasing. It is estimated that in 1996-7 consumption of sulphur was around 5,000 tons. This level of sulphur use has been suggested to be associated with the increase of national cashew production from the low 16 tons in 1986-7 to expected 100 tons of dried cashew nuts in 1997 (Poulton, 1997).

[2] Property rights in cashew production is complex. While some worry about unclear rights to land and use which may prevent smallholders from investing in new fields where the likelihood of getting higher returns is higher, to Eng. Xavier, provincial director for Agriculture and Fisheries in Nampula, the most important issue is that of
(continued...)

that sets fire into cashew fields; (5) less care of the cashew tree stock; and (6) lack of consistent research and replanting which have lead to ageing of the cashew tree orchard and the reduction of the cashew productive capacity. These factors have been recently under debate in attempts at rehabilitating the smallholder cashew sector.

Despite great efforts to increase planting, however, less success has been achieved, particularly with regard to incentives for more smallholder investments in cashew production. Policies and expectations in the sector which seek alternatives, recognize that the cashew farming sector is made up of subsistence farmers who account for over 92 percent of the cashew production. These farmers are widely dispersed across the provinces where cashew is grown and many are amongst the poorest and the least educated in Mozambique with no representation in cashew decision making institutions. In addition, smallholder cashew farmers, as many farmers in Mozambique face significant agricultural risk. Their ability to deal with it, depends to a large extent on their resource endowment and the level of needs they have to satisfy. Furthermore, many small farmers in the country are still operating at the subsistence level and are vulnerable to fluctuations in the environment. For many of these smallholders, food crop production may take priority over cashew in production plans every year. This priority setting

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[2](...continued)
property rights enforcement the cashew trees output. There is always an owner for every cashew tree, whether it is productive or yielding literally no nuts. Set fire and theft of nuts during harvesting time are widespread problems in Nampula, particularly for farmers with many trees and located far away form home. These issues require an institutional analysis to search for solutions that can prevent the loss of smallholder assets, and the lack of incentives to take care of existing trees or further investments in new planting.

induces less investments in cashew production over the long run (Deloitte & Touche, 1997) .

Thus there are still many questions to be answered with respect to strategies, policies and support required to stimulate smallholders to increased cashew production. The main policy relevant question has been whether Mozambican smallholder farmers can expand production and improve quality of cashew nuts under the current state of the smallholder cashew sector. More specifically, there is a need to understand potential investment decisions and available alternative technological options that smallholders need to consider in order to achieve the expected cashew production increase and quality improvements. In addition, in an environment where cashews are not the main crop, policy makers must devise incentives and institutional support arrangements that would encourage and assist smallholders to adopt the available alternatives and new technologies.

The next section provides an overview of current options smallholders may consider in the process of investing to increase cashew production and improve quality. An attempt is made to present the available options, and then appraise the feasibility of these options, given farmer's circumstances in Mozambique.

3.1 Smallholder's Investment Decisions on Alternative Technological Options in Cashew Production

Farmer's investments in cashew production and quality improvements in Mozambique must take into account the potential of the currently existing tree stock, and the option of planting new trees in both existing and new fields (INCAJU, 1998). During the 1980s, it was estimated that most of the existing cashew trees were over 25 years old, with a yield between 1-1.5 kgs per tree or about 100-150 kgs per hectare ---an initial average of 100 trees per hectare planting density (Nomisma, 1987, and Prasad et al., 1997). For at least last two decades significant replanting has not taken place. The reasons for the lack of replanting include the lack of superior genetic material for field planting leading to the gradual decline in cashew production and quality (Prasad, et al, 1997). These factors have added to the aggravation of biotic stresses viz., powdery mildew and tea mosquito bug in the decline of production and quality. As a result, new investment needs to take place at the farm level, if production is to be expanded and quality improved. Given that the current stock of cashew trees is mostly owned by the smallholder sector, an analysis of the incentives to farmers to invest in cashew is necessary. More specifically and fundamental, there must be an analysis of the smallholder investment process to detail the alternatives and choices available to farmers to boost the current levels of cashew production and quality.

3.1.1 Literature Review on Smallholder Technology Adoption

There are several factors that may influence farm-level decision making in the adoption of new cashew technologies and practices. The literature on technology adoption often cites variability of yields, prices and costs, farmers' aversion to and perception of risk, farmer's ability to diversify and to respond to weather and price information during the crop season or production cycle as the main factors in agriculture preventing widespread adoption of new technologies (Sanders, Shapiro, and Ramaswamy, 1996; Reardon, Delgado, and Matlon, 1992; Painter, 1986, 1987; Binswanger and McIntyre, 1987; and Bromley and Chavas, 1989). In the case of cashews, the perennial nature of cashew tree investments increases the likelihood of aversion to risk bearing, given the extended period over which returns must be realized.

Smallholder's response to changes in policies and availability of alternative cashew production technologies can vary for different households as characterized by a wide range of constraints facing them. Expectations of a common and generalized response cannot be justified unless an homogeneous population of smallholders cashew farmers can be found in Mozambique or elsewhere. Adoption of some technologies may occur by some farmers, but further adoption may be constrained by labor availability, particularly when farmers have competing farm and non-farm activities. Adoption of cashew technologies that are labor intensive such as stumping and top-working or requiring availability of scarce resources such as chemical control of PMD through spraying may be constrained by other household activities where labor yields a quicker investment return. Alternatively, land scarcity may induce adoption of cashew labor intensive technologies as a way to reduce walking distance in search of bush-fallow land for new planting.

Technology adoption must be profitable and risk levels must be low for most smallholders to adopt a new technology. Price collapses reduce profitability of enterprises, expected incomes and increase income variability, and this can be a principal disincentive to adopting new technologies. Price variations can also be reduced by improved transportation and communication which can increase output prices through reduced marketing margins and reduced input costs. Thus, better linkage to market may encourage intensification of agricultural production. Creating a profitable economic environment for farmers is one area in which government policy intervention can have a direct impact (Sanders, Shapiro, and Ramaswamy, 1996).

Risk aversion has been advanced as one of the reasons why farmers are hesitant to adopt new technologies requiring input expenditures. Risk reduction and assurance of minimum subsistence levels of food crops is a main concern to small farmers, particularly when long-term investment decisions need to be made. However, risk aversion may not be the key factor in the decision making process. Farmers may be pessimistic about the distribution of returns to resources from a given technology or new activity. Thus, the perceptions of the riskiness of new activity or technology seems to be more important factor than their aversion to risk in the adoption decision (Goodwin, Sanders, and de Hollanda, 1980).

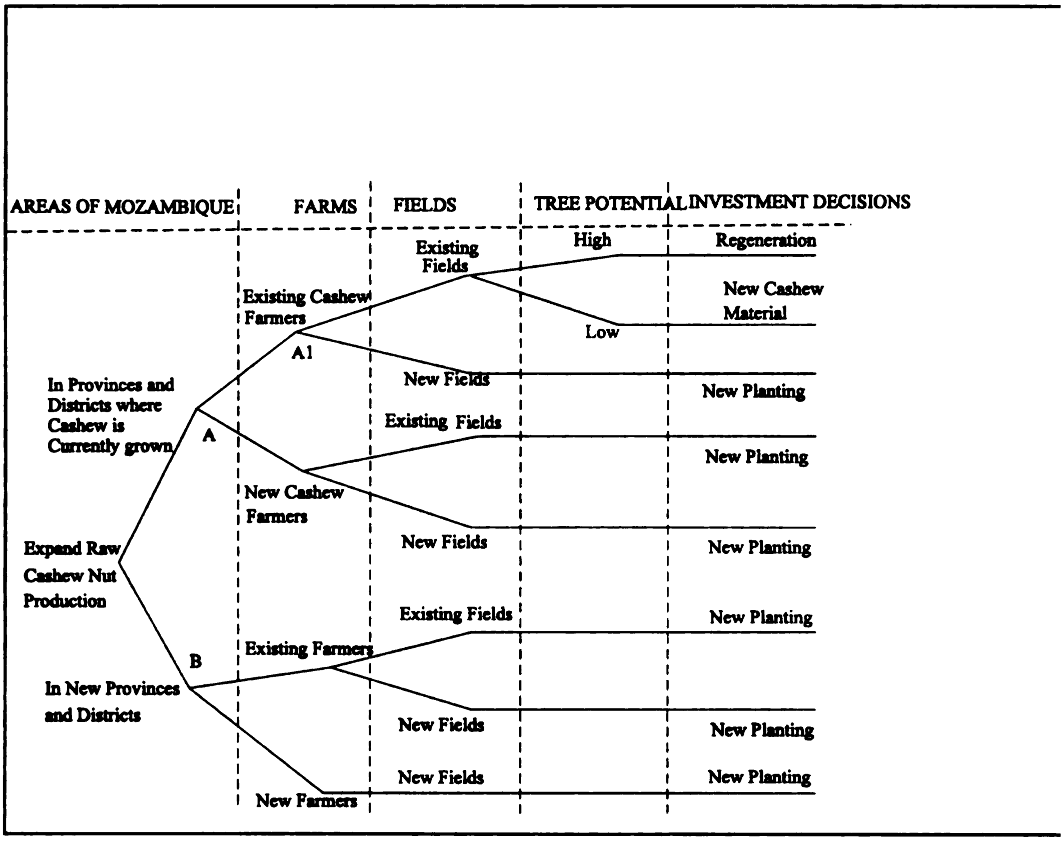
However, most farmers may perceive poorly the distribution of risky outcomes from new technologies, particularly when the investments pertain to long waiting periods to realize economic returns such as planting of new cashew trees. Farmer's pessimism about possible yield gains until they have more information may be more important than his/her risk aversion as an impediment to higher adoption rates. For example, studies have shown that farmers have in general adopted new yield-increasing technologies when there was adequate rainfall, they used water retention devices, when moderate fertilization and higher densities increased water use efficiency and when irrigation was available. Once water availability was assured, many farmers used soil fertility improvements generally involving higher input purchases (Sanders, Shapiro, and Ramaswamy 1996; and Anderson and Dillon, 1991). Therefore, the importance of farmer's poor-perception of potential gains can be an indication of the potential returns to public support of on-farm demonstrations of the new technologies and other extension activities. Improved transportation and communication may increase output prices through reduced marketing margins and reduced input costs. So better linkage to market may encourage intensification of agricultural production. Creation of profitable economic environment for farmers is one area in which government policy intervention can have a direct impact.

In the context of Sub-Sahara Africa, the factors affecting technology adoption are enhanced by the low and erratic rainfall, low fertility, and fragile soils which imposed large variations on yields. Furthermore, government efforts to stabilize variations on product prices have often been unsuccessful for principal crops in poorer developing countries (Sanders , Shapiro, and Ramaswamy, 1996).

As for cashew in Mozambique, there are two strategies available to go about expanding cashew production: (1) production could be promoted in provinces and districts currently growing cashew or (2) promotion could be targeted to potential areas in provinces and districts where there is no cashew or very little currently exist (Figure 3-1).

Historically, cashew has been grown in areas with high population density and sandy clay soils, mostly in coastal areas with medium altitude. Given the current

Figure 3-1 Smallholder Cashew Farmer's Investment Decision Process in Mozambique



distribution of the cashew tree stock, the latter strategy would likely be a costly and risky long-term solution, and it is dependent on many more investments in research to determine the potential of future sites.[3] As a result, this option is not attractive in the

[3] Tete, for instance, has historically grown cashews that were basically used to produce liquor to barter trade with slaves. At some point, cashew tree planting were forbidden because drinking in slave plantations became a serious problem. However, when Indian merchants engaged more vigorously in cashew trade, then colonial policy towards cashew changed. Trade licensing in rural areas was conditioned to planting a given number of cashew trees around the shops. This indicates that there might be regions where cashew trees where planted in marginal land as well as areas with some

(continued...)

short-run given the scarcity of both human and financial resources. Thus, the most likely viable option is concentrating on provinces and districts currently growing cashew. This provides a seemingly workable solution to increasing production and basically takes into account the investments already made in tree stock and farmers' experiences in cashew production and management. However, even in these areas, substantial increases in production will require considering two further options: (1) working with existing farmers on those fields which currently grow cashew or in new fields and fields where they grow no cashew, but other have other crops, and (2) providing incentives to farmers that currently do not grow cashew to consider growing cashew on their existing or potential new fields. Again, in the short-term an attractive strategy will be to engage current cashew growers to make profitable investments that would rehabilitate the existing cashew fields and the producing tree stock, under the existing farming systems. It is also possible that new trees could be profitable using available technologies on existing non-productive tree stock.

Farmer's investment decisions as shown in Figure 3-2 below takes into account that the starting point in Figure 3-1 is cashew production expansion or rehabilitation taking place in provinces and districts that currently grow cashew. The expansion of cashew production is considered to be possible under alternative (A1) whereby existing cashew farmers consider additional investments in either existing or new cashew fields. In existing cashew fields, the farmer has two additional options to invest in, depending on

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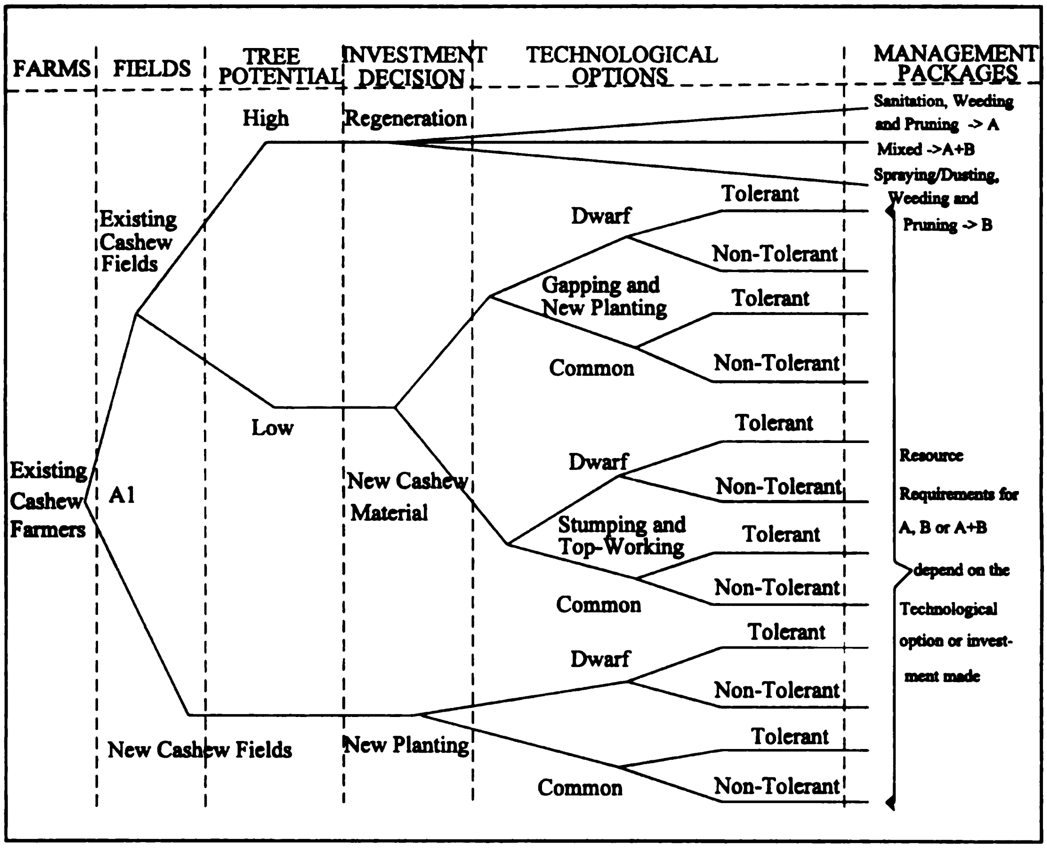
[3](...continued) potential for growing cashew.

Figure 3-2 Smallholder's Choice of Technological Options and Management Packages



his/her knowledge of the yield potential of the current tree stock. That is, the farmer must determine the yield potential of each of the tree in order to be able to make the decision about which type of investment to engage in. It is important to recognize that yields are highly variable on farmer's fields, and this true even with improved management practices (Neto and Caligari, 1997). Some cashew trees may produce nothing while others produce up to 20 kg of nuts. Often in most fields the lowest yielding 50 percent of the trees produce less than 30 percent of total production and many of these trees are uneconomical to treat with fungicides (Topper, 1999). Poor yielding trees may remain low-yielding for several years, particularly in overcrowded fields (Martin and Kasuga, 1995; and Topper, 1999). This is the main reason that thinning (cutting down some trees) is recommended as a management practice. Determining the yield potential of each tree it is a hard exercise and even an approximation to the real potential of the tree has a cost.[4] As a result, as this cost goes up, investors are more likely to base investments decisions on current yield or past yield patterns of cashew trees. However, once that yield level is known for each existing tree, the farmer may decide to invest in *regeneration* of the tree or investing in a *new tree planting* using available technologies. That is, if an existing tree has a medium to high yield potential it may suffice to attempt adoption of better management practices to increase production and quality of that tree. However, if the yield potential of the tree is low, then the farmer should consider investing in new plant material. Overall, it is important to recognize that production per existing tree can be substantially increased by introduction of certain regeneration practices.

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[4] Dr. Clive Topper, a crop protection specialist indicates that given the variability in cashew tree yields, within the same vicinity ---say the same hectare, an approximation to the true yield of each tree can only be possible by making some investments in treatment costs and then monitoring yield (our conversation Oct 21, 1997). Even then, one needs a long time period to construct a yield curve for each tree. The costs are related to cultural (sanitation) and chemical control (spraying and dusting) for powdery mildew, the primary cause of yield losses in cashew production in Mozambique.

According to Topper (1997) and INCAJU (1998) the following are *on-going management* practices that can be carried out under regeneration alternatives[5]:

(a) ***Chemical Control of Powdery Mildew Disease (PMD):*** control is undertaken by either spraying trees with wettable sulphur before the flowering season, or by sulphur dusting techniques applied using blowers during the flowering season.[6]

Considerable effectiveness in controlling PMD can be achieved by dusting at panicle emergence. Dusting is also effective if it is done early in the morning when dew helps to fix the sulphur to inflorescence. Selective targeting of this treatment to best trees may also improve application and thus yields.[7]

(b) ***Cultural Control of PMD***: Removal of sources of inoculums before flowering (sanitation) is used to delay the onset of the PMD epidemic and, selective thinning (pruning and gapping) to create less favorable micro-climate for PMD.

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[5] It is assumed that disease control and cultural practices are the only constraints to increased production for cashew trees with high yield potential.

[6] Problems with the dusting methods include a 75% loss in dusted sulphur which is drifted away from the target by blowing wind. Of the deposited material 85% is said to be lost in 14 days of application causing some serious environmental problems, particularly acceleration of soil acidification on sandy, acidic soils on which cashew is grown (Smith *et al.*, 1995).

[7] Without dusting in Tanzania, average yields were shown to be about 2 kg per tree varying from 0 to 6 kg per tree. These yields have increased as increased quantities of sulphur were applied. For instance, with 0.5 kg of sulphur per tree per season, yields varied from 0 to 10 kg per tree and with 1.25 kg sulphur per tree per season (the recommended rate) yields varied from 1 to 16 kg per tree (Martin *et al.*, 1997).

These two management practices are not mutually exclusive, however. The farmer may choose to apply both types of control on the existing productive tree stock to increase control for PMD incidence and thereby improve yield.

An alternative to the regeneration of existing trees is the use of new cashew material to replace existing unproductive cashew stock. Alternatives available to the farmer here include (1) *thinning* and replacing trees through a process known as *upgrading* which is the introduction of either *disease resistant/tolerant cashew material* into existing fields on existing gaps or where thinning has created sufficient gaps to allow room for new planting,[8] and (2) *stumping and top-working*[9] of the regrowth with improved *scion material.* Top-working allows rapid growth of the canopy and early yielding, but it is labor intensive at the tree stumping stages. The latter option can also be done with both improved and common material which could be tolerant and non-tolerant to diseases, and which requires different management practices. It is worth pointing out

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[8] Tolerant material results from selection based on the ability of trees to produce reasonable yields over several years without any control of PMD. However, there are cashew trees that by their biological nature have the ability to *escape* disease attacks by flowering earlier or later than normal. However, given that the quality of the nuts from late-flowering is likely to be poor, due to harvest after the onset of rains when farmers are busy with annual crops, this option could be a problem.

[9] In top-working ***patch-budding and side-grafting*** are done. The trees must be cut down to the trunk first, and the side-grafting done on the shoots sprouting from the trunk. The techniques can also be done on trees that have poor quality nuts resulting from disease attack or from burned trees. The surface of the cut of the trunk must be treated with fungicide and covered with tar or other preserving substance to avoid rot. Cuts should also be made slanting downward and not horizontally to avoid rain and dew water standing on the surface of the cut and penetrating which might encourage rottening of the stem. Patch-budding and side-grafting are very old techniques.

that due to the lack of improved material in Mozambique, farmers have been using non-tolerant material in planting new cashew trees, but obviously this cannot be considered as optimal situation.

An alternative to rehabilitation of existing cashew fields is planting new trees in completely new fields. Farmers can engage in planting new trees from dwarf and common cashew material that are both tolerant and non-tolerant to diseases. Technologies in this area include basically *tip-grafting.*[10]

As described above, there are technical alternatives to farmer's current practices to increase cashew production in Mozambique. However, whether these technical solutions are feasible for farmers under the current farming systems is still a gap in knowledge. Before a financial analysis of individual technical alternative option is undertaken, the

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[10] ***Tip-grafting*** is subdivided into ***Splice-grafting*** and ***Cleft-grafting***. The Splice-grafting involves slicing off the terminal part of a twig (varinha/graveto) of about 10cm long in about 3 to 4 cm long and grafting it on top of a seedling that has been topped with a similar cut at a place where it has the same diameter as the graft. It takes about few weeks until the graft has taken off and young plants can be transplanted to the field. Age of the seedling (2 to 10 months old), stage of grafting material (shoots already started a new flush, but they are not too young, after the leaves have lost their pink color, but not fully developed) and timing of grafting (early in the rainy season) are important factors for the success of splice-grafting.

Cleft-grafting involves cutting seedlings in a transverse section and cutting the remaining stem longitudinally. The graft, cut into the shape of a wedge, is put between the two separated parts of the stem of the seedling and then seedling and graft are wrapped with plastic ribbon. Disadvantage is that the opening of the center of the seedling never closes properly. Ten weeks old seedlings are far better than younger and older ones. Scions are the new material (of about 0.3 to 0.4 cm diameter) that is grafted with the unimproved rootstock shoots to produced this grafted material.

following section appraises these options and explores those which are most likely to be selected by farmers in view of the current state of the smallholder sector.

3.1.2 An Appraisal of Feasible Alternative Options to Smallholders to Increase Cashew Production and Quality in Northern Mozambique

There seems to be an agreement among cashew researchers and government officials working in cashew related issues in Nampula that three key priority areas/problems that affect smallholder cashew production and quality in Mozambique for which solutions must be sought are:

(1) the incidence and degree of Odium Anacardium disease (PMD) and the lack of mechanisms to solve it;[11]

(2) economic policy incentives, particularly low cashew producer prices. With liberalization of agricultural prices in 1996, average producer prices increased 8 to 15 percent between 1997/8 to 1998/9, from a low of $0.35 per kilo in 1996/7. The export share of producer price fluctuated between 45 percent to 52 percent during the period of 1996-99 (Mole and Weber, 1999); and,

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[11] For the first time in Mozambique, in 1998/9, a systematic research program started with on-station trials of chemical control of PMD. These trials are to continue this year, including on-farm experiments with the use of sulphur in tree treatment for PMD disease. However, despite the value put on sulphur for PMD control, many agents in the cashew sector have shown concerns over its impact on soil in Mozambique. In Tanzania results show that sulphur-using farmers have shown a higher average harvested cashew output than non-sulphur users (Shomari, 1998). Since 1986 that total imports of sulphur increased substantially. An estimate of about five thousand tons of sulphur in 1996-7 was reported as been consumed and associated with the increase in national cashew production from the low 16 tons in 1986-7 to expected 100 tons of dried cashew nuts in 1997 (Poulton, 1997).

(3) cashew property rights issue. Given widespread fire and theft of nuts, farmers have been concerned about the lack of an institutional framework through which these issues can be resolved. Problems of set fire and theft of nuts do not find a legal framework and other enforceable measures which would give farmers assurance of benefits from growing cashew, particularly in areas where coordination between the traditional and the formal legal system has not managed to function effectively.

As shown above, these problems add to a list of other issues such less care of the cashew tree stock, and lack of consistent research and replanting have lead to the reduction in cashew productive capacity in Mozambique. However, the three areas above are thought to be by far the major causes of declining productivity of the existing stock of cashew trees. Cashew research, extension and multiplication of disease tolerant and more productive material undertaken by a number of NGO's and INIA, the government run research institution and MAP extension network are all part of the efforts at reestablishing the country's lost productive capacity.[12]

Given these circumstances, some cashew researchers at CRP in Nampula have suggested that efforts at rehabilitating the cashew productive capacity in Mozambique should focus on developing improved varieties adapted to local conditions. That is basically, developing and testing varieties which are PMD tolerant or resistant, and high yielding. Although there might not be a consensus with respect to which organizations

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[12] See the "Capricon Survey" National Cashew Survey done by the CAPRICORN CONSULTANTS LIMITED and the report "Cashew Production Development Strategy 1996-2005 by AgrOli-Jose Olivares and Patricia Canon-Olivares; Internet: Olivares@reuna.cl.; 7831 Woodmont Avenue, Suite 318, Bethesda, MD 20814, USA.

carry on the type of research programs needed, there is at least an agreement on the need for a such framework, given the low productivity of the current genotype material, even in the absence of PMD (Paulo de Carvalho, Eliezer Camargo, and Prasad, 1998, personal discussions).[13]

Key informants agree that investment in completely new cashew fields represents a long-term option to existing farmers, provided property rights problems can be realistically faced and resolved. Thus, from option A1 in Figure 3-2, we will ignore long-run problems of property rights, and assume cashew can be expanded by (1) investing in the *regeneration* of existing high potential yielding trees, (2) investing in *new cashew material* on current cashew fields through gapping and planting of new trees and stumping and top-working, and (3) planting trees in new cashew fields.

Crop developers and cashew researchers will recognize that given the heterogeneity in cashew trees status within the same field, farmers will require different technological choices and a set of different on-going management activities to improve per tree production and quality. In doing so, there are alternative options that from the onset are not recommendable to farmers given their problematic nature. For instance, from Figure 3-2, it could not be an improvement to choose gapping and planting, or

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[13] Personal communication. Carvalho is an agronomist from Brazil working for Entreposto Comercial (EC) and responsible for company's cashew germplasm data bank, and on-station cashew trials and grafting in Monapo, Nampula. Camargo is also an agronomist from Brazil working with World Vision (WV) in Nampula in a wide range of research and extension activities. He is responsible for the WV cashew program in Nampula and Zambezia provinces. Prasad is a research fellow with INIA/INCAJU/MAP and have worked extensively in cashew in Nampula. He is now at a research station in the province of Inhambane.

stumping and top-working with, or proceed with new plantings of either dwarf or common variety cashew material that is non-tolerant to PMD and other diseases, particularly in an environment where disease incidence is too high, as it is in Nampula, and in Mozambique as a whole. Therefore, an investment decision on both technology and on-going management packages involving these options is *a priori* not to be considered in the farmers opportunity set.

Furthermore, it is worth mentioning that although spraying and dusting cashew trees may not be mutually exclusive choices, the adoption of say, spraying, can be constrained by availability of water, and making dusting a viable substitute in water scarce areas. In addition, regardless of their environmental effects as mentioned earlier, equipment and lack of credit may preclude the choice of one method in favor of the other.

The choice of new planting in completely new fields may be a costly and risky option for smallholders, given land scarcity and access as well as the unclear property rights over land. Prasad (1998) has suggested that smallholders in Nampula need to consider maximizing the use of the existing cashew fields and improve upon the on-going management practices in order to increase production and quality using available techniques of gapping and replanting, stumping and top-working with grafted and improved material.[14]

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[14] Results from the Cashew Rehabilitation Project (CRP) research programs show that with top-working production begins sooner than other options, and continues for just as long as newly planted material. The technique has a short learning curve. Despite its labor intensity with respect to cutting the trunk for grafting, the earlier fruiting can outweigh the cost of replanting. The grafted trees start producing after one year as

(continued...)

However, despite these seemingly encouraging results, data on farmers perspectives on strategies to increase cashew production in the study area challenges some of these results. Given the labor intensity of top-working and selective thinning, farmers with a large number of cashew trees requiring these techniques are usually the most labor constrained, and choose planting new trees of improved quality as their most natural choice for increasing production. Apparently, these farmers are trying to take into account the opportunity cost of their labor when they consider engaging in these activities, compared to using the labor in food crop production.

The narrowing of smallholder's options to increased production and quality does not mean , however, eliminating long term options. This is important to note because of some prevailing misconceptions about farmer's attitude towards cashew production. Many participants in the cashew industry, particularly traders and government officials have created the idea that farmers are not interested in cashew production, as the reason why they do not take care of the trees. Some traders, for instance, have suggested that cashew trees are "bush trees", they grow on their own, and thus do not required care. Prasad (1998) thinks otherwise. Farmers are interested in increasing cashew production and quality and all they need is institutional support, credit, and better incentives. Evidence of this is the increasing demand for improved seedlings, and new techniques

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[14](...continued)
opposed to 2-3 years that it takes, for example, for a new dwarf plant to flower, or 4-5 years for the traditional variety. Using the trunk of an existing unproductive tree is an advantage over a completely new stock. Thus top-working is the most natural option to smallholder farmers to regenerate the existing tree stock.

needed for a wide range of trees that are now unproductive. Cashew trees are not "bush trees", they do require care and maintenance which implies labor that might compete with other activities in the farm. What needs to be recognized, however, is that cashew is may not be the main crop within the smallholder crop portfolio. Farmers do seem to provide more attention to food crops, but this does not mean they don't care at all about cashew.

Based on recent observations of smallholder cashew fields in Nassuruma area, CRP researchers have reported that a representative farmer with an area of about half of a hectare (slightly above an acre) might have about 21 trees[15] and about 38 percent of these trees are more than 25 years old and produce literally nothing, another 28.6 percent are less than 25 years old, but still do not produce any nuts, another 28.4 percent are producing less than three kilograms per tree but suffer from severe attack of pests and diseases and only five percent of all trees are tolerant to disease and produce above eight kilograms per tree.

As a result, according to CRP researchers the best technical strategy seems to be the following:

(1) all unproductive smallholder trees that are older than 25 should be eliminated, and gapping and planting of improved material selected from Mozambican mother trees with tolerance to diseases and high yielding

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[15] Data from our survey indicates that a representative farm will have about 43 trees in a monocropped field and 27 trees in a mixed cropping field.

capacity used. Then, better management skills will be taught through extension training;[16]

(2) top-working on all unproductive trees less than 25 years;

(3) all less productive trees, but affected by diseases will be protected, meaning will be subject to sanitation,[17] a technique that reduces the canopy to the minimum with elimination of all the "thief branches" in the interior of the canopy. This technique is usually applied three times in a year, for positive results. In addition, other improved management practices will be transferred to smallholders in order to improve trees productivity; and

(4) the trees that are productive and tolerant to diseases will be selectively multiplied using grafting techniques.

INCAJU through its cashew development center in Nampula (Nassuruma research station) has stated that its master research and extension plan will anticipate support and collaboration of NGOs and private companies with interests in the cashew industry. The

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[16] At the time of this research, more than 100 mother trees had been identified from smallholder fields. Despite the fact that the nut size of these trees is small and they are selected from late yielding trees, the material is superior as far as their tolerance to diseases. In addition, dwarf nuts were imported from Brazil which helped to develop cashew material that is suited for local conditions. From this material complete resistance to disease were found, the yields are higher and the nuts are bigger. More than 200 dwarf trees from this material has been identified, but are not currently been multiplied. The material is being used in on-station grafting activities.

[17] During the rainy season PMD is apparently inactive within the tree branches under the canopy. When the dry season approaches PMD spreads out all over the canopy.

plan includes effort towards (1) producing tolerant cashew material, (2) use of chemical inputs to control PMD, (3) on-station trials and training for extension agents and farmers on different techniques such as sanitation, and top-working cashew trees with productive capacity (25-30 years old) by grafting with improved and new material (INCAJU, 1998).

3.2 Conclusions

This chapter has presented the state of knowledge about available smallholder investment and technical decisions with respect to technologies and management practices to increase cashew production. The chapter explores feasible alternatives to smallholders, given the characteristics of current cashew farming systems. Investment options include focusing on provinces and districts where cashew is currently grown, by existing cashew farmers and in existing fields. Given the heterogeneity in cashew tree status or potential, and the high cost to ascertain the tree potential, the best available knowledge suggest that farmers should consider adopting the following strategies:

(1) all unproductive smallholder trees that are older than 25 must eliminated. On these trees, gapping and planting of improved material selected from either local mother trees with tolerance to diseases, and with high yielding capacity must be used with improved management practices;

(2) all the cashew trees that are unproductive and less than 25 years old must be top-worked; and

(3) Diseased cashew trees with reduced productive capacity should be subject to sanitation, and management practices improved.

Given the different labor requirements of these options, and different labor and land availability among smallholder farmers, the options above require further analysis of the farming systems in which they might be applied. The analysis of the farming systems will provide insights about the potential adoption of these techniques and their likelihood of success for the potential diverse group of farmers in the smallholder sector in Northern Mozambique. The next chapter presents data on surveyed smallholder cashew households and proposes a framework within which analysis of options will be examined.

CHAPTER 4

TOWARDS A TYPOLOGY OF SMALLHOLDER CASHEW FARMERS IN THE NORTHERN PROVINCE OF NAMPULA

4.0 Introduction

The government's overall goal is to eliminate poverty by promoting economic and human development on a self-sustaining basis. Given the country's potential for cashew production and its experience and history in the world cashew markets, it is believed that cashew can be used to advantage to achieving such aims. For the cashew industry as a whole that means achieving sustainable increases in nut production and improved quality so as to contribute to rural income growth for the about a million of smallholders growing cashew in Mozambique (Strasberg et al., 1998), and to the country's balance of payments through more export earnings (INCAJU, 1998). More specifically, there is an urgent need for the current smallholder and processing sectors to adopt sustainable technologies which increase nut production and add value, domestically and economically. At the grassroots level, insights about potential differences among households in the smallholder sector may help to identify constraints and synergies which can be integrated into rural development policy statements and strategy design.

As found elsewhere, there are differences across farmers in the relative importance of agricultural and non-agricultural activities given the varying endowments of human and physical capital and access to markets (Simler, 1994). Similar results were found by Marrule et al., (1998) in Mozambique. The authors analyzed smallholder's income, land and cashew trees ownership and found that there two distinct smallholder groups: one which is "relatively less poor" with a larger stock of resources such as cashew trees and land, and relatively high income, and is capable of achieving relatively high levels of calorie intake, and the other group of smallholders with an opposite status. These differences seems to suggest that efforts at promoting agricultural intensification among smallholders who have less land, cashew trees and income may meet with significant difficulties. In these areas, one argument is that increases in agricultural productivity could be achieved indirectly by use of government's scarce resources to support less vulnerable smallholder groups, and by targeting spillover effects to limited resource groups thus achieving rural development with benefits to all farmers. Otsuka and Delgado (1995) presented a similar argument in favor of supporting high-potential areas to increase food production in Africa. These authors argue that efforts should be directed at developing technologies for high-potential areas to increase food production, and through trade reinforce comparative advantage of less favored areas in providing other products to more favored areas.

In sum, the differences described above suggest that more comprehensive policies consistent with the diversity of farmer groups in the smallholder sector are needed before, for example, adoption of improved management practices and alternative technologies can help to boost smallholder cashew production and quality in Mozambique. In this chapter, a summary of sampled smallholder characteristics is presented and then a typology of cashew smallholder farming households in the study area is developed. Before further statistical analysis is undertaken, it is worth recalling that the sample represents a group of households in specific areas of interest, as explained in Chapter One. The derived statistical indicators are meant to describe households in those areas across the districts surveyed, and findings may not be generalized to a range of households outside the study area. When degrees of freedom allow statistical t-tests are used, and to the extent possible the results are compared with findings of other studies in the study area.

The typology to be developed below is based on household level land area per adult equivalent (a constrained labor force approach) and takes into account variations in farming systems due to differences in agro-climatic conditions, availability of land and labor, access to improved agricultural technology, and opportunities for off-farm activities. In the next section we explore the general characteristics of the sampled households at the district level as an input to the following section where typology of cashew farmers is developed using all the households in the sample.

4.1 A Profile of Sample Smallholder Cashew Farmers

Tables 4-1 through 4-4 present summary statistics for smallholders in these three areas. They includes demographic, farm resources and crop patterns variables for the overall sample in each district surveyed in the study area. Each district was selected to represent one agro-ecological zone, and has a different potential for cashew production.

4.1.1 Demographic Characteristics

Food consumption needs, and consequently food security concerns in smallholder agriculture depend to a large extent on the size of the household. The number of members capable of contributing to food production and the amount of land available for cultivation will determine household's own food consumption in the absence of functional food and land markets, and with low purchasing power. On the other hand, output expansion and diversification through extensive cultivation as a policy orientation must take into account these relationships, particularly in Africa, and specially in areas of constrained land access for some households.

As Table 4-1 below shows, the mean size of a smallholder cashew household in the study area is around four members. This household includes 0.8 infants of less than five years old, 1.3 children of ages between six to fourteen years, 0.9 adult males, 1.1 adult females and 0.4 adults over sixty four years of age.[1] Given the distinction that need to be made between household size and family labor force, age composition of family members is an important factor. Family labor force determines labor available (assuming no hired labor) and ability to participate in on- and off-farm activities to generate income and sufficient output for the household's size. Household size and its

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[1] Note that national statistics (MAP/DE/TIA, 1996) indicate that, on average, the size of a rural household in Nampula is about 4.9 members. This included one infant, 1.4 children, 0.9 adult males, 1 adult female and 0.1 adults over sixty four years old. The national average rural household, however, has a size that varies between five to six members composed of one infant, 1.5 children, 1.1 adult males, 1.3 adult females and 0.2 adults over sixty four years of age (World Bank, 1998).

Table 4-1 Demographics and Resource Ownership per Household by District in Surveyed Cashew Areas in Nampula, 1998

Indicators	Districts/Agro-Ecological Zones			Typical Household
	Nacaroa	Mogovolas	Moma	
Demographics				
Household Size	4.69	3.4	4.0	4.2
Household Composition:				
Infants	1.1	0.4	1.0	0.8
Children	1.6	1.0	0.9	1.3
Adult Males	1.0	0.9	1.0	0.9
Adult Females	1.1	1.1	1.1	1.1
Aged	0.6	0.3	0.0	0.4
Age of the head of household (years)	50	54	35	48
Female Headed Households (percent)	6.30	6.30	none	5.00
Resources				
Labor Adult Equivalent (LAE)	2.52	2.19	2.32	2.38
Land Area per Household (ha/hh)	3.32	4.12	2.94	3.49
per LAE (ha/Lae)	1.41	2.04	1.32	1.59
Cashew Trees per Household[1]				
Total	46	69	96	63
in Monocropping	22	52	55	38
Density (trees/ha)	38	45	46	43
in Mixed cropping	24	17	42	25
Density (trees/ha)	19	24	39	25
Number of Households	16	16	8	40

Source: Smallholder Cashew Production Technologies Survey, MSU/MAP food security project, 1998 in Nampula.

1 Note that the actual average number of cashew trees per monocropped field in Nacaroa is 27 , in Mogovolas is 52, and in Moma is 40, while it is 18, 18, and 37 in mixed copping fields in Nacaroa, Mogovolas and Moma, respectively.

structure defines the level of dependency of younger members to the family labor force, and influences production decisions, given the limited/abundant labor. The average age of the head of the household varies from 35 years in the coastal district of Moma to 54 years in the highest cashew producing district of Mogovolas with a weighted average age of head of household across all districts of 48 years. Only about five percent of the households are headed by women which is low when compared to the average 15 percent from national statistics, and the Northern Mozambique estimate (including Zambézia, Nampula, Cabo Delgado and Niassa) of less than 13 percent incidence of female headship (World Bank, 1998). Female headship is to some extent related to the absence of an adult male in the household due to a number of reasons one of which is employment away from the village for extended periods in the year. One possible explanation, and certainly not exclusive for the low female headship in the study area, is the lack of employment opportunities which make males more available for on-farm activities. The destruction of tea processing plants during the civil war in Zambézia Province, Nampula's neighboring province and alternative labor market, and the current economic crisis of the cashew as well as low performance in the cotton processing sectors all have contributed to shrinking the pool of off-farm employment for males in Nampula, as a whole.

A comparison across districts/agro-ecological areas using a statistical t-test at the 95 percent standard confidence interval shows significant differences in household size and number of infant members in the household between the districts of Nacaroa and Mogovolas, and on the number of aged members between Nacaroa and Moma districts. Note that no old members were recorded in any of the households in the district of Moma. There was also significant statistical differences in the head of household's age between these districts, and the latter with Mogovolas district. Heads of households are significantly older in Mogovolas and Nacaroa districts than they are in Moma district.

The implications of household size and head of household's age differentials is that smaller households have high potential for more labor, but since they are led by young heads the likelihood of having fewer cashew trees is high due to the positive relationship of age, heritage and the size of cashew tree holdings (Mole, 1996 *work in progress*). On the other hand, households with older headship tend to have more cashew trees, but also have higher likelihood of lacking household labor resources to take care of trees, although they may have more resources to hire labor.

4.1.2 Resource Endowment

Land, labor and cashew trees are the three main resources to smallholder farmers in the study rural area. As in all cashew growing zones, cashew trees are an investment that generates a stream of income over a long period of time. During harvest, cashew sales provide an opportunity to ease households liquidity constraints and allow satisfaction of household needs. However, when land and/or labor is a constraint, cashew cannot contribute as much to household's income and food security as could be expected.

Data shows that the average farm size in the study area is 3.49 ha per household. For this farm size, each household has on average 2.39 labor adult equivalents (LAE) which results in 1.59 hectares of land per labor adult equivalent(Table 4-1, above).[2] Across districts, land area per household varies from the low 2.94 hectares in Moma District to the highest 4.12 hectares in Mogovolas District. Note that the district of

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[2] It has been shown that cashew growers tend to hold larger farm sizes. In addition, these farmers tend to crop larger food crop areas than non-cashew growers (Strasberg et al., 1998). Thus, having cashew trees seems to be positively correlated with growing more food. This provides important insights on the potential role of cashew in promoting food production and thereby improving food security in rural areas.

Mogovolas has the lowest household size, and also the lowest labor adult equivalents. This implies that on per adult equivalent and per capita basis, the district of Mogovolas is on average better off than any other areas studied. While no significant statistical differences were observed across districts/agr.-ecological areas in household labor adult equivalents, households in Nacaroa District have significantly smaller land area per adult equivalent than the households in Mogovolas District. Despite the smaller sample size, these results compare fairly well with those found by Strasberg (1997) for non-cotton growers in Monapo/Meconta and Care Open areas in Nampula Province. In these areas, an average household held 3.2 and 4.0 hectares of land, excluding fallow land with 2.5 and 2.8 labor adult equivalents, respectively. These land and labor holdings resulted in household land per labor adult equivalent of 1.4 and 1.6 hectares, respectively. Note that cotton is neither a primary nor even a grown cash crop by many households in the area of this study.

In addition to labor and land, an important household asset is the number of cashew trees they own. The data shows that the average number of total trees owned is about 63, of which 38 are located on pure stand fields while 25 are on fields with different food crop mixes.[3] The distribution of cashew trees per household across districts is different and statistically significant between the districts of Moma and Nacaroa, and the latter with the district of Mogovolas. Households in the district of Moma tend to have more cashew trees, both in total as well as under monocropped and

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[3] Note that a recent report indicates 60 cashew trees per household in the province of Nampula (World Bank, 1998), where the current study took place.

mixed cropped fields, than the districts of Mogovolas and Nacaroa. Based on field indicators, the districts of Moma and Mogovolas have more cashew trees per hectare than the district of Nacaroa, both on under mono- and mixed cropping fields. That is, accounting for the current number of cashew trees and the size of the *machamba* that a household own and number of cashew trees on it, the density is higher in Moma and Mogovolas districts. However, these observed differences on density are only statistically significant between the districts of Nacaroa and Moma on mixed cropping fields. Note that a high density for any given field means that shaded land area is greater and cultivation of other crops more limited. A word of caution is that one must keep in mind that Nacaroa District represents cashew growing areas with low potential for cashew production and the district of Moma despite its large number of cashew trees per household, has the smaller number of households in the sample.

4.1.3 Cropping Systems and Patterns of Land Use

On all the fields recorded, nine crops were listed either sole cropped or found in different crop mixes. Overall, 40.2 percent of all fields had food crops and no cashew, and 51.5 percent of all fields had a cashew tree on them. As Table 4-2 shows manioc, peanuts and cashew were grown either sole cropped or in combination with other crops. On average, sole manioc, peanuts and cashew accounted for about nine percent, four percent and 24 percent of all fields, respectively. There was no significant statistical differences across districts/agr.-ecological zones with respect to the proportion of fields under pure standing crops. Mixed manioc with peanuts, beans, and with beans and

Table 4-2 Cropping Systems per Household by District in Surveyed Cashew Areas in Nampula, 1998

Indicators	Districts/Agro-Ecological Zones			Typical Household
	Nacaroa	Mogovolas	Moma	
Cropping Systems	---------- percentage of fields with ----------			
Pure Stand Cropping				
Manioc	5.6	13.9	6.1	8.9
Peanuts	7.0	3.1	0.0	4.1
Cashew	19.7	24.6	33.3	24.3
Mixed Cropping				
Manioc and Beans	7.0	6.2	3.0	5.9
Manioc and Peanuts	1.4	6.2	12.1	5.3
Manioc, Beans and Peanuts	0.0	3.1	0.0	1.2
Cashew with Manioc	8.5	4.6	3.0	5.9
Manioc and Beans	9.9	3.1	3.0	5.9
Manioc and Peanuts	5.6	10.8	12.1	8.9
Manioc, Beans and Peanuts	7.0	4.6	9.1	6.5
Minor Crops	1.4	10.8	9.1	6.5
Vegetables	15.5	4.6	0.0	8.3
Fallow	9.9	4.6	6.1	7.1
Abandonment	1.4	0.0	3.0	1.2
Number of Fields per Household	4.471	4.065	4.133	4.2169
Total Number of Fields				

Source: Smallholder Cashew Production Technologies Survey, Nampula, Mozambique, 1998/9.
Note: There were 40.2 percent of all fields with food and no cashew, whereas 51.5 percent of all recorded fields had cashew trees on them.

peanuts accounted for about 12.1 percent while mixed cashew cropped with either manioc or manioc and beans or manioc and peanuts or manioc, beans and peanuts accounted for a total of 27.2 percent of all fields. Across districts/agr.-ecological zones no significant statistical differences were observed in terms of relative dominance of a given food crop mix and these food crops with cashew as represented in Table 4-2. Minor crops such as sorghum, millet, and rice were grown on about seven percent of the fields while vegetables accounted for eight percent of all fields. The reminder were fields either in fallow or abandoned.[4] The districts of Moma shows a statistically significant larger share of fields with manioc and peanuts, and a lower share of fields with manioc and beans than the district of Nacaroa. No fields with vegetables were recorded in the district of Moma, and no statistically significant differences were found on the proportion of fields either in fallow or abandoned across districts/agr.-ecological zones.

Table 4-3 shows the relative importance of the cropping systems both in terms of percentage of households that cultivate a given crop or crop mix, and the land area allocated to it. In general, in the province of Nampula the farming system is diversified and based on a range of cereals, root crops, fruits and vegetables. Overall, 83 percent of all households interviewed had cashew planted with either one or more food crops. On average, about 30 percent of all households had manioc, 19 percent had peanut and 73 percent had cashew under sole cropping.[5] Differences in relative importance of sole cropping were statistically significant between the districts of Nacaroa and Moma. In the latter there were more households cultivating sole cashew and no peanuts. Mixed cropping of two or more crops was also observed. The most common mixes were of

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[4] Abandoned fields are portions of land that at a given time period a household do not consider suitable for growing crops, often set aside for some reason such as crop rotation.

[5] In vast parts of Nampula province, peanuts are a cash crop, although they are also consumed at home.

Table 4-3 Production Systems and Patterns of Land Use per Household by District in Surveyed Cashew Areas in Nampula, 1998

Indicators	Districts/Agro-ecological Zones			Typical Household
	Nacaroa	Mogovolas	Moma	
Cropping Systems	--------- percentage of households with ---------			
Pure Stand Cropping				
Manioc	18.8	50.0	25.0	29.6
Peanuts	31.3	12.5	0.0	19.1
Cashew	56.3	81.3	100.0	72.8
Mixed Cropping				
Manioc and Beans	31.3	25.0	12.5	25.2
Manioc and Peanuts	6.2	25.0	50.0	20.9
Manioc, Beans and Peanuts	0.0	12.5	0.0	3.8
Cashew with Manioc	37.5	12.5	12.5	24.7
Manioc and Beans	43.8	12.5	12.5	27.8
Manioc and Peanuts	25.0	43.8	50.0	35.8
Manioc, Beans and Peanuts	31.3	18.8	37.5	28.7
Minor Crops	6.3	37.5	35.7	22.2
Vegetables	56.3	12.5	0.0	31.4
Patterns of Land Use	------------------------ Ha per Household --------------			
Food Crops only				
Cultivated Area	0.81	1.46	0.53	0.95
Manioc	0.16	0.47	0.13	0.25
Peanuts	0.16	0.09	0.00	0.11
Manioc and Beans	0.20	0.12	0.03	0.14
Manioc and Peanuts	0.03	0.25	0.25	0.14
Manioc, Peanuts and Beans	0.00	0.13	0.00	0.04
Minor Crops	0.00	0.27	0.12	0.11
Vegetables	0.26	0.14	0.00	0.17
Cashew				
Mono-cropped land area	0.75	1.31	1.16	1.01
Mixed cropped land area	1.29	1.04	1.00	1.16
Manioc	0.50	0.25	0.19	0.36
Manioc and Beans	0.47	0.41	0.13	0.38
Manioc and Peanuts	0.13	0.27	0.31	0.21
Manioc, Beans and Peanuts	0.20	0.11	0.38	0.21
Fallow land	0.44	0.31	0.19	0.35
Abandoned Land	0.03	0.00	0.06	0.03
Number of Households	16	16	8	40

Source: Smallholder Cashew Production Technologies Survey, Nampula, Mozambique, 1998.

manioc and peanuts (21 percent), manioc and beans (26 percent) manioc, beans and peanuts (29 percent) and cashew with one, two or more crops. The major cashew and food crop mixtures were: cashew/manioc, cashew/manioc/beans, cashew/manioc/peanuts/ and cashew/manioc/beans/peanuts.

One important fact to note is that sole cropped cashew is less common in the district of Nacaroa. Note also that there are more households growing cashew in combination with manioc, and manioc and beans than in other two districts. This is not surprising. As a low potential area for cashew production, one would expect that the few trees that a household may own would be under mixed cropping, particularly with the most common crops such as manioc and beans, if the hypothesis of higher yield under mixed cropping holds. Thus this might be both a result of households having less cashew trees, and households been located in less favorable conditions for cashew tree growing.

In the surveyed villages of Nacaroa District, cashew is often grown with manioc, and with manioc and beans, whereas in Mogovolas District villages cashew is commonly grown with manioc, and manioc and peanuts. In the district of Moma, cashew appears often in manioc and peanut fields as well as in combination with manioc, beans and peanuts. However, despite this diversity, statistically significant differences on the relative importance of mixed cropping could only be found between the districts of Nacaroa and Mogovolas with respect to the manioc and cashew crop mix. Minor crops such as rice, sorghum, millet and maize were cultivated by 22 percent of all households while 31 percent had also grown vegetables. Differences on these crops were found to be statistically significant between the districts of Nacaroa and Moma.

In terms of hectarage, land allocation varies according to the relative importance of each crop and crop mixes. Data shows that 87 percent of all households had, on average, cultivated land area of about 0.95 ha with food crops alone. Sole crop manioc and peanuts, and mixed crop manioc with beans and peanuts, minor crops and vegetables were cultivated on areas that vary between 0.11 to 0.25 hectares. Of this area, sole cropped manioc, and manioc mix with beans, and peanuts occupied a larger portion. With respect to cashew land area, each household had approximately two cashew fields. On average, the land area for pure stand cashew was about 1.0 ha while mixed cropped cashew was cultivated in about 1.2 ha per household. Cashew and manioc accounted for 31 percent of the cashew mixed cropping area while cashew mixed with manioc and beans accounted for 32.8 percent, and the reminder 37 percent equally distributed to mixed cropping with manioc and peanuts, and with manioc, beans and peanuts. Land allocation across districts varies significantly with respect to a small number of crops and crop mixes. This might be due to less differences in crop orientation. The number and type of crops grown in each agr.-ecological zone is similar. Significant statistical differences were found only with respect to land area allocated to mixed cropping of manioc and peanuts, and minor crops between the districts of Nacaroa and Moma, and Nacaroa and Mogovolas with Nacaroa villages allocating less area to these combination of crops.

The agro-ecological zone analysis above leads to the conclusion that households in low potential areas such as the district of Nacaroa have less cashew trees per household than those in more favorable districts of Mogovolas and Moma. Most of these cashew trees are under mixed cropped fields. Since these households allocated relatively higher land area to mixed cropping of cashew and food crops, this suggests that with fewer trees per household, households in these areas may be following an optimal strategy by inter-cropping cashew with food crops. Maximizing food crop area by planting a small number of cashew trees in a given field allows more food production, and better and more regular care of the tress. In the following sections we build on these differences and similarities of patterns found at the agr.-ecological zone level in developing a framework of analysis for typical smallholder cashew farms in the study area.

4.2 Towards a Typology of Smallholder Cashew Farms in Northern Mozambique

This section attempts to create a typology of cashew farms by grouping cashew producing households by an aggregate measure of land and own labor availability --- household land per adult equivalent. The goal is to establish the context within which the next chapters will evaluate the economics of alternative technological options available to each group of farmers to increase cashew production and quality.

The development of a typology of farms, particularly with respect to an important asset such as cashew trees for rural households, is an opportunity to explore household diversity, assess their potential responses to policy and to the necessary institutional and technical support needed to improve farming productivity. Cashew trees are productive assets and provide a significant portion of smallholder household income. Previous studies have shown that in the research area, 24 percent of the income comes from sales of cash crops, including cashew (Marrule et al., 1998; and Strasberg, 1997). Cash crops, and the number of cashew trees a household own plays an important factor in the differentiation among households in the smallholder sector. The typology approach to smallholder economic analysis has been used in different occasions and for different purposes (Simler, 1994; Bossier et al. 1994; Sebillotte 1994, and Laurent et al., 1998). The literature stresses the need to analyze diversity in the context of relating economic processes and technical change. For instance, David (1988) stresses this relationship as path dependency, the irreversibility of the innovation process and "technological trajectories" which constraints smallholder's flexibility for conceiving and adopting innovations.

The typology groups cashew farmers by the land area available to each adult labor equivalent in the household taking into account the characteristics already analyzed above. It must be noted that the scale of cashew production as determined by land and labor available is the characteristic of interest. Agro-climatic conditions affect the degree of adaptability of cashew and thus yields, whereas the land and labor determines the scale and management of the cashew orchard.[6] In Tables 4-4 and 4-5 below, each

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[6] Soil type is thought to be the most limiting factor for production than rainfall. Northwood (1962) pointed out often cashew is planted on sands which are insufficiently fertile for annual crops. Cashew is suitable in red fertile sandy loams with sufficient

(continued...)

tercile identifies implicitly one scale type of smallholder cashew farm. Thus, terciles one, two and three will represent a low, medium and high land to labor adult equivalent (L-AE) ratio smallholder cashew farm. In addition, households in the low L-AE farm category will be considered as relatively poor, particularly with respect to the land area per adult equivalent as compared to households in the upper farm categories. All the analysis to follow is based on a full sample of 40 households and statistical analysis is conducted within the standard 95 percent confidence interval. The next section presents farm type characteristics with respect to demographics and structure of the households within it, resources, and cropping systems all of which are based on a pooled sample and stratified as explained above.

4.2.1 Household Size and Structure

Table 4-4 presents a summary of statistics pertaining to the three types of smallholder cashew farms: low, medium and high categories. A typical cashew farm in this typology has a household of about 4.2 members, of which 0.8 infants, 1.3 children, 0.9 adult males 1.1 adult females and 0.4 aged members. Across farm category comparisons indicates that households in the low L-AE farm category are statistically

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[6](...continued)
drainage where it produces economic yields. Lack of water is a factor in yield reduction. Long periods of below average rainfall affect a number of trees which loose leaves and production may reach up to 40 percent less the normal. Under good rains production can double from 8 pounds per tree, when trees recover their vigor. Dry season storms during flowering and fruit-settling period/season also reduce yields. In general in warmer, more humid and higher rainfall (40-50 inch.) areas cashew grows faster and produces heavy yields when management is good.

Table 4-4 Size and Structure, and Resource Availability for Low, Medium and High L-AE Smallholder Cashew Farmers in Surveyed Cashew Areas in Nampula, 1998

Indicators	Smallholder Cashew Farm Category by Land per Adult Equivalent (L-AE)			Typical Farm
	Low	Medium	High	
Demographics				
Household Size	5.0	3.6	3.8	4.2
Household Composition				
Infants	1.1	0.5	0.9	0.8
Children	1.8	1.1	0.9	1.3
Adult Males	1.1	1.0	0.8	0.9
Adult Females	1.1	1.1	1.1	1.1
Aged	0.3	0.4	0.2	0.4
Age of the head of household	41	46	59	48
Resources				
Labor Adult Equivalent	2.73	2.40	1.92	2.38
Land Area *per* Household (ha/hh)	2.65	3.35	4.65	3.49
per Labor adult equivalent (ha/hlae)	0.95	1.39	2.57	1.59
Cashew Trees per Household				
Total	48	73	69	63
in Monocropping	24	51	39	38
Density (trees/ha)	45	46	37	43
in Mixed cropping	24	23	28	25
Density (trees/ha)	22	28	27	25
Number of Households	13	15	12	40

Source: Smallholder Cashew Production Technologies Survey, Nampula, Mozambique, 1998.

larger than the medium, but not statistically different from the households in high L-AE farms. In general low L-AE farms tend to be led by significantly younger heads of households and to have slightly more children and aged members than other farms.

Although the dependency ratio is higher on high L-AE farms, the burden for low L-AE farms is high given the limited resources available to them to feed a large household.[7] As will be shown below, these younger households tend to be resource poor in terms of total land and cashew trees across farm types.

4.2.2 Land, Labor and Cashew Trees

In previous sections it was suggested that land, labor and cashew trees make a difference among smallholders in rural areas. The average farm size in this typology is 3.49 hectares per household. However, there are significant differences in farm size across farm categories. Households in the low L-AE farm category own statistically less land area in total, and more labor per adult equivalent. As a result, these households also have significantly less land per adult equivalent. With respect to cashew ownership, a typical smallholder cashew farm owns on average 63 cashew trees of which 38 are on pure stand fields and 25 are on fields with food observable at the cropping system level. That is, farms in the low L-AE category have statistically less cashew trees under monocropped fields than medium and high L-AE category. Note that while low L-AE farms have the same proportion of their trees under both cropping systems, other farm categories have more trees under monocropping. Note also that mixed cropped fields

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[7] A poverty report "Pobreza em Moçambique: Perfil, Determinantes e Implicações para as Políticas", Ministério do Plano e Finanças (1998) indicates that poor households tend to have more children and infants than other households. That is, there is a high dependency ratio among the poor, given that the number of adults in the household is not significantly different across groups.

have fewer cashew trees across farm types. Furthermore, the data shows no significant statistical differences in tree density across farm categories, except between cropping systems whereby monocropped fields have a higher density than mixed cropped fields across farm categories. This shows that farmer's attitude towards risk can effect cashew's relative importance within the farming system.[8] To maximize space for food crops in cashew mixed cropping fields, having fewer trees per land area is an important strategy for more diversified agriculture, particularly where land access is a problem. This suggests that production of more food crops, for say, food insecure households forces an optimization of space on existing plots. With missing food markets for some of these farmers, food security can only be guaranteed with own production. If households have constrained access to land, fewer cashew trees on a given land area may be an optimal strategy.

An analysis of household member's participation in agricultural activities shows that 61 percent for all members in low L-AE farm category participate in cashew and other agricultural activities compared to 70 percent in medium to high L-AE smallholder farms (Table 4-5). Thus, the implication of the above findings would suggest that with relative excess of labor and low participation in agricultural activities, household members on small scale farms have the potential to participate in rural labor markets,

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[8] Note that small farms allocated a smaller proportion of land area devoted to cashew production to monocropped cashew than any other farm type (28.5 percent as opposed to 58.2 and 48.9 percent for medium and large farms, respectively).

particularly in working for better off farms which lack labor to take care of their cashew trees.

To summarize, the data shows that relatively poor cashew farmers tend to have less land per labor adult equivalent and fewer cashew trees across farm categories. That is, relatively poor cashew owning households are characterized by relatively less land and cashew trees, and relatively more labor. In contrast, there are households in the high L-AE farm category that are relatively better off in terms of land both in total and on a per adult equivalent basis.[9]

4.2.3 Cashew Cropping Systems

Table 4-5 shows that sole cropping of food crops is mainly in manioc and peanuts, whereas mixed cropping places cashew with manioc, beans and peanuts. On average about 30 percent and 19 percent of the households cultivate manioc and peanuts, respectively, as sole crops. Cashew is also grown as a sole crop by about 73 percent of the households. Few low L-AE farms grow sole manioc and few high farms grow sole

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[9] Similar analysis within each agro-ecological areas shows that across these areas farmers in the high potential zone are relatively better off in terms of land both in total and on a per adult equivalent basis. However, these farmers have less labor force per household when compared to farmers in low and medium potential areas. With exception of Moma, low potential areas and poor households have less land and cashew trees, but relatively more labor and thus less land per adult equivalent. In addition, given the low number of cashew trees in low potential zones, for the households in this area poverty seems to be pervasive because cashew cannot contribute to income as a cash crop, as much as it does in high potential areas..

Table 4-5 Patterns of Land Use Low, Medium and High L-AE Smallholder Cashew Farm Categories in Surveyed Cashew Areas in Nampula, Mozambique, 1998/9

Indicators	Smallholder Cashew Farm Categories by Land per Adult Equivalent (L-AE)			Typical Farm
	Low	Medium	High	
Cropping Systems	---------- percent of households with ----------			
Sole Crops				
Cassava	8.5	33.5	50.4	29.6
Peanuts	25.5	20.3	10.2	19.1
Cashew	74.5	85.3	56.8	72.8
Mixed Crops				
Manioc and Beans	25.5	22.2	29.2	25.5
Manioc and Peanuts	14.2	13.2	37.7	20.9
Manioc, Beans and Peanuts	5.3	0.0	6.4	3.8
Cashew with Manioc	25.5	25.6	22.9	24.7
Manioc and Beans	41.1	9.0	33.1	27.8
Manioc and Peanuts	37.9	48.5	19.1	35.8
Manioc, Beans and Peanuts	31.2	27.8	26.7	28.7
Minor crops	20.9	20.7	25.4	22.2
Vegetables	42.6	14.7	36.9	31.4
Patterns of Land Use	------------------ Hectares per Household -----------------			
Food Crops only				
Cultivated Area	0.68	0.78	1.47	0.95
Manioc	0.09	0.28	0.40	0.25
Peanuts	0.13	0.13	0.05	0.10
Manioc and Beans	0.10	0.17	0.16	0.14
Manioc and Peanuts	0.07	0.09	0.28	0.14
Manioc, Peanuts and Beans	0.05	0.00	0.06	0.04
Minor crops	0.09	0.07	0.18	0.11
Vegetables	0.15	0.04	0.34	0.17
Cashew				
Mono-cropped land area	0.49	1.36	1.22	1.00
Mixed cropped land area	1.23	0.98	1.27	1.16
Manioc	0.29	0.43	0.35	0.36
Manioc and Beans	0.41	0.09	0.67	0.38
Manioc and Peanuts	0.22	0.31	0.08	0.21
Manioc, Beans and Peanuts	0.31	0.15	0.17	0.21
Fallow Land	0.19	0.20	0.69	0.35
Abandoned Land	0.04	0.04	0.00	0.03

Source: Smallholder Cashew Production Technologies Survey, Nampula, Mozambique, 1998.

peanuts and these differences are statistically significant. However, mixed cropping manioc with beans, and cashew with one or more food crops is statistically more common in low L-AE farms than it is in medium to high L-AE farms. It was also observed that mixed cropping of manioc with beans and peanuts is less common than any other combinations across farm categories. One possible reason for this is given that peanuts are a cash crop and have a shorter cycle, farmers may be forced to reduce the long cycle bean density in order to maximize returns to resources for the shorter cycle peanut crop. This suggest that farmers may be willing to forego beans to maximize space for peanuts, by growing mixes of either manioc with beans and no peanuts, or manioc with peanuts and no beans.

With respect to mixed cropping of two or more crops, the most commonly found are manioc with beans(26 percent), manioc and peanuts (20 percent), and cashew with one, two or more crops. The major cashew crop mixes are often cashew, manioc and peanuts (36 percent), cashew, manioc, beans and peanuts (29 percent), cashew, manioc and beans (28 percent), and cashew and manioc (25 percent). With exception of mixed cropping of cashew with manioc and peanuts, low L-AE farms seem to be more likely to mix crop cashew than high L-AE farms. As for minor crops such as rice, sorghum, millet and maize no statistically significant differences across farmer categories are observed.

In terms of hectarage, an average cashew farm would have 0.95 ha under food crops alone. Of these amounts of land, peanuts would account for 0.10 ha while sole manioc, the main crop in the study area would take up to 0.25 ha, and its combination with either beans and/or peanuts would occupy 0.42 ha. Finally minor crops like sorghum, rice and millet and vegetables are grown in areas of 0.11, and 0.17 hectares per household, respectively. The data shows that, in terms of acreage, high L-AE farms allocated far more land to food crops with no cashew than low L-AE farms. These differences are statistically significant. In addition, of the total area devoted to food crops and no cashew, sole manioc ---the main staple food, in the study area--- is the larger portion in high L-AE farms than it is in low L-AE farms, followed by vegetables, and the combination of manioc and peanuts, and manioc and beans.

Some important facts in Table 4-5 worth mentioning are the fact that where peanuts are grown sole, low L-AE farms allocated more land than high L-AE farms. However, when peanuts are mixed cropped either with manioc or manioc and beans high L-AE farms allocated more land than low L-AE farms. Furthermore, where cashew is mixed with any other crop other than peanuts, high L-AE farms allocated more land area than low L-AE farms. Whereas where peanuts and cashew are mixed with any other crop, low L-AE farms allocated more land area. High L-AE farms also allocate more land area to both mono- and mixed cropping of cashew than smaller farms. Given that high L-AE farms have also a larger area devoted to food crops alone, they have a larger total area on food crops which suggests that they are likely to produce more food than low L-AE farms. As for low L-AE farmers peanuts are the only cash crop these farmers can grow with the limited land area they have available. However, given that cashew provide cash at a period when peanut harvest and marketing are over, a few trees scattered in a small plot, may be sufficient to cover for some liquidity constraints in times of difficulties. This explains part of the peanuts *vs.* cashew orientation differences between low and high L-AE farms. Land in fallow and abandoned do not show any significant statistical difference across farm groups. This is to be expected given the scarcity of land and difficulties in access to land.

In summary, it seems clear that mixed cropping and particularly of manioc with beans and peanuts, and combinations of either one or two of these crops with cashew is more important for low L-AE farms than it is for other farm categories. The extent of importance of mixed cropping by poor households supports the observation that with a smaller landholding, diversification is a common mechanism to reduce risk of crop failure. That is, given the smaller total land area, the opportunity cost of land on mono-cropping is too high. Risk reduction can only be dealt with by mixed cropping to meet household needs in food consumption. In terms of land use, there are no significant differences in the number of fields per household within and across agro-ecological zones although the farm size is smaller for poor households than for less poor households. Land and number of cashew trees per household are positively correlated.[10] That is, farmers with more land have more cashew trees, particularly trees in pure stand fields. Nonetheless, it is important to note that despite this positive correlation between land area and number of cashew trees, the density of cashew trees is very different on both monocrop and mixed crop fields across all farm categories.

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[10] This finding is consistent with national statistics which indicate that in Nampula for instance, on average farmers with fewer cashew trees per household fall mostly within the smallest farm size category, likewise farmers with more cashew trees tending to fall within bigger farm size (Strasberg, Mole and Weber, 1998).

4.3 Conclusions

This chapters has provided background information on a typical cashew producing household in the study area. The description of the farming system in cashew producing zones has been presented and provided sufficient information to develop a framework of analysis of the smallholder cashew sector.

The typology developed above suggested that there seems to be micro level diversity among smallholder cashew farming households, and this will likely have important advantages for policy making and strategy design. The diversity results from the skewed distribution of economic status of farmers particularly with respect to access to productive assets such land and cashew trees. Recognizing this diversity and keeping in mind that there are no universal solutions, but a range of policy targets and technology options, may help avoid the exclusion of some farmers due to ignorance of their specific constraints.

It was noted that central to this typology approach was the amount of land area per adult equivalent which defined the smallholder farm categories in this analysis. Differences across groups in resource endowment, including the number of cashew trees by cropping system, the number of cashew trees owned, and differences across potential zones for cashew production were examined. The analysis has shown that there are variations in household land and patterns of land use, as well as labor availability both across agro-ecological zones and across farm categories. An important conclusion to this analysis is that poor farmers who are often small by the number of cashew trees, have often less land in total and in per labor adult equivalent basis, but they are relatively labor abundant. The degree of members participation in cashew and other agricultural activities in low L-AE farms suggests that households on these farms have the potential to participate in rural labor markets given their relative labor surplus and high dependency ratio. That is, with relatively larger household size and potential for bigger labor force, low L-AE farms have more members to feed for the same number of adults who are able to participate in agricultural activities than relatively larger farms. As a result, with less land and less cashew trees, low L-AE farm are more vulnerable and less capable to engage in riskier activities.

Overall, the typology analysis above seems to suggest that the degree of farmers differentiation is not determined solely by differences in agro-climatic conditions, but by constrained access to resources such as land as suggested elsewhere. With limited land, more trees can be brought into production by increasing the density whether fields are sole cropped or mixed crop which may limit food production in mixed cropped fields. The next chapter builds on the patterns observed above and develops a model to estimate cashew yield per tree. The model will provide insights in per cashew tree yield differences across farm categories, densities, and cropping systems. These insights will help in developing the framework to analyze the profitability of crop enterprises as they form the basis for the examination of farmer's potential technological options to increase cashew production on existing fields.

CHAPTER 5

FACTORS AFFECTING SMALLHOLDER CASHEW TREE PRODUCTIVITY IN NORTHERN MOZAMBIQUE

5.0 Introduction

Cashew (*Anacardium occidentale*) is a native of Southeastern Brazil from where it was introduced during the 16th century to other countries. Today, the largest world producers are India, Brazil, Mozambique and Tanzania. To a large extent, cashew was initially planted for purposes of checking erosion on the coastal areas in India (Sekar and Karunakaran, 1994), and in Mozambique (Leite, 1995), but later it became an important crop, particularly for poor farmers in rural areas (Tsakiris, 1967; Leite, 1995; and Ramalho, 1963). Cashew possesses genotype and phenotype characteristics which makes its yield variability between trees and seasons one of the most difficult factors in research, particularly in breeding and improvement of cashew management practices (Neto and Caligari, 1997). For instance, research on-station with clones and individual trees in Mozambique and Tanzania has shown that relatively higher cashew yield variances are associated with seasons of decreased management, whereas low variability is positively correlated with 'good' years.[1] These insights suggest that improved management practices can be highly rewarding, despite natural and biological variations across trees and seasons (Neto et al, 1994).

[1] Trial findings from the Ricatla Cashew Research station in Mozambique, and the Naliendele Agricultural Research Institute in Tanzania.

This chapters presents four yield models which examine hypothesized factors affecting cashew tree yields in smallholder fields in Northern Mozambique. A brief survey of relevant literature is presented exploring the determinants of cashew tree productivity, followed by a theoretical and empirical model specification, and then estimation, and analysis. The chapter ends with conclusions on the relevant factors affecting cashew tree productivity and implications for research, and for farmers' incentives to invest more resources into cashew production.

5.1 Theoretical Review

Despite the profuse nature of cashew flowering, the yield potential of a cashew tree can be observed from the degree of flowering and fruiting.[2] There are, however, a number of genotype and environmental factors that influence tree yields, including soil fertility, moisture, management, and pests. There seems to be little, if any, variations in genotype factors among smallholder cashew trees, whereas, environmental factors vary across different agro-ecologies in Mozambique. Cashew, a drought tolerant crop is grown in a variety of agro-ecological conditions. Often, cashew is found planted on poor soils not suited for other crops. As long as soils are deep and freely drained, cashew responds favorably to high levels of organic matter and mineral nutrients. In these soils, cashew growth is distinctive, and mature tree yield differences are less marked because trees can send their roots further down for nutrients (Northwood, 1962; and Opeke 1982).

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[2] On average, at a given flowering period, only one tenth of flowering sets to yield fruits (Ohler, 1994; and Opeke, 1982).

In addition to soil type, rainfall level and its distribution along the season are important factors thought to affect yield. High rainfall in general is good for cashew, but at specific times it is not particularly favorable due to the easy development of fruit rot under high rainfall and humidity conditions.[3] At the same time, lack of water can reduce yield. Long periods of below average rainfall make cashew trees loose their leaves and production can be up to 40 percent less than normal. With good rains trees recoup vigor and production can double. It is reported that rainfall levels must be around 900-1,100 mm annually and must also be evenly distributed over the nine to 10 months of its growing season (Opeke, 1982). Despite fruit rot and the high probability of *Helopeltis* attack due to extra moisture during the wet season, varying rainfall patterns seem to some extent to be related to the biennial bearing characteristics of older cashew trees. Another critical natural factor for cashew development is direct insolation, clear or cloudless skies. While these factors favor cashew production, excessive overcast skies and wind storms, have a negative effect on cashew yields (*ibid.*).

An additional natural factor with some effect on yield and harvest timing is altitude. Higher altitudes seem to put back the main harvesting period by about one to two weeks. Altitude above 1,200 m have a negative impact on yields (*ibid.*). Note that one of the sites for the present research (Nacaroa) is located in such an area where cashew harvest starts as early as July-August. The cashew biological cycle in the study area starts with the red flushing of new leaves on about June/July, followed by panicle

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[3] Often the fruit rot before ripening as a result of fungal damage, particularly in high rainfall areas. This conditions has been known as *fruit rot*.

emergence from July onwards. Some late flowering is observed in October which leads to the second flowering and expansion of the harvesting period to late January. However, harvesting starts in late September and early October, and persist throughout until February, with a first nut production peak between October and November, and second in January. According to Nathaniel (1994) the apple quality of the second flowering season is usually poor, which suggests that the nut quality may be of poor quality as well.

The major difference in cashew tree yields, however, seems to come from differences in temperature along the season and across regions, rather than from altitude. Under improved management practices cashew grows very fast and produces heavy yields in warmer, more humid and higher rainfall areas. It seems that ideal temperatures are in the range of 24 to 29 degrees centigrade with a maximum of 35 degrees centigrade, despite the fact that dry season storms during the flowering and nut/fruit settling period may reduce yield in these areas. Given that often these climatic conditions are found in the coastal areas of Mozambique, it has been suggested that the coastal areas are potentially the most suitable areas for cashew production (Northwood, 1962; Opeke, 1982; and Jeff Hill, 1998, personal communication). However, as reported earlier, under this environment *Helopeltis* attacks are frequent and this requires prevention measures. Hence it is necessary to study whether the additional gains in yield in these locations may outweigh the cost of preventing or fighting the insect.

As it was in Tanzania, improvements in tree and field management practices will have the most significant influences on tree yield and overall production in the next five years in Mozambique (Topper and Caligari, 1998; and INCAJU, 1998). However, it seems unlikely that improved management practices will have significant impact on yield, if disease control strategies are not in place. The negative effect of disease incidence on yield is compounded by planting density and spacing, particularly high grouping density when trees mature at irregular spacing (Tsakiris, 1967). For example, yields at close spacing of 20 ft. by 20 ft. are higher in the first fruiting years, but decline considerably over the years as trees become less vigorous and canopies compete with one another. The main reason is the excess demand for evapo-transpiration over water availability, as competition for water and nutrients rises, and canopies of adjacent trees overlap (Dagg and Tapley, 1967).[4] As the canopies overlap, fewer panicles and thus nuts are set and increased shading improves powder mildew disease (PMD) survival conditions (Topper et al., 1999).

These findings suggest that spacing and thinning, and thus labor into these activities, are crucial factors/determinants of cashew yield. It also indicates that pest and disease are two other factors with strong negative impact on yield. Research has shown that PMD incidence is probably the most serious disease in cashew production, and the primary cause of low yields in Mozambique.[5] In addition to PMD, there are cashew trees

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[4] It has been estimated that lateral spread of the cashew root system is approximately twice that of the canopy ground coverage, and for a six-year old tree the root system would interlace at 40 ft intervals and meet at 50 ft. (Tsakiris and Northwood, 1967).

[5] PMD spores are wind-spread and germinate at humidity of 90-100% and at an optimum temperature of 26-28^{0} C. PMD develops annually as an epidemic during the dry season (Castellani and Casulli, 1981). The disease affects young growing tissues on all aerial parts of the tree, but the most serious effect comes from infection of the flowers

(continued...)

which apparently are not affected by PMD, but have negligible yields due to what is known as "*black panicle syndrome*" (BPS). Flowers from trees affected by BPS are borne on long, thin, and blackened panicles with few lateral branches of pale colored leaves. Flowers dry out naturally to a brown color, rather than grey/black as is the case of PMD attack (Topper et al, 1999).

Other factors which contributes to low yields in the study area are fire and sucking pest damage from *Helopeltis spp*. Damage from fire is also considered to be a major problem and to some extent has a strong negative impact on new cashew planting, given the lack of sufficient economic incentives and institutional innovations within the current legal system to better enforce property rights, and thereby provide incentives for newer smallholder tree investments. *Helopeltis* damage causes black lesions on panicles and new shoots which leads to its death and thus yield loss. It is believed that there is a high level of PMD incidence and other diseases across most of Mozambique's cashew growing areas, and there seems to be relatively little variation within villages in the study area. The potentially major differences might be across agro-ecological zones, especially in areas with great variation in rainfall patterns and temperature (Jeff Hill, 1998, personal communication).

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[5](...continued)
which are often killed by the disease failing to set nuts. Diseased trees often produce very little or have no yield at all.

The following section presents results and estimates of cashew tree genotype factors contributing to yield from on-farm control and treatment trees in several sites in Nampula Province as well as estimates from our survey sites.

5.2 On- and Off-Farm Parameter Estimates

This section estimates yield per tree based on panicle and nut counts. First, results from experiments (both on- and off-farm trials) in Nampula province are presented and serve the purpose of comparison with results from panicle and nut counts from our survey. These indicators are drawn from research undertaken by Topper, Caligari and Bobotela (1998-99) under financial and material support of the AMIS II project of the USAID mission in Maputo, Mozambique, with field technical supervision from the World Vision NGO.

Table 5-1 shows mean values of actual yield from the trial sites, and three parameter measurements that are used to estimate per tree yield based on nut counts. The three parameter estimates are the mean canopy diameter, mean nut count per square meter, and the mean nut weight of clean nuts all taken from sampled trees in on- and off-farm site experiments, and the survey area of this study.

Experiment subjects were *common* trees from Nassuruma, Geba and Monapo districts in Nampula Province, with the exception of one trial in Monapo which involved Brazilian *dwarf* varieties. Common or traditional is the current cashew variety owned by all the smallholder subjects of this research. The data that is most relevant and

Table 5-1 Results and Estimates from On- and Off-Farm Experiments with Common and Dwarf Cashew Varieties in Nampula, Mozambique, 1998/9

Indicators	Sites of the Cashew Crop Protection Trials in Northen Mozambique				MAP/FSP area
	Trials with the Traditional Common Variety			Brazilian Dwarf	
	Nassuruma [a]	Geba [b]	Monapo [c]	Monapo	Traditional Common Variety
Canopy diameter (meters)	13.00	10.86	6.62	5.10	8.03
Mean nuts per m^2	na	na	15.40	13.80	5.25
Mean nut weight (g)	na	na	6.74	8.10	5.70
Yield		-------------------------------- (kg/tree) -------------------------------			
Treatment					
Anvil	2.86	2.20	na	0.24	na
Bayfidan	2.45	2.46	na	0.32	na
Sulphur	2.22	2.02	na	0.31	na
Estimated Yield from Control Areas	0.35	1.12	3.60	0.26	1.15 [d]
Estimated Yield from Treatment Areas	4.00	3.00	7.20	4.50	na

Source: Topper, Maddison and Bobotela (1999) "Final report on the Cashew Crop Protection Trials in Mozambique, 1998/99 and Smallholder Cashew Production Technology Survey, 1998/99.

a Yield data is actual yield from output collection and weighting on trees subject to treatments and control observation.

b Estimated yield data is from nut counts on trees subject to treatment whereas treatment and control yield was not attempted due to theft of nuts in the trials.

c Estimated yield is an estimate of actual yield data.

d This is an estimate of the mean yield from our survey sites based on panicle and nut counts.

na = not available

comparable to this study is from the experiment in Monapo where yield is an estimate based on similar data collection and computational methodology. Data for yield estimation was collected using the square meter method. A square meter frame is built and randomly placed on the northern and southern sides of the canopy of each sampled tree to record inside the square the number of panicles and nuts the tree was able to set. Two samples were taken twice from each tree from the onset of fruiting to the peak harvest period. In addition, measurement of the canopy diameter is recorded and used later to estimate the tree yield.

Two adjustments in yield calculations were made, given the natural and significant variability in yields per canopy surface area from trees within a given field, even under disease control, good management, and sparse tree planting. First, cashew nuts do not yield evenly across canopy surface, and secondly not all the nuts set have the same probability of maturing. These adjustments need to be reflected in yield calculations. Following research advice, two adjustments were made in our calculations at the 75 percent chance for both surface coverage and fruit maturity. That is, we assumed that there is a probability of 75 percent that the canopy area will be as productive as the sampled square meter area used for the nut counts, and the same probability that the sampled nuts would have had produced mature apples/nuts. In addition to these adjustments, each clean nuts was assumed to weight on average 5.7 grams. This is a standard factor used in similar calculations. The formula used to estimate the yield per tree is as follows:

$$Yield_j = (\gamma + \varphi) * \Psi * Cad_j^2 * N_w * CA_p * NA_p \qquad \textit{Equation} \quad 5{:}1$$

where:

$Yield_j$	is the estimated yield of j[th] tree (in grams) from the nut count,
γ,φ	are the maximum mean nut counts from the northern and southern side of the sampled tree, respectively,
Ψ	is equal to $\pi/4$,
Cad_j	is the mean canopy diameter of the j[th] tree,
N_w	is the mean nut weight on the nut count,
CA_p	is the probability that the canopy area will be as productive as the square meter sampled area used for the nut counts, and
NA_p	is the probability that the sampled nuts would have produced mature nuts/apples.

Equation 5:1 above generates mean yield per tree data for the 216 trees initially sampled for the present study of determinants of cashew tree productivity. This data is represented by the $Yield_j$ variable in the next sections on yield model specification and estimation for 205 trees actually included in the analysis.

5.3 The Cashew Tree Productivity Model Specification

Given that inputs and labor time for improved cashew management practices and thus yield is made on a per tree basis, the model is built and estimated at the tree level. Further analysis in the forthcoming chapters will be conducted on per hectare basis, although the starting point will always be at the tree level. The equation used for the cashew tree productivity models is as follows:

$$Yield_j = f\,(Geno_f\ ;\ Nat_f\ ;\ Farm_f\ ;\ Vill_j\ ;\ Inte) \qquad \textit{Equation}\ \ 5{:}2$$

where:

$Yield_j$	kgs of raw nuts per tree,
$Geno_f$	are some genotype factors which include the number of panicles set ($Nupa_j$) and a phenotype disease status variable ($Disea_i$), for j=1,...n and i=0,1.
Nat_f	are natural factors including soil type (So_j), altitude of the field (Alt), rainfall levels (Ral), rainfall distribution (Rad_j), and intensity of rain (Intra), for j=1,...m.
$Farm_f$	includes whether the tree is in a mono- or mixed cropped field (Sys_i), density or the number of cashew trees per hectare (Dens), the number of AE labor days applied per tree, excluding harvest (Labt), and the farm type category ($Categ_j$) for i =0,1 and j =1,2, and 3.

$Vill_j$ a dummy location variable(=1 for j^{th} village, and =0 otherwise) for the five villages of the study, and

Inte an interaction variable of farming factors.

As will be observed in Tables 5-5 and 5-6, Equation 5:2 above is used to estimate three models using the random-effects GLS estimation procedure. The models are estimated at the field/tree level, and parameter estimates are elasticities of each independent variable with respect to changes in cashew yields. The main purpose of these models is to explore the impact of both farm and field level characteristics on cashew yields. Therefore, to the extend possible variables at the household and district level are included in the models. Village dummies included in some of the models seek to capture geographical and unobservable village-level factors with impact on cashew yields. In Model I rainfall information is excluded to avoid its multicolinearity with the village dummy variables. That is, rainfall data was recorded at the district level in which villages are located. As a result, these data are highly correlated with village characteristics summarized by the village dummy variables.

Similarly, Model II does not include village dummies variables which are correlated with district/village level rainfall data. Model III is an expansion of Model II and introduces a number of interaction variables. Of particular interest are: (1) the interaction of density with the cropping systems, farm L-AE categories, and village dummy variables; and (2) the interaction of labor with farm L-AE categories and village dummy variables. With respect to density the hypothesis is that high density in a given field would lead to yield loss due to overcrowding of trees. The farmer's overall loss will be higher in a mixed cropping field because of the reduction in cultivation area for food crops. It is worth mentioning that yield loss increases with increased shade area, which improves conditions for the development of PMD. Therefore, the interaction between density and cropping system is expected to have a negative effect on yield. These effects will be different depending on farm L-AE category and geographical location.

Labor is another variable of interest. As will be shown in Table 5-4, low and high L-AE farms allocated relatively more labor per tree to mixed cropped cashew fields than they did to trees on monocropped fields. Medium L-AE farms allocated about the same amount of labor per tree on both monocropped and mixed cropped cashew fields. However, overall survey data shows that cashew received very little attention as compared to other crops. As in the case of density, the labor effect on yield will equally vary depending on farm L-AE category and village.

Variables used in each model are described in Table 5-2 and their likely impact on yield is discussed below before the estimation of the actual models is undertaken using linear regression methods. Table 5-4 presents summary statistics for the variables used by farm types and cropping system.

5.3.1 Genotype and Phenotype Factors Affecting Yield

Genotype and phenotype characteristics of the cashew trees are represented in the equations by the number of panicles set ($Nupa_j$) and disease status ($Disea_i$). As suggested above, the number of panicles set proxies for the potential of the tree to set and mature fruits/nuts provided that the degree of overlap is lowered, and the probability for nuts set to mature is high. Thus we expect that at a given probability, a disease free or at least at some level, an increase in the number of panicles set ($Nupa_j$) will lead to an increase in yield.

Within this group of factors an important biological constraint on cashew nut production is the degree of disease tolerance or resistance. In the model a disease status binary variable ($Disea_j$) is used and includes disease type and other tree conditions as observed during panicle and nut counting visits to farmer's fields. On each sampled tree where nut counts were recorded, panicles were observed for signs of any abnormalities, including disease, fire or sun damage which could prevent the maturing of the fruit/nut. It is expected that high incidence of these factors will greatly reduce yields.

5.3.2 Environmental Factors Affecting Yield

Natural conditions including soil type (So_j), altitude of the field with respect to the sea level (Alt), rainfall levels (Ra_j) and its distribution (Rad), and intensity (Intr) are included as explanatory variables. It was noted earlier that the soil type and moisture levels have an effect on yield. Moisture levels are related to disease incidence and are expected to be captured by the effect of variables such as rainfall and altitude. While trees in loamy sandy soils and within moderate moisture levels are expected to have a positive effect on yield, this impact may be reduced by the current levels of disease incidence in the study area. It should be noted that data from this study is not from an experimental design, results reflect untreated cashew trees as they are found in farmers fields.

5.3.3 Farming System Factors Affecting Yield

As Joseph (1987) pointed out, smallholder farming systems are characterized by mixed cropping of perennials crops and a number of other annual crops. This pattern of cultivation caters to both cash and food needs from owned small plots, and matches the smallholder attitude towards risk and uncertainties that characterized the smallholder sector. Often, when food markets are unreliable, farmer's labor earnings and cash crop proceeds cannot be easily converted into needed food purchases, and farmer's may shift their priorities towards food production, and in some cases this may preclude cash crop production. The practice of inter-cropping or mixed cropping with trees has shown a number of advantages for farmers. In cashew production, it helps to keep the groves clean due to regular maintenance of food crops vital to farmer's food security. Although there are no conclusive findings with respect to the effect of mixed cropping on cashew yields, there is however some evidence that cashew tree yields on mixed cropping fields tend to be high than those in monocropped fields (TIA 96). This seems to be a composite effect of better care and age of the trees, given that most of the fields with sole cropped mature cashew trees are no longer suitable for other crops. Furthermore, it is likely that the majority of trees under monocropping are older than those in mixed crop fields. To capture these variations between cropping systems, a binary variable for cropping system

(Sys_i) is included. It is expected that when a tree is grown in a monocropped field it has lower yield as compared to a tree in a mixed copping system.

An important factor in profitability analysis of technology and input use in cashew production is the field planting density. Apart from biological constraints resulting from the variability in cashew yields, farming decisions which result in high density for mature trees and differences in field yield as a result of differences in density can be considerably significant. Thus, looking at tree yield for fields with different densities such as high, medium and low may be desirable and useful for the analysis of returns to labor, and the need to devise profitable management packages at the tree level. To capture these aspects a variable (Dens) representing the number of cashew trees per hectare on the field were a given tree is found is included to proxy for overcrowding of the field. It is expected that high densities will have positive effect on field yield per hectare basis, but above average increases in density will reduce tree yield due to overcrowding, tree stress and easy of spread of infectious disease.

The amount of care given to a tree is crucial to its productivity. With improved economic incentives one would expect an increase in the amount of labor time per tree devoted to pruning, weeding and other practices by different types of farmers. Alternatively, increased need for self-sufficiency in food crops may compete for labor and thereby encourage farmers to leave cashew trees unattended during periods of required tree care, leading to reduced yields. It is important to note that the competing labor needs between cashew and other crops is related to timing of the required activities on both types of crops. However, given the smallholder household's priority setting in favor of food crops, most of the labor devoted to cashew has been "off-season" which often has little or no effect on yield, or if undertaken may actually reduce yield.[6] To capture variability in labor endowment, the variable Lab_t is included in the model to represent the number of AE labor days spent per tree (family and hired labor, excluding harvest labor) during the growing season. We note that labor shortage is probably the most limiting factor for the rehabilitation of unproductive trees, mainly for households with many cashew trees, less family labor and capital, and/or propensity to hire labor.

In addition to density, cropping system and labor variables, a dummy variable ($Categ_j$) is added to differentiate yield by type of farms in the study area. It is hypothesized that small farms have relatively higher yield than other farms. One reason is that the latter have most of their trees under mixed cropping which is hypothesized to yield relatively more per tree than those trees on sole cropped fields. That is, better care to food crops is believed to have a positive spillover effect on cashew tree yields under mixed cropping systems.

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[6] For instance, pruning should be undertaken earlier in the year (February-March, or April to the most). During this period most of the farmers are busy with weeding of maize, beans and peanut fields, and cotton in some areas. As a result, pruning cannot be undertaken. If farmer's decide to prune their trees later, that means between May and June (food crop harvesting period) most of the trees are flushing and ready to soon start flowering. Lack of pruning may turn harvest difficult, and some farmers are tempted to prune some trees. The pressure put on the tree while pruning during flowering forces flowers with high potential to set panicles and nuts to fall.

5.3.4 Unobservable Village Factors Affecting Yield

As reported in earlier chapters, the study was conducted in three districts each representing one potential area for cashew production. Pooling of the sample provides greater insights of variations in agro-ecological conditions in which the trees were drawn. In addition, differences in infra-structural conditions can have a differential effect on incentives to improve cashew production in different areas. Thus to capture the effect of such variability in a multitude of factors which are not explicitly captured by the predetermined factors in the estimated models, a dummy village variable ($Vill_j$) is included when explicit factors at the same level are excluded. It is expected that tree yields are lower in villages in Nacaroa district than they are in Moma and Mogovolas districts given its location in an area less suitable for cashew, as noted in earlier chapters.

5.4 A Statistical Overview of the Determinants of Cashew Tree Productivity

Table 5-2 presents definitions of all the variables included in the yield equation, as defined in section 5.3. Table 5-3 and 5-4 report on summary statistics for all variables. These are calculated from survey and secondary data. There are a number of aspects worth noting before an analysis of the regression results is undertaken. As reported in earlier chapters, and research from other sources confirms, the yields are generally low. For a typical smallholder farm, the yield per tree under monocrop and mixed crop is 1.12 and 1.22 kilograms. That is, on average a tree under mixed crop has a higher yield than that under monocrop. There is only one exception to this observation by low L-AE farms (the farm categories are still defined as in Chapter 4). That is cashew tree yields are

Table 5-2 Definitions of Independent Variables included in the Cashew Yield Equation

Variable Name	Variable Content
Yield	Kgs of raw cashew nuts per tree, as measured by Equation 5.1
Genotype factors	
$Nupa_j$	Mean number of panicles set by the j^{th} cashew tree(j=1,...N), based on two takes (North and South sides) of each sampled tree, and
$Disea_i$	A dummy disease condition indicator (=1 a given tree shows either panicles, stems or nuts with signs of any kind of disease attack, sun or fire damage, and =0 otherwise).
Natural factors	
So_j	A dummy variable soil type and color (=1 for the for i^{th} soil typw, and =0 otherwise, I=1,2, and 4),
Alt	Altitude in meters (m), taken from the GPS reading of the tree position in the field where it is located,
Ral	Rainfall levels, in millimeters (mm),
Rad_j	A dummy variable for rain distribution (=1if rain was reported to have fallen in the field/area where trees are located in month j, =0 otherwise, j=1,...12) , and
$Intra_j$	A dummy variable for intensity of rain (=1 for intensity j, =0 otherwise, with j=0,1,2, and 3) to indicate "no rain," " low," and high intensity of rain.
Cropping factors	
Dens	Number of cashew trees per hectare (density), based on the number of cashew trees currently in the field($Size_c$) where the tree is located,
Sys	A binary variable (=1mixed cropping, and =0 monocropping) for the cropping system of the field in which the tree is located,
Lab	Total labor adult-equivalent days (including family and hired labor) used in all cashew cultivation practices per tree, excluding harvest labor, and
$Categ_j$	A dummy variable for smallholder farm category(=1 for the j^{th} farm, and =0 otherwise, with j=1,...3), based on the total land area per adult equivalent at the time of the study.
Village	
$Vill_j$	A village dummy (=1 for village j, and =0 otherwise, with j=1,...5) for structural factors not accounted for in the explicit variable definitions, above.
No. Of Observations	205 trees out of 216 initially sampled in 69 cashew fields

Source: Smallholder Cashew Production Survey in Nampula, Mozambique 1998/9.

Table 5-3 Rainfall Levels in Surveyed Districts in the Northern Province of Nampula, Mozambique, 1997/98

Months	Surveyed Districts in the Province of Nampula		
	Nacaroa	Mogovolas	Moma
	------------ mm------------		
January	192.5	170.4	178.5
February	256.5	267.4	301.5
March	172.3	69.6	7.3
April	25.0	38.9	132.7
May	0.0	2.5	0.0
June	0.0	9.3	23.3
July	0.0	10.5	0.0
August	3.5	9.8	0.0
September	4.8	9.5	1.4
October	13.3	0.0	9.4
November	2.5	10.2	0.0
December	7.5	75.8	25.5
Total	583.9	673.9	679.6

Source: Direcção Provincial de Agricultura e Pescas de Nampula, Unidade de Aviso Prévio, 1998/9.

lower on mixed cropping fields for the low L-AE farms. This may not be an exceptional result rather, it indicates that most of the trees on low L-AE farm mixed cropped fields are younger and the majority at below economic yield.

Furthermore, although the differences in tree yields on monocropped fields are not statistically significant across farm categories, low L-AE farms show a higher yield than other farm categories. While the overall yield per tree by cropping system is exceptionally low, it is in line with prior research results (Topper, 1999). Note that high

Table 5-4 Summary Statistics for Yield Equation Variables

Variable	Smallholder Farm Categories by Land per Adult Equivalent (L-AE)						Typical Smallholder Cashew Farm	
	Low		Medium		High			
	Sole Crop	Mixed Crop	Sole Crop	Mixed Crop	Sole Crop	Mixed Crop	Sole Crop	Mixed Crop
Dependent								
Yield (Kgs/tree)	1.45	0.69	0.93	1.24	1.11	3.37	1.12	1.22
	(3.90)	(0.95)	(1.67)	(1.67)	(2.13)	(3.38)	(2.57)	(1.83)
Independent								
Genotype factors								
$Nupa_j$ (pa./m^2)	10	13	10	11	11	15	10	12
	(4)	(5)	(4)	(4)	(4)	(5)	(4)	(5)
$Disea_i$ (percent)[1]	71.0	27.0	43.0	26.0	51.0	33.0	52	25
	(46.0)	(45.0)	(50.0)	(45.0)	(50.0)	(51.0)	(50.0)	(44)
Natural factors								
Alt (m)	1064.5	1010.4	893.5	992.2	1009.1	828.7	974.2	982.5
	(504.4)	(438.8)	(356.3)	(426.5)	(474.3)	(192.9)	(441.9)	(412.3)
Ral (mm)	4.85	7.70	7.18	11.15	6.24	28.5	6.26	11.4
	(3.0)	(10.6)	(8.7)	(14.2)	(3.9)	(14.4)	(6.2)	(13.9)
Rad_j[2]	61.7 percent		42.0 percent		17.2 percent		41.0 percent	
Int_i[3]	38.3 percent		66.7 percent		42.2 percent		48.8 percent	
Cropping factors								
Dens(trees/ha)	52	32	44	43	48	39	48	38
	(19)	(19)	(13)	(15)	(8)	(22)	(15)	(17)
Labt (AE/tree)	0.72	2.22	1.02	1.02	0.60	1.42	0.82	1.58
	(0.6)	(2.0)	(1.4)	(1.1)	(0.7)	(1.6)	(1.06)	(1.66)
Sys_i (%)[4]	56 percent		71 percent		88 percent		69 percent	
$Categ_j$[5]	31.9 percent		39.1 percent		29 percent		100 percent	
Village Factors								
$Vill_j$ (%)	Villages are Nampaco, Nametho, Issura, Nivine and Milapa from where 18.8, 18.8, 26.1, 20.3 and 15.9 percent, the cases were drawn from randomly, respectively.							

Source: Smallholder Cashew Production Survey in Nampula, Mozambique, 1998/9.
[1] Proportion of cases reporting either disease signs or sun and fire damage; [2] Highest percentage of cases with rain falling during September and November with next highest been the month of October; [3] Highest percentage of cases with high intensity rain, except for the medium farm where percentage refers report of low intensity rains; [4] Highest proportion of cases falling into monocropping system, except for small farm type; and [5] Proportion of cases from each farm category. Numbers in parenthesis are standard deviations from the mean values.

L-AE farms have trees under mixed cropping with yields comparable to the three kilograms from national estimates (TIA 96). This yield levels also compared with the current yield per tree as suggested by researchers in Mozambique (INCAJU, 1999; Strasberg et al., 1998; CAPRICORN, 1997).

Another important aspect in Table 5-4 is the fact that there are no statistical differences in genotype factors across categories of farms and cropping systems. This is no surprise given that the cashew variety owned by cashew farmers in Mozambique is largely the same. However, the finding has strong implications for cashew research. If genotype factors determine yield levels, as is suggested, then research and extension services ought to improve the current cashew variety, and search for other varieties is needed to provide farmers with more options to counter the natural variability of cashew trees.

In addition to genotype factors, natural and farming system factors are most likely to affect yields. While natural factors are out of farmer's control, farming systems are likely to be influenced by the farmer. In earlier chapters, we have discussed the effect of factors such as temperature, rainfall and its distribution on cashew yields. Unfortunately, it was not possible to collect nor obtain from secondary sources temperature data for the study areas. However, rainfall levels recorded by the Food Security unit at the Provincial Directorate of Agriculture and Fisheries in Nampula were kindly made available, which allowed cross checking of the farmer's reported months of rain in the study areas. For instance, what the Rad_j variable shows in Table 5-4 is the percentage of cases in which months farmers reported that rain had fallen in the field/area of study. For example, in

61.7 percent of smallholder small farms fields, rain were reported to have fallen the most in September and November, with the second highest in October. Although it is not reported in the table, data is available for the number of days it rained in a given area.

The same interpretation must be given to the variable *Intr* which reports the highest proportion of cases in which farmers said rainfall had fallen with high intensity. The other options for this variable are "no rain" and "low" intensity rain. Note that good distribution of rain, over the production cycle is important. High intensity of rains in smaller periods of time, and long periods of dry weather can reduce yield. This was the case during the study period. On average, two days of intense rain were reported mostly during the September and November months, leaving the remaining period with a long dry season which damaged the emerging panicles for the second flowering and fruit bearing season.

With respect to farming practices, the table shows two dimensions of relevance. These are the number of cashew trees per hectare, the cropping system in which cashew trees are grown, and the amount of labor devoted to management of cashew trees, excluding harvest labor. Data shows that low L-AE farms tend to have fewer cashew trees per hectare under mixed cropping and slighter more under monocropping than high L-AE farms. However, these differences in density are not statistically significant. Recall that we have reported in Chapter Four that on average low L-AE farms have less land and cashew trees. Given that low L-AE farms have difficulties in accessing land, mixed cropping is the only alternative they have to secure both food and cash, which must come from the sales of cash crops. As a result, for the space required for cashew trees and the need to grow more food, putting fewer cashew trees per unit of land area is an optimal strategy.

The variable Sys_t shows the proportion of cases falling into monocropping system. That is, for instance, about 88 percent of the cashew trees sampled from high L-AE farms fields were under monocropping, compared to the 56 percent from low L-AE farms. As noted elsewhere, the sample of trees were drawn randomly, thus this statistic should suggest that low L-AE farms tend to have fewer trees under sole cropping as compared to high L-AE farms.

Interesting statistics are those shown by the labor variable Lab_t which indicates the amount of adult-equivalent days devoted to cashew tree management. A typical cashew farm spent about 0.82 and 1.60 labor adult equivalent days per tree under mono- and mixed cropping, respectively. This amount of labor on a per tree basis is very low. There were statistical significant differences in family labor per tree allocated to cashew management across farm categories and cropping systems. High L-AE farms allocated time per tree below average and low L-AE farms the opposite. In terms of total labor per tree, there seem to be no significant differences across farms. This suggests that medium to high L-AE farms, to some extent are able to cover the shortage of family labor by using hired-in labor, when needed. However, given the current state of the cashew industry, it seems even more important to pose the question of "Why do farmers still not hire in as much labor as the management requires for increased productivity of the current cashew orchard?" In addition, the observations above lead, at least hypothetically to the issue of increases in cashew productivity requiring increased productivity in food crop production to make cashew an attractive enterprise. The lower family labor levels applied to cashew, particularly in high L-AE farms who seems to be in capacity to mobilize the necessary resources results from two factors. First, many of the high L-AE farm households are old and they lack family labor to manage both cashew and food crops. Secondly, despite recent efforts to liberalize agricultural prices, including cashew prices there is still lack of financial and economic incentives for farmers to engage in profitable cashew investments in the context of their whole farming system. That is, economic incentives in the current cashew industry cannot provide sufficient returns for farmers, for example, to hire labor and expect to break-even. Thus, priority is often to secure food. The profitability of cashew in the context of a typical farming system will be examined in the following chapters.

A final note in this section is that given farmers often give priority to food crops, most of the activities with potential strong impact on cashew yield such as pruning, cannot be performed timely in order to obtain a positive impact on yield. As a result, the labor that is devoted to cashew activities is mostly "off-season" and does not seem to contribute very much to yield. This labor probably facilitates theft by making collection of nuts easier, but helps prevent fire damage.

5.5 Estimation and Discussion of the Results

According to our initial expectations, there are three results of importance from the estimated models. As explained in section 5.3 the two models presented in Table 5-5 (Models I and II) are similar in their functional form. Differences between the two models refer to exclusion of rainfall information in Model I.

Considering that these results come from survey and observation data, and in comparing them with other farm level yield determinants studies (Strasberg, 1997), the performance of these models can be considered acceptable. Overall, the effect of included variables on cashew yield variations in both models is jointly significant at one percent significance level. The signs of the most important variables are as expected. Differences in statistical explanatory power is explained below.

The number of panicles a tree is able to set is the most direct cashew biological factor proxying for the potential of the cashew tree to bear fruit, in the model. The degree of resistance and tolerance to disease, an increasingly sought after goal in cashew research reflects the ability of the tree to bypass negative effects of environmental factors. The widespread incidence of *Oidium* and *Helopeltis* insect attacks in Mozambique are the most challenging factors in cashew production. In addition, the development of cashew varieties either tolerant or resistant to *Oidiun Anacardium* will be a most rewarding task for today's cashew research programs in cashew producing countries, particularly in Mozambique. The negative and statistical significance of the estimate on the effect of disease on yield in both models confirms this challenge, and is consistent with Topper's

Table 5-5 Random-Effects Regression Results of the Cashew Tree Yield Models

Variables	Parameter Estimates			
	Model I	**S. E.**	**Model II**	**S. E.**
Genotype /Factors				
Nupa	4.66	(0.90)*	4.80	(0.93)*
Disea	-2.51	(0.85)*	-2.37	(0.87)*
Natural Factors				
Soil2	-4.52	(2.88)	-3.80	(3.19)
Soil 3	1.18	(1.63)	0.81	(2.03)
Soil 4	1.27	(2.33)	1.63	(2.47)
Alt	-0.21	(1.44)	0.13	(1.64)
Ral			0.02	(0.34)
Rad1			3.06	(4.03)
Rad2			4.85	(4.11)
Rad3			0.24	(4.30)
Rad4			2.21	(4.69)
Rad5			-4.12	(3.54)
Rad6			-0.68	(3.41)
Rad7			1.35	(4.13)
Intra2			0.93	(1.26)
Cropping Factors				
Dens	4.94	(2.49)**	4.66	(2.61)***
Sys	22.29	(10.59)**	20.02	(11.12)***
Labt	-0.54	(0.39)	-0.54	(0.40)
Categ2 (Medium L-AE)	1.09	(1.07)	1.20	(1.11)
Categ3 (High L-AE)	-1.14	(1.25)	-2.22	(1.48)
Village Factors				
Vill2 (Nampaco)	-1.86	(1.41)		
Vill3 (Issura)	1.99	(2.33)		
Vill4 (Nivine)	3.07	(1.72)***		
Vill5 (Milapa)	3.74	(1.79)**		
Density and Cropping System	-5.77	(2.75)**	-5.08	(2.89)***
Constant	-25.75	(14.91)***	-24.82	(14.61)***
Wald Test		[p-values]		[p-values]
Cropping Factors	9.79	[0.08]***	11.12	[0.05]**
Farm Category	4.62	[0.09]***	7.25	[0.03]*
Density and Cropping System	4.45	[0.10]***	3.30	[0.19]
Village Dummies	8.56	[0.04]**		
Rainfall Variables			16.13	[0.06]***
Chi-Square	99.26	[0.00]***	101.14	[0.00]***
No. of observations	205		205	

Source: Smallholder Cashew Production Survey in Nampula, Mozambique 1998/9.
Note: Dependent Variable: Natural logarithm of Yield per tree. All continuous variables are natural logarithm transforms of original data. * significant at 1 percent; ** significant at 5 percent; *** significant at 10%.

(1998) recent findings from both on-station and in farmer's fields trial research in Nampula.[7]

Soil type, altitude, rainfall both in levels, its distribution and intensity were examined. Despite the statistical insignificance of the coefficients on soil type variables, their signs in both Model I and II are consistent with prior knowledge of their effect on yield. As mentioned earlier, deep and well drained red sandy loams are the most suited for cashew as compared to clayish soils. The coefficients on variables ($soil_3$ and $soil_4$) seems to provide some empirical support to the conventional wisdom that red sandy loam soils may be better suited for cashew. Cashew is sensitive to high altitude, and as explained in Section 5.1 altitude above 1,200 mm is not favorable to cashew production. Areas further inland in Nampula (as it is the case of Nacaroa District) tend to be less suitable for cashew production due to the high altitude and temperatures.

In the cropping factors category, the density and cropping system variables both have a positive and statistically significant coefficients at five percent significance level. Alternatively, the family and hired labor variable has a negative and statistically insignificant parameter estimate in both Model I and II. The result on cropping system is consistent with prior expectation that trees on mixed cropped fields seem to show relatively higher yields than those on mixed cropped fields. With respect to density, its

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[7] High levels of *Oidiun Anacardium*, known as the Powdery Mildew Disease (PMD) were found in nine out of ten 'low yield' on-farm sites, and in three other on-station fungicide trials in Nampula. Although these findings do not reveal the degree of incidence among different types of farmers as one would expect given the differences in field planting densities, our results provide empirical evidence of the negative impact of disease and fire damage on cashew yields.

effect on yield must be examined in conjunction with its interaction with the cropping system variable. Note for instance that the coefficient on density is positive and statistically significant (at five percent in Model I, and at 10 percent in Model II). However, the interaction of density with cropping system is negative and statistically significant at five and 10 percent, in Model I and II, respectively. That is, the net effect of density on yield is negative (-0.83, and -0.42 for Model I and II, respectively). We will discuss further this issue later, using results from an expansion of Model I. Note also that the Wald test of density and all of its interactions show a joint statistically significant effect on yield at the 10 percent level for Model I. In addition, further testing of the cropping factors (density, cropping systems, amount of labor per tree, and farm category) shows that these factors have a statistically significant joint effect on yield at 10 percent level in Model I and five percent level in Model II which indicates the importance of these factors in explaining variations in cashew yields.

Although there are no conclusive findings on the relative incidence of low yield potential trees on monocropped vs mixed cropped fields, there are indications that trees under mixed cropping (see Table 5-4, exception for small farm fields) have, in general, higher yield. The statistical significance of both density, cropping system and their interaction in these models confirms our expectations that one potential factor for low yields on farmer's fields is the effect of overcrowding. These results are consistent with recent results from Topper et al., (1999) in Nampula Province.

The negative effect of tree overcrowding results from the fact that in a high densely populated cashew orchard, tree canopy and root systems compete both for nutrients and space. While nutrients and water are rapidly depleted, canopy interlacing reduces fruiting area and facilitates a rapid spread of *Oidium Anacardium*, a deadly disease for panicles and nuts. This is particularly important in the study area because of the nature of trees overcrowding on farmer's fields. That is, some farmers have the trees planted by groupings which results in spots of higher density than the density that can be calculated on a per hectare basis. As a result, while an increase in per hectare density can allow higher per tree yield when done at recommended spacing levels, an increase in grouping density will substantially decrease both yield per tree and per hectare due to the rapid spread of PMD. This is the reason why there is no reason to expect yield per tree, as opposed to yield per field, to increase with increase in density. Farmers may expect an increase in the yield per hectare, but an above average increase in density may reduce yield per tree.

It has been found in earlier work by Strasberg, Mole and Weber in Mozambique using the TIA 96 national agricultural database that farmers in the smallholder sector with few trees seemed to have consistently higher yields. The yield differentials by farm categories from the current study provides some insights about this. In fact, all other factors held constant, cashew yields on low L-AE farms are slightly higher than those from high L-AE farms. The negative sign of the high L-AE farm category variable ($Categ_3$) suggests this observation. Note that, in the literature small farms are often reported to have lower yields than larger farms due to lack of economies of scale in the use of modern inputs. Although the use of modern inputs in cashew production in Mozambique is little to non-existent, under the current state of cashew production the results show that low L-AE farms who are small show some advantage in managing cashew orchards.

The empirical estimates from the village dummy variables indicate that yields in Nampaco village, district of Nacaroa (*$Vill_1$*, in the intercept term) are significantly lower than any other village accounting for all other factors. Furthermore, at the 10 percent significance level, yields per tree in Nivine and Milapa villages, district of Mogovolas are higher than in any other villages. Recall that Nampaco ($Vill_1$), and Nametho ($Vill_2$) villages are located in the low potential area for cashew in the district of Nacaroa, whereas Issura village ($Vill_3$) is located in the medium potential coastal district of Moma, and Nivine village ($Vill_4$), and Milapa village ($Vill_5$) are in the high potential district of Mogovolas. The data shows that yield per tree is higher in the district of Mogovolas (1.95 kgs) than it is in Moma (1.67 Kgs) and Nacaroa (0.44 kgs) districts. The differences are statistically significant between Nacaroa and Mogovolas confirming the expectations that Nacaroa is a low potential area for cashew production.

As pointed earlier, Model II introduces rainfall information. Village variables are dropped due to multicolinearity. The results on genotype, natural and cropping factors are similar to those in Model I. This means that the village dummy variables in Model I capture well the rainfall information excluded in the estimation process. Therefore, further analysis focuses only on the effect of rainfall information as shown by the model estimates in Table 5-5.

The rainfall levels and pattern during the year of study was not the best (see Table 5-3). Rain came in early in August (Rad_1) with high intensity for a few days, and too late in September and November, and October (Rad_5 and Rad_6) to have a positive effect on yield.[8] In fact, the coefficient on rainfall levels has a positive (Model II), but not statistically significant effect on yield. However, the most important result from this model is the fact that the joint effect of rainfall on cashew yield is statistically significant at 10 percent, as shown by the Wald test. It was noted earlier that late rains towards the end of the first flowering and onset of the second, particularly at high intensity and within small intervals of time are not optimal. Rains must fall regularly during the flowering period and continue to do so over the season in order to allow the onset of the second flowering in November and December. During the 1998/9 season, rains were scarce up until the end of January when the harvest was almost over. The second flowering was not observed in most of the cashew trees which resulted in overall low yields.

5.6 Effects of Density and Labor Changes on Yield Estimates

The evaluation conducted in this section is driven by three observations from previous analysis. These are:

(1) based on measured fields and numbers of cashew trees counted during the survey process, a typical smallholder one hectare monocrop and mixed crop cashew field will have 48 and 38 cashew trees, respectively. These densities are still lower

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[8] Note that variable *Rad* was coded from zero to seven, with zero to mean no rain, and one to seven the actual months in which rains were reported to have fallen in a specific area. For example, one for the month of August, two for August and September, three for August and December, four for September, five for September and November, six for October, and finally seven for October and December.

than the recommended 45-65 trees under row planting. Although one must be careful about the recommended spacing due to the nature of crops farmers often inter-crop with cashew, it has been noted earlier that farmers tend to have most of the trees in dispersed groupings, rather than having evenly spaced on their fields. This observation suggested that farmers can possibly increase density by (a) thinning out unproductive trees within the groups, and (b) rearranging field layouts by planting new trees following recommended row spacing;

(2) alternatively, changes in the incentive structure could bring, at least in theory farmers to realize the benefits to invest more labor at the right timing into cashew management. If these changes can be effected, then perhaps substantial returns could be realized to the benefits of the sector; and

(3) finally, the data shows on average that 47 percent of all sampled trees were affect by either disease of some kind, or/and sun/fire damage. Results from the yield analysis shows that disease is an important factor for the low cashew yields in the study area. Thus, disease control is a serious problem.

Table 5-6 expands Model I by including further interactions of density and labor with cropping systems, farm category, and village dummies. The objective of this new model is an attempt to estimate the relative effects of changing density and labor

Table 5-6 Random-Effects Regression Results of the Extended Cashew Tree Yield Equation

Variables		Parameter Estimates		
		Coef.	S.E.	p-value
GENOTYPE FACTORS				
Nupa		5.47	0.93	0.00*
Disea		-2.36	0.85	0.00*
NATURAL FACTORS				
Soil2		-8.96	3.27	0.00*
Soil3		1.47	2.15	0.49
Soil4		-0.51	2.39	0.83
Alt		2.10	1.63	0.19
CROPPING FACTORS				
Dens		1.65	4.03	0.68
Sys		18.03	13.90	0.19
Labt		-0.34	0.97	0.69
Categ2 (Medium L-AE)		74.22	27.79	0.01*
Categ3 (High L-AE)		24.85	22.38	0.27
VILLAGE FACTORS				
Vill2 (Nampaco)		-62.36	34.09	0.08***
Vill3 (Issura)		-80.69	29.70	0.01*
Vill4 (Nivine)		-57.62	32.33	0.08***
Vill5 (Milapa)		-34.69	23.30	0.14
Constant		-30.87	19.66	0.12
INTERACTION FACTORS				
Density and Cropping System		-4.64	3.61	0.19
Density and Smallholder Cashew Farm Category				
with Medium L-AE		-18.80	7.14	0.01*
with High L-AE		-6.31	5.87	0.28
Density and Village Dummy Variables				
with Nampaco (Nacaroa District)		15.20	8.53	0.08***
with Issura (Moma District)		21.76	7.59	0.00*
with Nivine (Mogovolas District)		14.97	8.22	0.07***
with Milapa (Mogovolas District)		9.93	6.04	0.10***
Labor and Smallholder Cashew Farm Category				
with Medium L-AE		0.89	1.20	0.46
with High L-AE		3.23	1.41	0.02**
Labor and Village Dummy Variables				
with Nampaco (Nacaroa District)		-1.76	1.35	0.19
with Issura (Moma District)		0.56	1.38	0.68
with Nivine (Mogovolas District)		-4.43	2.10	0.04**
with Milapa (Mogovolas District)		0.38	2.01	0.85
Wald Test	Farm Category	7.33		0.03**
	Density and all of its Interactions	14.89		0.06***
	Labor and all of its Interactions	21.68		0.00*
Chi-Square		117.33		0.00*
No. of observations		205		

Source: Smallholder Cashew Production Survey in Nampula, Mozambique 1998/9.
Note: Dependent Variable: Natural logarithm of Yield per tree. All continuous variables are natural logarithm transformations of the original data. * significant at 1 percent; ** significant at 5 percent; *** significant at 10%.

allocation on yield, under conditions of sole and mixed cropping systems by farm category, and location. Furthermore, as will become clear, the results show more specifically either geographically or by farm category where the effects are more pronounced. For instance, while the effect of density on yield seem to be statistically insignificant (as shown by the coefficient on the *Dens* variable alone), the interaction of this variable with the village dummies (labeled as density and village dummy variables, in the table) have statistically significant effect on yield. It shows that the effect of changing density on yield is, in percentage terms statistically significant (at five percent level) and higher for farms in the village of Issura in Moma district than in any other village. Given that fields in Moma District show a slightly higher density (Table 4-1, Chapter 4) compared to other districts, this result suggests that cashew tree grouping density is lower on fields in Moma than is the case for Nacaroa and Mogovolas districts.

Another important result is that density seems to matter only for farms in the medium L-AE category. This may suggest that these farms may have relatively low density per cluster of trees compared to farms in other category. Data available show that these farms have relatively more cashew trees per hectare on sole cropped fields than low and high L-AE farms which may, in part, explain this result. Note that the Wald test for joint significance of density and all of its interactions on cashew yield shows a statistically significant effect at 10 percent level. The implication of this result is that density is an important factor in explaining cashew yields, but its effect varies across farms and geographical location.

With respect to labor at the village level, the overall result is that labor had a negative but statistically insignificant impact on yield. Results show that this impact is negative in Nampaco and Nivine villages. In the latter, the effect is statistically significant at the five percent level. In contrast, the impact of labor on yield is positive, but statistically insignificant in Nampaco and Milapa villages. If one accounts for the overall impact of labor (including the coefficient on Lab_t variable which is statistically insignificant at the conventional standards) these effects will be even smaller. At the farm level, again the results are statistically significant only for farms in the high L-AE category. Note that the Lab_t variable include both family and hired labor. High L-AE farms hired significantly more labor to cashew activities than farms in other categories. This may explain the positive and statistical significance of the result. The overall impact of labor across farms and villages is tested jointly using the Wald test. The results show that the joint impact of these variables on cashew is statistically significant at one percent level. This suggest, in fact, that amounts of labor allocated to cashew across farms and villages is not sufficient to make a significant impact on yield. As result, efforts at encouraging farmers to put more labor into cashew, particularly at the right time could have a pay-off in terms of yield gains. These findings seems to be consistent with those obtained in Tables 5-5.

The analysis with respect to changes in density and labor allocation in Table 5-7 assumes that the corresponding trees are disease free, and cultivated under mono- and mixed cropping systems only by low L-AE and high L-AE smallholder farms. The selection of Nampaco and Milapa villages is to represent study sites with low and high

Table 5-7 Relative Change Effects of Density and Labor on Estimated Cashew Yield per Tree for Low and High L-AE Smallholder Cashew Farms under Different Cropping System in Northern Mozambique, 1998/91

Factors	Villages and Smallholder Farm Categories by Labor Adult Equivalent (L-AE)			
	Nampaco (Nacaroa District)		Milapa (Mogovolas District)	
	Low	High	Low	High
	--------------------- percentage changes [1] ----------------------			
<u>**Cropping Factors**</u>				
Cashew Density				
Monocrop	16.85	10.54	11.58	5.27
Mixed Crop	12.21	5.91	6.94	0.63
Labor				
Overall	-2.10	1.13	0.04	3.27
<u>**Diseased Trees**</u>				
Monocrop	69.23	81.81	0.00	62.50
Mixed Crop	33.33	0.0	33.33	33.33

Source: Smallholder Cashew Production Survey in Nampula, Mozambique 1998/9.
[1] Percentage changes in all calculations are based on results of the Model in Table 5-6.
[2] Percentage of trees with some signs of disease attack, sun or fire damage.

potential areas, respectively for cashew production. As shown, the relative effects of increasing density on yield for farms in the low L-AE in the village of Nampaco is about 12 percent for mixed cropped cashew trees and about 17 percent on monocropped trees. That is, a change of a percentage point in the density will increase the yield per tree by about 17 percent on monocropped cashew fields, and about 12 percent on mixed cropped fields in the village of Nampaco. These changes are relatively lower in the village of Milapa. The potential reason for this is the fact that farmers in Nampaco have fewer trees that those in the Milapa villages. Recall that these two villages are located in zones of different potential for cashew production.

The same patterns is observed with respect to the high L-AE category. As one would expect, the incremental effect of density on yield is also smaller on mixed cropped fields compared to that on monocropped fields. This reflects the degree of competition between cashew and food crops.

Where most of the benefits can potentially be brought about is from changes in current labor allocation patterns to make improvements in existing trees. The estimates are presented for overall amount of labor as opposed to by cropping system because of lack of degrees of freedom. Additional labor under the current labor allocation system does not contribute to yield for farms in low L-AE category in the village of Nampaco, and contributes very little in the village of Milapa. As stated earlier, only labor allocated by farms in the high L-AE category has a positive and significant effect on yield because of their hiring ability. Nonetheless, these amounts of labor seem to be insufficient to raise yield. The results suggest that incentives to add more labor, particularly at the right timing would contribute the most to increased yield on farms in the low L-AE category. For instance, if the labor currently allocated to cashew management could be applied at the right time it could potentially contribute between less than a half percent change to about three percent across farm categories and villages. The issue, however, still remains as to how to convince farmers of these potential benefits to better timing in labor allocation.

In the last two rows of Table 5-7 the proportion of cashew trees affected by disease are presented for low L-AE and high L-AE farm categories under mono- and mixed cropping systems. Note that the proportion of cashew trees affected by disease is consistently lower on mixed cropping fields and lower among low L-AE farms. This finding confirms earlier suggestions that there might be something farmers do to their food crops which helps to keep away some of the damages that cannot be as easily prevented on sole cropped fields. For instance, fire guards help to reduce the risk of fire damage to both food and cashew crops. Keeping weeds off the fields may also help to lower insect attack to cashew flowers and panicles, depending on which crops are in the field. One possible reason for higher incidence of diseased trees could be the cultivation of "*feijao boer*" in cashew fields. This type of beans is an important crop in the household's food basket and therefore widely grown in the study area.[9] This crop has been suggested to be a host of *Helopeltis* a sucking insect which attack cashew trees, in addition to PMD, specifically *Oidium Anacardium* a serious cashew disease. Another possible explanation is the high tree grouping density in most farms. This results in a high number of affected cashew trees. Control of the disease requires collective action with better and more effective means to win the battle against PMD. Presently, any activity by farmers to control PMD may only help to keep the disease to relatively low levels, rather than abolish it.

[9] *Feijao Boer* is the Portuguese name for Pigeon peas.

In sum, the three dimensions analyzed indicate their importance in explaining low yields. Given that farmers have most of the cashew trees in dense groupings (on either mixed or sole cropped fields) as opposed to orderly row planting arrangements (Ruthenberg, 1976; Hardwood, 1979) thinning and replanting and thereby increasing per hectare tree density could be one strategy to improve yields. However, the contribution from increased density through thinning may not yield a higher payoff, if any replanting takes place with material currently used that has weak genotype and phenotype characteristics. Wide spread incidence of PMD, and the weak genotype planting material in the hands of farmers may preclude the benefits of thinning/replanting investments. Thus the results here only provide some insights about the effect of current disease incidence levels, and the need to improve the current genotype material, while contributing to understanding of what kind of environment for improved incentives (especially labor use) are needed to increased farmer's investment in cashew production.

5.7 Conclusions

This chapter has examined some of the key determinants of cashew tree productivity under on-farm conditions in Northern Mozambique. Apart from the genotype factors found to be significant in explaining yields, red sandy loam soils, tree density and variations in farm type characteristics seems to also significantly influence tree yields. The most important finding is related to the effect of the amount of labor on yields, which was negative although statistically insignificant. Survey data shows that the amount of labor allocated to cashew is often very little, and not at recommend time period in the growing cycle. These two factors seem to explain the negative and statistically insignificant coefficient on the relationship between labor use and yield. However, when labor is analyzed in conjunction with others interaction factors its joint impact is statistically significant at one percent level which provides insights about the incentives to invest in more labor, particularly to be used at the right time of the growing cycle. The current approach to tree management and disease control requires labor to be used when it conflicts to a large extent with activities needed on food crops. Given the lack of reliability of rural food markets, and cash earnings opportunities, and the low economic incentives for cashew producers, farmers set priority for food cropping activities and shift labor for cashew activities to be done later in the agricultural season. Since some of the recommended cashew activities with a potential strong impact on yield cannot be shifted away, they are simply not executed. This has been done for a long of period of time, which has led to the spread of PMD.

To conclude, the results and analysis provide insightful information on research needs and help to inform questions about supply response in the cashew policy debate. Lowering disease incidence levels, improving the current genotype material, and creating an environment for improved incentives to increased smallholder farm investments in cashew production, particularly labor use are urgent issues in the forefront of the cashew industry success requirements.

The yield models from this chapter will be used to estimate mean yield per tree, which at different cashew tree densities per cropping system and farm category will help to calculate mean yield per hectare for the profitability analysis in the following chapters.

CHAPTER 6

PROFITABILITY ANALYSIS OF SMALLHOLDER CASHEW CROPPING IN THE NORTHERN PROVINCE OF NAMPULA

6.0 Introduction

This chapter uses partial budgeting to assess the economic performance of the current smallholder cropping systems in the cashew belt of the Northern Province of Nampula. Farm enterprise budgets developed serve two purposes (1) to evaluate the financial profitability of farmer's enterprises, and (2) to generate data for the LP model in the next chapter aimed at exploring the effects of smallholder's resource constraints to adoption of new technologies and improved managements practices in cashew production under alternative policy situations. The section to follow presents a brief synopsis of smallholder resource use by crop enterprises and smallholder farm categories in the study area.

6.1 Smallholder Labor Allocation and Returns to Resources in Nampula Province

The labor input requirements for all the enterprises are computed from the survey conducted during the 1998/9 study period. For the purpose of this analysis, an enterprise include one or more crop combinations encountered in a given field. With exception of manioc yield data, all other crop yield information was generated by this research. Yield data for manioc was obtained from the 1995 smallholder household survey data set (NCD) in Nampula. Output and input prices used in the budgets are producer prices for the 1998/99 agricultural season and reflect government policy at that time. These prices were obtained from the Agricultural Marketing Information System (SIMA), a joint Michigan State University (MSU) and Ministry of Agriculture and Fisheries (MAP) price information system in Mozambique. Prices of agricultural implements were estimated from farmer's reported prices and cross checked with market prices recorded during the study period. Wage rates for hired labor are median wage rates for the province of Nampula obtained from the 1998/9 MSU and MAP smallholder productivity study. Fixed costs for the current cropping activities include only depreciation on agricultural hand tools, given that use of heavy equipment was not observed among sampled households.

The recorded enterprises included sole peanuts, manioc, and cashew and manioc mixtures with beans and peanuts. As suggested by Strasberg (1997), in areas of relatively low levels of agricultural technology and seemingly land abundance, returns to land are not crucial, but returns to family labor are important because typically labor represents a key constraint in smallholder yearly production plans. Nonetheless, both land and labor seems to constraint cashew production in the study area. FSP studies in Nampula have provided insightful information with respect to household's constrained access to land (Marrule, 1997), and suggested its importance to returns to smallholder land holdings. Recall that in Chapter Four, it was shown that there were marked differences in land per AE across smallholder farm categories. It was indicated that some farms were land scarce while others were household labor constrained. In the next section we explore the effects of some of these constraints, with particular focus on labor allocation decisions across enterprises and smallholder farm categories.

6.1.1 Smallholder Labor Allocation to Cropping Activities

The smallholder farm categories under the analysis are considered homogeneous with respect to technology in the production of both cashew and food crops. Due to similarities between households in the medium and high L-AE farm categories, the analysis focuses only on differences between households in the low and high L-AE smallholder farm categories. We note that all enterprise budgets are on a per hectare basis. Differences in land and labor resource endowments should not affect directly the profitability of the crop enterprises, unless there are differences among farms in risk management strategies. Of crucial importance here is the timing and quality of labor utilized. Often the most productive household members will pursue relatively more rewarding activities in detriment to on-farm activities. As a result, children and unsupervised hired labor is used on-farm. These labor quality issues affect on-farm productivity, thereby contributing to the differences in on-farm productivity alluded to above. However, as mentioned earlier, both land and labor can condition the ability of the farms to pursue the most optimal management strategies and thus be forced to adopt sub-optimal allocation of these resources. Indeed, labor allocation varies for the same activity and for the same cropping enterprise across smallholder farm categories. This is important and as it will become clear later, differences in risk management and farming skills seem to explain the observed differences in labor allocation.

In Table 6-1 labor use in different enterprises is presented by type (family, hired in and total) and by farm category. With respect to food crop enterprises which did not include cashew, total labor profile shows that households in the low L-AE farm category

Table 6-1 Labor Use per Hectare by Low, Medium and High L-AE and Typical Smallholder Cashew Farm Categories in Different Enterprises in Surveyed areas of Nampula, 1998/9

Enterprise	Smallholder Cashew Farms Categories by Land-Adult Equivalent(L-AE)									Typical Smallholder cashew Farm		
	Low (L-AE)			Medium(L-AE)			High (L-AE)					
	Family	Hired in	Total	Family	Hired in	Total	Family	Hired in	Total	Family	Hired in	Total
Food Crops only	Labor Adult-Equivalent days per Ha											
Peanuts	82.7	16.4	99.1	243.6	8.3	251.9	265.6	-	265.6	157.4	11.1	168.5
Manioc	88.6	-	88.6	66.6	5.5	72.1	59.1	37.0	96.1	101.1	13.6	114.7
Manioc *with* B	309.3	-	309.3	206.5	-	206.5	58.8	3.2	62.0	208.4	0.9	209.3
with P	335.7	-	335.7	125.9	-	125.9	106.6	1.5	108.1	182.9	0.7	183.6
with B *and* P	197.0	25.0	222.0	187.5	14.0	201.5	189.6	9.5	199.1	189.5	9.6	199.1
Cashew and Food Crops												
Cashew	32.0	0.9	32.9	29.8	0.5	30.3	9.6	8.7	18.3	25.3	2.7	28.0
Cashew *with* Manioc	72.9	5.9	76.4	50.8	2.2	78.6	187.8	0.2	188.0	110.6	2.5	113.1
Manioc *with* B	212.2	24.9	237.1	140.5	6.1	146.6	261.7	-	261.7	166.1	12.4	178.5
Manioc *with* P	208.9	-	208.9	202.1	1.5	203.6	171.1	0.7	171.8	197.8	0.8	198.6
Manioc *with* B *and* P	269.7	4.1	273.8	100.6	-	100.6	108.6	5.2	113.8	166.4	3.4	169.8

Source: Smallholder Cashew Production Technology Survey, Nampula, Mozambique 1998/9.

Note: B= Beans; and P=Peanuts. The typical smallholder farm is a weighted average over the L-AE farm categories. It takes into account the sample size.

used about 37 percent of total labor used by farms in the high L-AE farm category in sole cropping of peanuts. About 17 percent of this labor was hired labor, of which most was employed in harvesting activities. In contrast, households in the high L-AE farm category did not hire any labor for this enterprise. Another observation regarding total labor use is that, households in the low L-AE farm category used more labor in total than those in the medium and high L-AE farm category, in all the mixed cropped manioc enterprises. While high L-AE farms employed hired labor in all manioc enterprises, low L-AE farms did not, except in the case of manioc, beans and peanuts enterprise. High L-AE farms hired about 24 percent more labor than did low L-AE farms. While, all the hired labor by low L-AE farms was employed in the harvest of peanuts, high L-AE farms employed hired labor in field preparation and seeding, weeding and thinning, and harvest (about 95 percent, in the harvest of sole manioc).

With respect to enterprises which included cashew, the pattern of labor use across enterprises and farm categories seems to indicate that low L-AE farms used about 80 percent as much labor in total in sole cashew as farms in the high L-AE category. Most of this labor (97.3 percent) was family labor. About 47.5 percent of the labor used by high L-AE farms on sole cropped cashew was hired in, of which about 98 percent was used in weeding and harvesting, and the reminder in pruning of cashew trees. Furthermore, on mixed cropped cashew with manioc, low L-AE farms allocated less labor in total than high L-AE farms. The latter used more than twice the labor used in the same enterprise by low L-AE farms. However, low L-AE farms used more hired labor time than high L-AE farms. Most of the labor on both farm types was allocated to weeding, thinning, and harvesting. The hired labor on both farm types was also used in weeding and thinning, although high L-AE farms used about 10 percent more labor on weeding than low L-AE farms.

Use of total labor per hectare was not significantly different between low L-AE and high L-AE farms on mixed cropped cashew with manioc and beans. However, high L-AE farms used about nine percent more labor than low L-AE farms. About 50 percent of the hired labor was used in land preparation and planting, and the reminder in weeding and thinning. High L-AE farms did not hired any labor for this enterprise. While low L-AE farms did not hire any labor for mixed cropped cashew with manioc and peanuts, these farms used about 22 percent more labor than high L-AE farms. High L-AE farms were able to hire in labor for land preparation and seeding. Lastly, low L-AE farms used more than twice as much total labor per hectare for mixed cropped cashew with manioc, beans and peanuts than high L-AE farms. While both types of farms relied mostly on family labor, high L-AE farms were able to hire relatively more labor than low L-AE farms. All hired labor was employed in land preparation and seeding food crops in both farm types.

In Table 6.1 we also compute labor use by a typical smallholder cashew farm, which shows a similar pattern to that observed by farms in the L-AE farm category analysis. Namely, a typical smallholder household would rely mostly on family labor to grow all crops. The amount of family labor used is also higher on mixed cropped fields than it is on sole cropped fields, both for food crop combinations without cashew, and for those grown with cashew. Furthermore, a typical household would be able to hire labor. The amount of hired labor is higher for sole cropped peanuts and manioc, and mixed cropped manioc with beans and peanuts than it is in other food crop combinations. This is also the case for mixed cropped cashew with manioc and beans (as it was for farms in the low and medium L-AE categories). The family labor allocation pattern seems to suggest that a typical smallholder cashew farm also emphasizes intercropping of manioc with other crops. It is not apparent, however, whether mixed cropped peanuts play as much the same role as it played on low L-AE farms. A typical smallholder farm allocates about 70 percent more labor to sole cropped peanuts than farms in the low L-AE category. Given that peanuts are a cash crop, and the relatively easy access to land by high L-AE farms, it is possible that these farms are more specialized in sole cropped peanuts, in which case the amount of labor used can be justified with significantly higher yields than those obtained by low L-AE farms. In the following sections, where we analyze enterprise profitability by L-AE farm categories, we may return to this point.

Analyses at both the L-AE farm level and at the typical level, lead to at least three key points about labor use patterns. First, there seems to be a pattern in the amount of labor used. Some farms use more labor compared to what an average smallholder farm would have allocated to a given enterprise. Accounting for all potential measurement errors in the data, it seems that a potential explanation for this result is the fact that land cultivation by household's members is a collective activity in rural areas. Although one would expect that more labor would take less time to undertake a given task, in many instances shirking is a problem. Specially, when more labor is available for a collective activity such as land clearing and preparation, weeding and planting performed in a limited space, the productivity per participating member seems to decline. It is common to observe a number of people working in a tiny land area. Apart from differences in yield resulting from differences in rainfall, humidity and soil types in the study area, shirking problems added to factors such as quality of labor hired, the timing of labor allocated to cropping activities during the agricultural season referred to earlier, have an impact on productivity and might well explain the un-profitable enterprises among some of the smallholder cashew farm types.

Second, the pattern seems to describe best the use of labor by those farms in the low L-AE farm category. Recall that a low L-AE implies basically a high labor to land ratio. Furthermore, in Chapter Four it was shown that households in the low L-AE farm category while land-poor were relatively labor abundant. Studies have provide some evidence about land-scarce households behavior with respect to on-farm activities (Evans, 1997; Peters, 1993). These studies report households having a tendency to neglect on-farm activity in favor of off-farm employment during the peak season in search of cash and food. Often this has led to late land clearing and planting, weeding and thinning reported to reduce crop yields by about 20 percent to 30 percent (Alwang and Siegel, 1999).[1] Alwang et al (1996) also have pointed out that during the peak agricultural season poor households are more likely to withdraw children from school to help on the farm. All these factors may explain the labor productivity and pattern use in most of the

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[1] Some authors have suggested that late land clearing and planting as well as untimely and insufficient weeding are reflections are signs of labor shortages (Donavan, 1994; and Sahn and Arulpragasan, 1993).

farms in the study area, particularly those in the low L-AE category. It might be the case that more productive members in these farms are favoring off-farm activities when cash and food demand raise and on-farm activities are left to less productive members in the household.

Third, one would expect more resourceful farms such as those within the high L-AE category to have hired more labor across enterprises than was observed. Although this was not the case, these farms did hire labor for more enterprises than farms in the low L-AE category, especially those in enterprises which included cash crops. Results from the aggregate analysis show that an average smallholder cashew farm do hire labor across all enterprises. The amount of labor hired is often higher on sole cropped fields than is the case for mixed cropped.

The forthcoming section examines smallholder returns to resources applied across enterprises by farm categories. The analysis focus first on food crop enterprises which did not include cashew. Then the performance of enterprises including cashew is also examined.

6.1.2 Profitability Analysis of Smallholder Cashew Cropping

This section examines the financial performance of the current smallholder food crop enterprises. These enterprises include sole peanuts, manioc, and cashew and their combinations across land per adult equivalent farm categories. A partial budget for each enterprise is constructed. These budgets are based on the smallholder cashew farm typology developed in Chapter Four. For each set of crop enterprises (food crops without cashew *vs* those with cashew) we first discuss enterprise profitability measures for representative low, medium, and high L-AE smallholder farm types. Then we aggregate over all farms to examine the profitability of crop enterprises from the perspective of a typical smallholder cashew farm in the study area.

A comparative evaluation of the most common food crops grown without cashew is presented first. Then cashew and its combinations with food crops are examined. All the tables show yield information, value of production, operating costs and performance measures such as returns to land, family labor and management, and returns per AE day of family labor. As will be shown later, yields vary across farming systems and farm categories. This reflects not only agro-climatic conditions, but also differences in farm resource management. The daily off-farm wage rate is assumed as a reference point for the opportunity cost of family labor against which the profitability of the enterprises is examined. Total outlay costs include the cost of hired labor on clearing and preparing the field crops, weeding and thinning, and harvesting, and depreciation of agricultural tools. These costs are presented in Tables 6-2 through 6-8.

6.1.2.1 Returns to Food Cropping Enterprises

The costs and returns realized from food crop enterprises under the current cropping systems are presented by smallholder L-AE farm category in Tables 6-2 through 6-5. Table 6-2 shows that the net returns per family AE labor day in the low L-AE farm category across enterprises vary from the low \$0.46 on sole peanuts to the high \$1.48 on

Table 6-2 Comparative Evaluation of Returns to Food Crop Enterprises for the Low L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Food Crop Mixtures				
	Peanuts	Manioc	Manioc and Beans	Manioc and Peanuts	Manioc, Beans and Peanuts
Yield Information	---------- kgs per Ha ----------				
Mean Yield					
Peanuts	190.28	-	-	432.57	435.57
Beans	-	-	132.89	-	132.89
Manioc	-	764.1	722.1	722.15	722.57
Budget Items	---------- $ per Ha ----------				
Gross Receipts	53.28	131.81	159.39	245.69	280.51
Operating Costs					
Purchased inputs, excluding labor	0.48	0.48	0.95	0.95	1.43
Hired labor	14.91	0	0	0	20.06
	---------- AE labor days per Ha ----------				
Family Labor	82.7	88.63	309.3	335.7	197.1
Performance Measures	---------- $ per Ha and $ per AE labor day ----------				
Net Returns to Land, Family Labor and Management per Hectare	37.89	131.33	158.44	244.74	259.02
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.46	1.48	0.51	0.73	1.31

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/99.

sole manioc. Within this interval, only the latter and the mixed cropped combination of manioc with beans and peanuts can be grown profitably by low L-AE farms at the daily off-farm mean wage rate of $0.98. Accounting for potential measurement errors in the data and the partial nature of the crop budgeting method, it is possible that smallholders in the low L-AE category could also grow profitably the mixed cropped combination of manioc and peanuts. The differences in returns are due to varying yields and levels of labor more of it was used than in any other enterprise. One point to note in Table 6-2 is the fact that yield on sole peanuts is very low, as well as the amount of labor devoted to it, compared to other crops. Given that labor requirements for peanuts are not significantly different from those for manioc, peanut yield seems to be accounting more for the low profitability performance of this enterprise than does labor. This may suggest that either the land devoted to sole peanuts is small and marginal, or the productivity of labor on sole peanuts is low compared to manioc. In fact, sole peanuts land area was 5.4 percent of all cultivated land area per household in the low L-AE category. Note also that these farms used about 57 to 70 percent (309.3 and 335.70 AE labor) more family labor in growing intercropped manioc with both beans and peanuts than was the case in the most profitable enterprise (sole manioc). In addition, beans have lower yield relative to peanuts, a cash crop with a higher market price. Beans yield and price cannot over weigh the returns from relatively high yield and price of peanuts. Nonetheless, it appears that where peanuts is present, it makes a difference in terms of profitability for this group of farms.

In Table 6-3 costs and returns for farms in the medium L-AE smallholder category are presented. Returns range from the low of $0.67 per day of family labor from the least profitable enterprises (sole peanuts and mixed cropped manioc with beans) to the high of $1.74 per day of family labor of the most profitable enterprise (mixed cropped manioc with peanuts). In addition to sole cropped manioc where medium L-AE farms earned a net return per day of family labor of $1.63, these farms add about $1.41 per day from the enterprise of mixed cropped manioc with beans and peanuts. Note that for medium L-AE farms peanuts seems to be profitable only under mixed cropping

Table 6-3 Comparative Evaluation of Returns to Food Crop Enterprises for the Medium L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Components	Food Crop Mixtures				
	Peanuts	Manioc	Manioc and Beans	Manioc and Peanuts	Manioc, Beans and Peanuts
Yield Information	kgs per Ha				
Mean Yield					
Peanuts	612.32	-	-	503.12	503.12
Beans	-	-	228.31	-	228.31
Manioc	-	650.01	458.19	458.19	458.19
Budget Items	$ per Ha				
Gross Receipts	243.6	112.13	138.85	219.91	279.73
Operating Costs					
Purchased inputs, excluding labor	0.54	0.54	1.07	1.07	1.61
Hired labor	8.31	3.3	0	0	14.03
	AE labor days per ha				
Family Labor	243.6	66.5	206.4	126	187.8
Performance Measures	$ per Ha and $ per AE labor day				
Net Returns to Land, Family Labor and Management per Hectare	162.6	108.29	137.78	218.84	264.09
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.67	1.63	0.67	1.74	1.41

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/99.

conditions, as was the case for low L-AE farms. Differences in returns across enterprises for these farms is also explained by differences in labor use and low yields. For instance, where yield of most valued crops is relatively high (ex. sole peanuts), family labor use is almost twice as high as that used in the most profitable enterprise. The same pattern shows up in the manioc and beans enterprise where labor used was about 64 percent higher than that used in the manioc and peanut enterprise.

Table 6-4 Comparative Evaluation of Returns to Food Crop Enterprises for the High L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Food Crop Mixtures				
	Peanuts	Manioc	Manioc and Beans	Manioc and Peanuts	Manioc, Beans and Peanuts
Yield Information	kgs per Ha				
Mean Yield					
Peanuts	870.9	-	-	286.57	286.57
Beans	-	-	185.38	-	185.38
Manioc	-	774.84	453.67	453.67	453.67
Budget Items	$ per Ha				
Gross Receipts	243.87	133.66	126.83	158.5	207.07
Operating Costs					
Purchased inputs, excluding labor	0.59	0.59	1.17	1.17	1.76
Hired labor	0	33.44	8.34	3	15.29
	AE labor days per Ha				
Family Labor	265.6	59.1	58.8	106.6	189.5
Performance Measures	$ per Ha and $ per AE labor day				
Net Returns to Land, Family Labor, and Management per Hectare	123.01	99.63	117.64	154.33	190.02
Net Returns to Land, Family Labor, and Management per Family AE Labor Day	0.92	1.69	2	1.45	1

Source: Smallholder Cashew Production Technology Survey , Nampula 1998/99.

Similar results were obtained in the analysis of smallholder high L-AE farm category. As Table 6-4 shows, these farms can grow profitably sole manioc, and all of its mixtures with beans and peanuts. Sole peanuts is not a profitable enterprise when judged against the assumed opportunity cost of labor of $0.98 per labor day. Net returns per day of family labor range from $0.92 on sole peanuts to $2.00 on mixed cropped manioc with beans. Within this category of farms, the highest net returns are boosted by the low levels of labor used. Note that the farms in this category have relatively low levels of labor use in most of the food enterprises. While recognizing the potential effects of measurement errors on these labor estimates, it is important to note that similar ranges were observed in other studies. For instance Strasberg (1997) estimated family labor use on manioc enterprises ranging from 51.39 AE days per hectare by low yield tercile households to 142.51 AE days per hectare by high yield tercile households in the non-cotton growing category. If one recalls that households portrayed in Table 6-4 are those in the high land to labor ratio, lack of family labor and relatively low levels of hired labor might be the factors explaining the results obtained in this category.

Let us now turn to analysis of a typical farm. Table 6-5 shows results from the aggregate analysis for food crops grown without cashew. Net returns per family AE labor day for a typical smallholder cashew farm vary from the low \$0.65 on mixed cropped manioc with beans to the high \$1.24 on manioc in combination with beans and peanuts. Within this net return interval, profitability measures show that at the daily off-farm mean wage rate of \$0.98, only sole cropped manioc and manioc intercropped with peanuts can be grown at profit by the typical average cashew household. The net return per family labor day on sole peanut suggest that with full accounting of potential measurement errors in the data a typical household could also grow profitably sole peanuts. The net returns to labor, land and management per family AE labor day is lowest on mixed cropped manioc with beans, and this is particularly explained by the relatively higher labor levels used compared to other crop enterprises within the farm. The most profitable crop mixture is mixed cropped manioc with beans and peanuts which earned a net return

Table 6-5 Comparative Evaluation of Returns to Food Crop Enterprises for the Typical Smallholder Cashew Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Food Crop Mixtures				
	Peanuts	Manioc	Manioc and Beans	Manioc and Peanuts	Manioc, Beans and Peanuts
Yield Information			kgs per Ha		
Mean Yield					
Peanuts	441.41	-	-	406.66	406.66
Beans	-	-	175.31	-	175.31
Manioc	-	774.84	536.14	536.14	536.14
Budget Items			$ per Ha		
Gross Receipts	124.43	133.66	138.42	206.35	252.28
Operating Costs					
Purchased inputs, excluding labor	0.53	0.53	1.07	1.07	1.6
Hired labor	11.11	11.31	2.25	1.37	15.37
			AE labor days per Ha		
Family Labor	157.4	101.1	208.4	182.9	189.5
Performance Measures			$ per Ha and $ per AE Labor day		
Net Returns to Land, Family Labor and Management per Hectare	112.79	121.82	135.09	203.91	235.31
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.72	1.2	0.65	1.11	1.24

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/99.

of $1.24 per AE labor day. An important point to note is that the current allocation of land by a typical smallholder cashew farm does not favor the most profitable crops, with the exception of sole manioc. Under the current cropping system, land area for mixed cropped manioc with beans and peanuts is about one percent of total cultivated area whereas that of sole manioc is about eight percent. Alternatively, sole peanuts occupies about three percent, and four percent of area is for mixed cropped manioc with beans, and mixed cropped manioc with peanuts, respectively. The high profitability shown by the manioc crop combination with beans and peanuts is due to high crop yields.

At the typical level, there seems to be no clear pattern on net returns across enterprises with respect to which crop enhances profitability as was the case for farms in the low L-AE category where peanuts seemed to make a difference in the profitability of mixed cropped enterprises. Nonetheless, manioc and peanuts continue to be important for a typical household as was the case for each of the L-AE farm types, particularly in the low L-AE category.

To summarize, these results show that farms in the low L-AE category would not grow profitably any of the food crops, except sole cropped manioc and mixed cropped combination of manioc with beans and peanuts. It appears that peanuts make a difference in the profitability of mixed cropped enterprises for this category of farms. This seem to suggest that between cashew and peanuts, the most commonly grown cash crops in the study area, low L-AE farmers are more likely to grow peanuts. This may be due to peanuts' low requirement in land area, and its role in the household as an alternative source of cash. In contrast, the likelihood for high L-AE farms to grow profitably manioc enterprises is high (as it is for medium L-AE farms). However, these farms are growing sole peanuts at loss. For all categories of farms, low profitability seems to be driven mainly by differences in labor use per unit of land (l-l ratio), particularly in those enterprises where households relied mostly on family labor, potentially of low productivity.

At the typical household level, it is hard to identify any general pattern with respect to which crops receive relatively more importance than other crops. However, as is the case for the L-AE farm type, sole manioc and peanuts under mixed cropping conditions seem to play an important role in household cropping systems. As it was pointed earlier, this may be reflecting the fact that manioc is the main food staple for households in the study area while peanuts is an alternative source for cash, next to cashew.

6.1.2.2 Returns to Cashew-Food Cropping Enterprises

This section discusses the profitability performance of the current smallholder enterprises which included cashew cultivation. The analysis focuses on cashew grown either sole or intercropped with food crops. Table 6-6 shows that low L-AE farms realize positive net returns across enterprises. However, in both sole cashew, and mixed cropped cashew with manioc and beans, the net returns are below the opportunity cost of labor. In the most profitable enterprises net returns per family labor day vary from $1.04 to $1.76 with the lowest on mixed cropped cashew with manioc, beans and peanuts, and the highest on mixed cropped cashew with manioc. The second best enterprise for low L-AE farms includes peanuts. In this enterprise, however, labor used was also high. For instance, labor use in the cultivation of mixed cropped cashew with manioc and beans, cashew with manioc and peanuts was almost three times higher than that used in the most profitable enterprise (cashew and manioc). However, this amount of labor was allocated mostly to manioc, and not to cashew.

This pattern of labor use seems to confirm earlier findings that farmers are putting little labor into cashew, particularly on sole cropped fields. Furthermore, it appears that labor allocated to other crop enterprises is not resulting in higher yields. If one accounts

Table 6-6 Comparative Evaluation of Returns to Cashew and Food Crop Enterprises for the Low L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Cashew	Cashew and Manioc	Cashew, Manioc and Beans	Cashew, Manioc and Peanuts	Cashew, Manioc, Beans and Peanuts
		Cashew and Food Crop Mixtures			
Yield Information		------ kgs per Ha ------			
Mean Yield					
Cashew	75.4	22.08	22.08	22.08	22.08
Manioc	-	722.15	722.15	722.15	722.15
Beans	-	-	132.89	-	132.89
Peanuts	-	-	-	432.57	432.57
Budget Items		------ $ per Ha ------			
Gross Receipts	28.65	132.96	167.78	254.08	288.9
Operating Costs					
Purchased inputs, excluding labor	0.48	0.95	1.43	1.43	1.9
Hired labor	0.6	3.54	27.93	0	6.83
		------ AE labor days per Ha ------			
Family AE labor days	32	72.9	212.2	208.9	269.6
Performance Measures		------ $ per Ha and $ per AE labor day ------			
Net Returns to Land, Family Labor and Management per Hectare	27.58	128.47	138.42	252.66	280.17
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.86	1.76	0.65	1.21	1.04

Source: Smallholder Cashew Production Technology Survey , Nampula 1998/99.

for household own consumption, these losses are even higher.[2] It is, therefore, reasonable to conclude that low L-AE farms may not be selling any output at all.

Alternatively, Table 6-7 present summaries of the cashew-food enterprise budgets for the medium L-AE smallholder cashew farm category. Here the returns per AE family labor day across enterprises vary from the lowest of $0.49 on sole cashew to the highest of $2.96 on mixed cropped cashew with manioc, beans and peanuts. In

[2] Note studies in Nampula indicate that about 58 percent of the household income is from value of household retained food staples (Benfica, 1998).

Table 6-7 Comparative Evaluation of Returns to Cashew and Food Crop Enterprises for the Medium L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Cashew	Cashew and Food Crop Mixtures: Cashew and Manioc	Cashew, Manioc and Beans	Cashew, Manioc and Peanuts	Cashew, Manioc, Beans and Peanuts
Yield Information		---------- kgs per Ha ----------			
Mean Yield					
Cashew	40.92	53.32	53.32	53.32	53.32
Manioc	-	458.19	458.19	458.19	458.19
Beans	-	-	228.31	-	228.31
Peanuts	-	-	-	503.12	503.12
Budget Items		---------- $ per Ha ----------			
Gross Receipts	15.55	99.3	150.12	240.17	299.99
Operating Costs					
Purchased inputs, excluding labor	0.54	1.07	1.61	1.61	2.15
Hired labor	0.3	1.54	10.16	2.07	0
		---------- AE labor days per Ha ----------			
Family Labor	29.8	50.8	140.5	202.13	100.6
Performance Measures		----------$ per Ha and $ per AE labor day ----------			
Net Returns to Land, Family Labor and Management per Hectare	14.71	96.68	147.35	236.49	297.84
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.49	1.9	1.05	1.17	2.96

Source: Smallholder Cashew Production Technology Survey , Nampula 1998/99.

addition to intercropped cashew with manioc, beans and peanuts, other profitable enterprises included mixed cropped cashew with manioc ($1.90), mixed cropped cashew with manioc and peanuts ($1.17), and mixed cropped cashew with manioc, beans, and peanuts ($1.05). While low prices and low yields explain the low net returns on sole cropped cashew these farms also used relatively more labor on the cashew/manioc/beans and cashew/manioc/peanuts crop mixtures. This has reduced their profitability.

The results for farms in the medium L-AE category contrast with those in the high L-AE category. For example, Table 6-8 shows that farms in this category can profit from

Table 6-8 Comparative Evaluation of Returns to Cashew and Food Crop Enterprises for the High L-AE Smallholder Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Cashew	Cashew and Food Crop Mixtures: Cashew and Manioc	Cashew, Manioc and Beans	Cashew, Manioc and Peanuts	Cashew, Manioc, Beans and Peanuts
Yield Information		------------------------kgs per Ha-----------------			
Mean Yield					
Cashew	53.28	131.43	131.43	131.43	131.43
Manioc	-	453.67	453.67	453.67	453.67
Beans	-	-	185.38	-	185.38
Peanuts	-	-	-	286.57	286.57
Budget Items		---------------------$ per Ha ------------------			
Gross Receipts	20.25	128.2	176.77	208.44	257.01
Operating Costs					
Purchased inputs, excluding labor	0.59	1.17	1.76	1.76	2.35
Hired labor	6.15	0.12	0	1.17	8.57
		------------------------AE labor days per Ha----------------			
Family AE labor days	9.6	187.8	261.7	171.1	108.6
Performance Measures		-------------$ per Ha and $ per AE labor day---------			
Net Returns to Land, Family Labor and Management per Hectare	13.51	126.91	175.01	205.51	246.09
Net Returns to Land, Labor and Management per Family AE Labor Day	1.41	0.68	0.67	1.2	2.27

Source: Smallholder Cashew Production Technology Survey , Nampula 1998/99.

cashew cultivation under sole cropping, and under mixed cropped conditions with manioc and peanuts, and with beans and peanuts. An examination of the enterprise budget summaries suggest that net returns per AE family labor day range from $0.67 to $2.27. The lowest net return is from mixed cropped cashew with manioc and beans, and the highest from mixed cropped cashew with manioc, beans and peanuts. Households here are able to profit more when both cash crops (cashew and peanuts) are grown together. Enterprises including peanuts and cashew yielded the highest net returns relative to those without both crops. These results confirm findings highlighted earlier about households in the high L-AE farm category allocating more resources to those enterprises which included both peanuts and cashew, than those farms in the low L-AE category which do not have an option between these two crops due to constraints on land.

Apart from whether peanuts and cashew were in a particular combination and contributed to the higher net return it is worth noting that cashew yields are also different both by cropping system and among farm categories. Recall that in Chapter Five on determinants of cashew productivity we had the opportunity to discuss these differences. The highest cashew yields per tree were found on mixed cropped cashew fields for farms in the high L-AE category whereas the low L-AE farms had shown the highest cashew yields per tree on sole cropped cashew fields. Furthermore, it should be noted that yield per hectare is driven both by cashew yield per tree and density. With respect to the latter, farms in the low L-AE category have a higher density (52 trees) on fields where they show higher yield per tree. However, as Table 6-6 shows a yield per hectare on mixed cropped cashew fields of about 29 percent of that on sole cropped fields. The mixed cropped fields have a density of about 32 cashew trees. Alternatively, with a higher yield per tree on mixed cropped fields, high L-AE farms have a higher yield on per hectare basis. Nonetheless there are no significant statistical differences in density on mixed cropped fields across L-AE farm categories.

Aggregating results in Table 6-9 present financial enterprise profitability measures for a typical smallholder cashew farm which show positive net returns across all cashew enterprises. However, in both sole cashew, and mixed cropped cashew with manioc and beans, the net returns are below the opportunity cost of labor of $0.98 per

Table 6-9 Comparative Evaluation of Returns to Cashew and Food Crop Enterprises for the Typical Smallholder Cashew Farm Type in Surveyed Areas in Nampula, 1998/99

Enterprise Information	Cashew	Cashew and Food Crop Mixtures			
		Cashew and Manioc	Cashew, Manioc and Beans	Cashew, Manioc and Peanuts	Cashew, Manioc, Beans and Peanuts
Yield Information		kgs per Ha			
Mean Yield					
Cashew	53.76	46.36	46.36	46.36	46.36
Manioc	-	536.14	536.14	536.14	536.14
Beans	-	-	175.31	-	175.31
Peanuts	-	-	-	406.66	406.66
Budget Items		$ per Ha			
Gross Receipts	20.43	110.16	156.03	223.97	269.9
Operating Costs					
Purchased inputs, excluding labor	0.53	1.07	1.6	1.6	2.14
Hired labor	1.88	1.58	13.94	1.01	5.66
		AE labor days per Ha			
Family AE labor days	25.3	110.6	166.1	197.8	166.4
Performance Measures		$ per Ha and $ per AE labor day			
Net Returns to Land, Family Labor and Management per Hectare	18.02	107.45	140.49	221.35	262.1
Net Returns to Land, Family Labor and Management per Family AE Labor Day	0.71	0.97	0.85	1.12	1.58

Source: Smallholder Cashew Production Technology Survey , Nampula 1998/99.

labor day assumed for the analysis. Taking into account that the analysis is partial, and a number of variables in the household decision making are not fully accounted for, it is possible that both the $0.85 and $0.71 net returns per labor day on sole cashew and mixed cropped cashew with manioc and beans are close to the opportunity cost of labor, in which case a typical smallholder cashew farm would have been able to grow profitably all the cashew crop enterprises. Note that the most profitable cashew enterprises include the two cash crops, cashew and peanuts. In addition, these enterprise include manioc, the single most important food staple in the study area, in terms of food security. As was the case for medium L-AE farms, a typical household farm is able to profit more when both cash crops (cashew and peanuts) are grown together. Enterprises including peanuts and cashew yielded the highest net returns relative to those without both crops. Recall that a similar result was found with respect to households in the medium and high L-AE farm category. These households allocated more resources to those enterprises which included both peanuts and cashew, than those farms in the low L-AE category which do not have an option between these two crops due to constraints on land.

In summary, the profitability differences across the various farm types can be explained both by the high value of both peanuts and cashew in those crop combinations where both appear, and the differences across cropping systems and farm categories on cashew yield per tree, and density. In the next section, we build upon on the profitability measures obtained above within each farm category to make comparisons across farm categories.

6.1.3 Inter-Farm Comparisons of Enterprises Profitability

This section compares enterprise profitability indicators across smallholder farm categories. It is important to bear in mind some key points referred to in previous sections about differences in resource endowments, particularly land and labor which leads farms in each category to allocate more of a particular resource into the cultivation of specific crop, in detriment of , in many cases, seemingly most profitable enterprises. Access to sufficient land and timely family and/or hired labor is crucial for the observed patterns of enterprise performance by farms in different categories. Of particular importance is the fact that households in the low L-AE category have less land area per AE compared to those in the medium and high L-AE categories. This implies, and the data confirms, that each household in the low L-AE category has less total land area while it has relatively more family labor available than households in other farms categories. As one carries out the analysis that follows, in addition to yield and prices, resource allocation to different enterprises will become important in interpreting the results. These variables affect the magnitude of the enterprise returns obtained by the farm.

Private profitability across farm categories in Table 6-10 shows that on land cultivated with food staples without cashew, farms in the low L-AE category earned lower net returns per family labor day compared to farmers in other categories for all crop enterprises, except on mixed cropped manioc with beans and peanuts where high L-AE farms obtained the lowest net return to family labor. However, as mentioned earlier if one accounts for potential measurement errors, profitability of mixed cropped manioc with peanuts could have been higher than observed for the low L-AE farms. On that count, it seems that low L-AE farms would have exhibited lower losses as they did on sole cropped peanuts, but relatively higher on mixed cropped manioc with beans compared to farms in other categories.

It is also shown that farms in the high L-AE category earned the highest return per family labor day only on enterprises where peanuts were not part the crop mixture. On sole cropped manioc high L-AE farms earned the lowest returns to land, labor and management compared to farms in other categories. In addition, when family labor is

Table 6-10 Returns to Labor, Land and Management by Crop Mixes and Smallholder Farm Types in Surveyed Areas of Nampula Province, 1998/9

Enterprise Combinations	Smallholder Cashew Farm Categories of Land per AE						Typical Smallholder Cashew Farm	
	Low		Medium		High			
	($/AE day)	($/ha)	($/AE day)	($/ha)	($/AE day)	($/ha)	($/AE day)	($/ha)
Food Crops Only								
Peanuts	0.46	37.89	0.67	162.60	0.92	243.28	0.72	112.79
Manioc	1.48	131.33	1.63	108.29	1.69	99.63	1.20	121.82
Manioc *with* Beans	0.51	158.44	0.67	137.78	2.00	117.64	0.65	135.09
with Peanuts	0.73	244.74	1.74	218.84	1.45	154.33	1.11	203.91
with Beans *and* Peanuts	1.31	259.02	1.41	264.09	1.00	190.02	1.24	235.31
Cashew and Food Crops								
Cashew	0.86	27.58	0.49	14.71	1.41	13.51	0.71	18.02
Cashew *with* Manioc	1.76	128.47	1.90	96.68	0.68	126.91	0.97	107.45
with Manioc *and* Beans	0.65	138.42	1.05	147.35	0.67	175.01	0.85	140.49
with Manioc *and* Peanuts	1.21	252.66	1.17	236.49	1.20	205.51	1.12	221.35
with Manioc, Beans *and* Peanuts	1.04	280.17	2.96	297.84	2.27	246.09	1.58	262.10
Wage Rate per Labor Day, ($US)					**0.98**			

Source: Smallholder Cashew Production Technology and Smallholder Productivity Survey in Nampula Province, Mozambique, 1998/9.

valued at its opportunity cost, none of the farms in other categories could realize positive returns to land on mixed cropped manioc with beans as did high L-AE farms.

With respect to cashew-food cropping enterprises, sole cropped cashew was not financially attractive to farms in the to low and medium L-AE categories. These farms earned net returns per family labor day of $0.86 and $0.49, respectively. These estimates are below the opportunity cost of family labor on off-farm activities. Only farms in the high L-AE category could earn net returns per day of family labor above the opportunity cost, and positive returns to land. Under mixed cropping conditions, farms in the medium L-AE category earned the highest net return per family labor day on mixed cropped combinations of cashew with manioc ($1.90), and with manioc, beans and peanuts ($2.96). On both enterprises, low L-AE farms could realize a positive net returns above opportunity cost of labor. In contrast, on this enterprises high L-AE farms could not realized returns per family labor day above the off-farm wage rate on mixed cropped cashew with manioc. Further analysis indicates that low L-AE farms could earn net returns to land about 22 percent above those earned by medium L-AE farms on mixed cropped cashew with manioc(note that returns to land were negative for high L-AE farms). On mixed cropped cashew with manioc and peanuts, returns to land were about 24.5 percent above those obtained by medium, and 26.6 percent on those earned by high L-AE farms. However, low L-AE farms earned about 91 percent less returns to land than those earned by farms in the medium L-AE category, the highest in the sample. A note here is that even when cashew comes into play, still manioc and peanuts seems to be the most important crops for the farms in the low L-AE category.

The patterns described above seems to show that positive returns to land on sole cropped manioc across farm categories reflect the importance of this crop to the smallholder's food security strategy. Furthermore, it sheds light on the relative importance of intercropping for some households as a mechanism of risk diversification. While beans and peanuts play a role in household food consumption, a sole cropped field of manioc provides an insurance against production failure on intercropped fields.[3] This is not necessarily the case for sole cropped peanuts where small and marginal portions of land seem to be used with very low productivity of labor, as it seems to be for the case of farms in the L-AE category. In fact, sole cropped manioc makes up about eight percent of total cultivated land area by a typical smallholder cashew producer in the study area. This is the highest proportion of cultivated land area allocated to both single crop or crop mixtures observed in the data. Sole peanut makes up only about three and half percent of total cultivated land area by a typical smallholder cashew farm.

We also examined enterprise budgets for a typical smallholder cashew farm. The results indicate that a typical smallholder cashew farm would grow profitably sole cropped manioc ($1.20 per family labor day) and mixed cropped with peanuts ($1.11 per family labor day), and with beans and peanuts ($1.24 per family labor day). In these enterprises, the household would earn a net return per family labor day 22.5 percent, 13.3 percent and 26.5 percent, respectively above the daily off-farm wage rate. Returns per

[3] Often farmers have referred to some sole cropped manioc fields where harvest is delayed compared to other fields where harvest may be shortened as a result of food shortage or need to grow other crops.

day of labor on the typical sole cropped manioc farm were lower than that low, medium and high L-AE farms would earn. This is also generally the case for mixed cropped manioc with beans, mixed cropped manioc with peanuts, and mixed cropped manioc with beans and peanuts. Accounting for all missing variables, it could be possible that the profitability of sole cropped peanuts was higher than observed. Note again that the latter two enterprises include peanuts which we referred to as the only cash crop alternative to cashew for land-poor households. In addition, under the prevailing economic conditions, a typical smallholder cashew farm would grow crops with cashew profitably only when the crop mixtures include manioc and peanuts ($1.12 per family labor day), or manioc, beans and peanuts ($1.58 per family labor day). With these enterprises, a typical farmer would have earned net returns to labor, land and management higher than those earned by a high L-AE farm type. However, net returns per labor day are lower on mixed cropped cashew with manioc, beans and peanuts compared to those earned by a farm in the medium and high L-AE category on this enterprise. Note that the range of net returns to family labor ($0.71 - $0.97) for the sole cropped cashew, mixed cropped cashew with manioc both manioc and beans is not significantly different from the opportunity cost of labor. Allowing for measurement errors, and missing factors in a household's resource allocation decision, these enterprises may be profitable as well. These results suggest, however, even when cashew is grown under a mixed cropping system, the presence of peanuts in the crop mixture is important for the profitability of the whole combination.

To summarize, it should be pointed out that the analysis conducted above has assumed that farms within each category used the same technology in both production of cashew and food crops. The analysis of a typical smallholder cashew farm seems to reflect most of the same findings when the analysis is done by L-AE category. Namely, that the observed reluctance by farmers to keep producing certain crops or crop combinations with low profitability reflects the multiple objectives they need to satisfy under constrained circumstances. When farmers have to meet food security requirements, allocation of resources to production of staple foods is more important than to cash crops. This is the case for the presence of manioc and peanuts in most profitable enterprises. In addition, enterprises such as sole cropped cashew will remain unprofitable for so long in the household's portfolio because of the high cost to clear these fields from uneconomic trees. As food security remains a priority in the household, labor cannot be diverted into these activities, especially when incentives are low and farmers are skeptical about the outcomes of their investments.

While potential measurement errors in the data may exist, differences observed in the analysis has shown that there are marked differences in labor allocated to different crops across farm categories, and this was explained to be a result of differences in labor intensity, productivity and resource management. These differences explain to a large extent the range of enterprise profitability across farm categories.

6.2 Conclusions

The purpose of the chapter was to assess the financial performance of current smallholder food and cashew enterprise activities. The analysis by farm category across enterprises show that low L-AE farms can only undertake profitably sole manioc, and mixed cropped manioc with beans and peanuts. Alternatively, both medium and high L-AE farms were found to grow profitably manioc with most of its mixtures with beans and peanuts, but were growing sole peanuts at a loss. Medium L-AE farms also realized low returns on mixed cropped manioc with beans. It was also found that farms in the low L-AE category could not grow cashew profitably, either sole or intercropped with manioc and beans. However, one must interpret the result from the sole cashew enterprise for this group of farms with caution. Measurement errors or difficulties in accounting for all factors in smallholder decision process regarding resource allocation may have had an effect on the net return per family labor day obtained for this enterprise. Still the analysis suggest that it is difficult to explain why these farmers were growing sole cropped cashew. Farms in the medium L-AE category realized net returns per family labor day above the opportunity cost of labor off-farm in all cashew enterprises, except in sole cropped cashew. Only farms in the high L-AE category could profit from cashew cultivation on sole cropped fields while they realized net returns per family labor day below the opportunity cost of labor on mixed cropped cashew with manioc and in combination with manioc and beans.

While there was not a definite pattern which to explain farmer' crop orientation across both the L-AE farm and typical farm categories, all farms were found to have a crop portfolio which included the most commonly grown crops in the study area. The financial analysis shows that differences in profitability across enterprises and/or farm categories were driven either by differences in yield levels, or output prices. Differences in the amount of labor used also contributed to the observed profitability patterns. For instance, it was shown that farms in the low L-AE category allocated more labor resources on fields where manioc and peanuts were the most important crops than did farms in the medium and high L-AE smallholder categories. These findings seem to provide insights about smallholder low L-AE farm's risk attitude which may result from land constraints and the need to produce sufficient food for their own consumption. On the other hand, the fact that the only food enterprises in which farms in the low L-AE category realized returns either close or above the opportunity cost of labor were those which included manioc and peanuts may suggest that these farms see these crops as very important for their food security status. Peanuts is the only most immediate alternative source for cash for these resource-poor households compared to more resourceful farms in the medium and high L-AE categories who can count on both cashew and peanuts.

Furthermore, the low levels of labor use observed in sole cashew cropping across smallholder cashew farm categories seems to provide insights about perceived effects of the current economic conditions on farmer's incentives to take care of existing cashew trees. On the other hand, the fact that smallholder farms in the high L-AE category seems to be able to hire in significantly more labor across enterprises than those in the low L-AE category provides another piece of information on the hiring ability of some households in the smallholder sector. As most of the hired labor is particularly employed in weeding and harvesting, it is not clear however, whether high L-AE farms ability to pay, is *in kind,* or if it happens that these farms have the cash or better access to financial resources not available to other farms. Results from the typical analysis supports these findings, particularly with respect to relatively less profitable enterprises. It seems that farmers persist with relatively unprofitable crops or crop combinations due to multiple objectives they need to satisfy under constrained circumstances. When farmers have to meet food security requirements, allocation of resources to production of staple foods seems to get first priority and thus food crops become more important than cash crops.

In Chapter 7 we pursue the goal of setting up a model which takes into account the financial information computed above and the resource constraints analyzed in previous chapters to introduce innovations in the current smallholder cashew cropping systems and look at choices made by farms in different L-AE categories.

CHAPTER 7

A FINANCIAL AND ECONOMIC ANALYSIS OF THE IMPROVED SMALLHOLDER CASHEW FARMING SYSTEMS IN THE PROVINCE OF NAMPULA

7.0 Introduction

In Chapter Three, a number of technological options were examined for farmers seeking to improve cashew productivity. In Chapter Six crop budgeting was used to estimate and compare net returns per hectare and per family labor day across crop enterprises using traditional cropping practices. Although these profitability measures may well serve as policy guidelines, they have some limitations for on-farm planning. First, net margins comparisons disguise high cost (but profitable) alternatives which may be unaffordable for resource-poor farmers. Second and most important, farm operations often compete for the same resources. This creates an opportunity cost of resource use which cannot be depicted in crop budgeting without further analysis. Thus inter-relationships among farm operations in the use of common resources require a system approach to farm analysis, particularly when farmers are looking for alternative ways to improve current practices.

In this chapter we propose to examine three packages which include chemical control of PMD (*CCPMD*), top-working plus chemical control of PMD (*TWCPMD*), and integrated cashew management (*ICM*). For the purposes of this study, in addition to *CCPMD* and *TWCPMD* packages, the *ICM* package includes thinning and replanting of cashew trees. These packages apply only to cashew, regardless of the sole or intercrop mixture in which they are applied. The *TWCPMD* package differs from the *CCPMD* package by the inclusion of top-working. Top-working is a technique by which the canopy of an old and unproductive cashew tree is completely replaced by a new one through grafting of new and improved planting material. In this package, it is assumed that the farmer will top-work 28 percent of his/her trees, and spray the reminder to control for PMD.[1]

The data used in the analysis of new technologies and improved management practices in cashew production is mostly obtained from secondary sources. It is important to note that these technologies are still being tested on-station in Mozambique. That is, implementation of these packages is not yet within the smallholder on-farm realm. As a result, all the budgets assessing the profitability of these technologies are synthetic and reflect similar practices in other countries where they have been tested, used and their impact assessed. For instance, technical coefficients on labor required to perform certain tasks of top-working, thinning and replanting cashew trees were obtained from Embrapa (in Brazil) while estimates for chemical control of PMD were obtained from the Tanzanian experience, and trials still underway in Mozambique. Expert advice was kindly provided by scientists both in Mozambique and Britain about the similarities of conditions in which cashew is grown. This was extremely helpful in making the

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[1] See Chapter Three for details on the proportions of cashew trees subject to treatment under each alternative technology and management improvement packages. These proportions were suggested by cashew researchers in the study area based on their observation of trees on farmers' fields. Age and degree of disease infection are the major variables in the decision of which tree will be subject to a given treatment.

necessary judgements and adjustments in estimates to reflect as much as possible Mozambique conditions.

Thus the role of this chapter is to generate insights about the relative sensitivity of farm's profit from adoption of new technologies to changes in profit determinants, or the magnitude of changes in output price, yield or input cost needed to make improved cashew technology profitable. As a result, the chapter will (1) estimate(under current smallholder cashew cropping conditions) the costs and returns to labor for one of the three new technology and improved management practices packages examined in Chapter Three, (2) compare these estimates with those from Chapter Six on traditional cashew cropping practices, and (3) use that information in developing a smallholder cashew household linear programming model to evaluate one of the technologies in the context of a whole farm system, and (4) build a capital budgeting model for other technologies to examine the time pattern of costs and returns to farmer's investments.

The next section appraises the financial profitability of one technology and improved management practices package described in Chapter Three ---chemical control of PMD(*CCPMD*) when applied to fields in which cashew is part of the enterprise mix.

7.1 Profitability Analysis of a Cashew Productivity Enhancing Technology

Farmers and policy makers in Mozambique have recognized the need for alternative technologies and improved management practices to reverse the declining trend in cashew productivity. Wide spread incidence of powder mildew disease (PMD) and increasingly aging trees have decreased yields, making the search for alternatives a pressing need to increase productivity on the approximately 97 thousand hectares of land that today host the national cashew orchard, most of which are producing insignificant yields or are not producing at all.

In Chapter Three we explored possible strategies for smallholders to increase production. Towards the end of that chapter, we have suggested feasible options for farmers operating under Mozambique's conditions. This section sets the stage for the LP model to be developed in the next section to evaluate the conditions under which smallholders currently cultivating cashew would be willing to invest in *CCPMD* package to improve existing cropping systems.[2] We recognize that whether smallholders can engage in these investments depends primarily on whether cashew production is sufficiently profitable. Part of this analysis has been conducted in Chapter Six.

The number of cashew trees per field (density) and the yield improvements are the two main factors in the profitability analysis of new cashew investment. The density levels used in the analysis are those found in Chapter Five and refers to the number of cashew trees per hectare under monocropped and mixed cropped cashew fields by low, medium and high land per adult equivalent ratio (L-AE) smallholder cashew farms. We note that the number of cashew trees in the field determines the amount of labor and other inputs needed to improve yields. The yield per tree is affected by both the density, and the amount of labor and other inputs going into the tree's management. In Chapter Five, we had the opportunity to evaluate the impact of a number of factors on yield, among

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[2] For details on the essence of these technology packages refer to Chapter Three.

those the cashew tree density and labor. Here it suffices to summarize that under the current levels of PMD and age of the trees, the higher is the density, the lower is the yield per tree, and thus more labor and other inputs would be required to increase yields.

The analysis of the *CCPMD* package is partial in the sense that profitability of an individual enterprise does not take into account the conflicts which might occur with simultaneous use of farmer's resource. In order to account for those inter-relationships in resource use one should value resources at their opportunity cost. A whole farm analysis will be conducted later when a household model is developed to look at the resource competition issues, particularly those related to alternative use of land and labor resources under traditional and new cropping activities.

In the next set of tables we present the costs and returns by farm category and by alternative cashew enterprise. Total costs include costs of purchased chemicals, grafting material, tractor services, and maintenance and harvesting costs. These costs are presented in Table 7-1 along with returns for the *CCPMD* package as applied on a sole cropped cashew field. As shown, under current economic conditions, chemical spraying of cashew trees to control PMD on sole cropped cashew trees appears unattractive across all farm categories. Returns to land and labor are negative for all farms. Despite the fact that farms in the low L-AE category realize positive returns, at current input and cashew prices it appears that none of the farms can benefit from the package under cashew sole cropping conditions. Net returns are in the range of negative 26 cents to 16 cents per labor day for farms in the low L-AE category, negative 68 cents to negative 47 cents for the medium L-AE category, and negative 53 cents to negative 25 cents per labor day for

Table 7-1 Financial Analysis of Sole Cashew Enterprise under Existing and Improved Production Practices by Low, Medium and High L-AE Smallholder Cashew Farm Types in Surveyed Areas of Nampula, Mozambique, 1998/9

Parameters	Smallholder Cashew Farm Categories and Technology Packages					
	Low(L-AE)		Medium(L-AE)		High(L-AE)	
	TRAD	CCPMD	TRAD	CCPMD	TRAD	CCPMD
Density and Yield Data						
Density (trees/ha)	52	52	44	44	48	48
Yield (kg/tree)	1.45	2.90	0.93	1.86	1.11	2.22
Price ($/kg)						
Cashew	0.38	0.38	0.38	0.38	0.38	0.38
Budget Items						
Gross Receipts ($/ha)	28.65	57.30	15.55	31.10	20.25	40.49
Operating Costs ($/ha)						
Purchased Inputs(excluding labor)	0.48	67.54	0.54	57.28	0.59	62.49
Purchased Services	0.60	2.61	0.30	2.03	6.15	2.22
Total Labor Use (man days/ha)	32.00	49.18	29.80	41.61	9.60	45.39
Performance Measures	-------------$ per ha and per AE labor day-------------					
Net Returns to Land, Labor and Management per hectare	27.58	-12.84	14.71	-28.21	13.51	-24.21
Net Returns to Land, Labor and Management per Family AE labor day	0.86	-0.26	0.49	-0.68	1.41	-0.53

Source: Smallholder Cashew Production Technology Survey in Nampula, Mozambique, 1998/9. TRAD stands for Traditional and CCPMD, for Chemical Control of PMD package.

farms in the high L-AE category. These net returns per day of labor are all below the opportunity cost of 98 cents per labor day assumed in the analysis. Note also that in comparing net returns per labor day before and after the application of the package, farmers across categories are actually worse-off than under the traditional sole cashew cropping situation.

The reason for these low returns are the extremely low cashew yields on sole cropped fields and the low cashew prices. Only farms in the low L-AE category are currently obtaining yields above one kilogram per tree on sole cropped fields. Additional labor and other inputs as required by the package add more to the cost than the low prices and yield improvement add to the gross returns. In terms of cost, the major cost is fungicides, which is a function of the number of trees to be treated. Note that earlier it was mentioned that while all cashew trees in a farmer's field may required spraying, this number will be smaller as farmers choose other technological alternatives such as top-working and thinning/replanting. Cash outlays are driven mostly by the spraying. The cost of planting and grafting material is very small compared to chemical inputs as required by other technological options. Efforts at reducing the cost of fungicides, or finding cost effective alternatives to it could have a high pay-off to farmers adopting new technologies in cashew productivity improvement.

An analysis of chemical control of PMD in the case of improvements on mixed cropped cashew with manioc is presented in Table 7-2. It indicates that farms in all L-AE categories are able to realize positive returns. There are three points worth noting, however. First, note that the *CCPMD* package yield low net returns per day of labor in each farm category. Second, the net return per labor day for this package is the lowest in the high L-AE category. Finally, with exception of the high L-AE category, farmers are worse-off with the adoption of this package. That is, the net returns per day obtained are lower than those before the application of the package.

Table 7-2 Financial Analysis of Cashew and Manioc Enterprise under Existing and Improved Production Practices by Low, Medium and High L-AE Smallholder Cashew Farm Types in Surveyed Areas of Nampula, Mozambique, 1998/9

Parameters	Smallholder Cashew Farm Categories and Technology Packages					
	Low (L-AE)		Medium (L-AE)		High (L-AE)	
	TRAD	CCPMD	TRAD	CCPMD	TRAD	CCPMD
Density and Yield Data						
Density (trees/ha)	32		43		39	
Yield						
Manioc (kg/ha)	722.15	722.15	458.19	458.19	453.67	453.67
Beans (kg/ha)	-	-	-	-	-	-
Peanuts (kg/ha)	-	-	-	-	-	-
Cashew (kg/tree)	0.69	1.38	1.24	2.48	3.37	6.74
Price ($/kg)						
Manioc	0.17	0.17	0.17	0.17	0.17	0.17
Beans	-	-	-	-	-	-
Peanuts	-	-	-	-	-	-
Cashew	0.38	0.38	0.38	0.38	0.38	0.38
Budget Items						
Gross Receipts ($/ha)	132.96	140.35	99.30	119.56	128.20	178.14
Operating Costs	------------------------- $ per Ha --------------------------					
Purchased Inputs(excluding labor)	0.95	42.22	1.07	56.53	1.17	51.47
Purchased Services	3.54	5.14	1.54	2.16	0.12	1.98
	------------------- man days per Ha --------------					
Total Labor Use	72.90	97.55	50.80	68.85	187.80	183.08
Performance Measures	------------------- $ per Ha and $ per AE labor day --------------					
Net Returns to Land, Labor and Management per Hectare	128.47	93.99	96.68	60.88	126.91	124.70
Net Returns to Land, Labor and Management per Family AE labor day	1.76	0.96	1.90	0.88	0.68	0.68

Source: Smallholder Cashew Production Technology Survey in Nampula, Mozambique, 1998/9.
TRAD stands for Traditional and CCPMD, for Chemical Control of PMD package.

With respect to the first point, the *CCPMD* package applied to a mixed cropped field of cashew with manioc yields a net return of 96 cents per labor day for farms in the low L-AE category, 88 cents for the medium category, and 68 cents for the high L-AE category. These returns are all below the 98 cents opportunity cost of labor which makes the package not worth investing in the cashew and manioc enterprise. Note that accounting for potential measurement errors it is possible that differences between net returns per labor day obtained by farms in the low and medium L-AE categories and the opportunity cost of labor are statistically insignificant in which case these farms could potentially benefit from the adoption of the package.

Table 7-3 shows results of the *CCPMD* technology as applied to an enterprise of mixed cropped cashew with manioc and beans. Here farms across categories earn positive, but low returns. Net returns per labor day are the lowest for farms in the low L-AE category. These farms earn a net return of 50 cents per labor day with the adoption of *CCPMD* package. Note that the package does not raise net returns per labor day above those obtained without it across all L-AE categories. In addition, net returns per labor day are all below the opportunity cost of labor, the profitability measure used in this analysis. This suggest that chemical control of PMD on cashew trees under mixed cropping with manioc and beans may not be an attractive investment to smallholder farmers.

In Table 7-4 a similar analysis is presented for the case of the cashew, manioc and peanuts enterprise. Here, with one exception in the medium L-AE category where the

Table 7-3 Financial Analysis of Cashew, Manioc, and Beans Enterprise under Existing and Improved Production Practices by Low, Medium and High L-AE Smallholder Cashew Farm Types in Surveyed Areas of Nampula, Mozambique, 1998/9

Parameters	Smallholder Cashew Farm Categories and Technology Packages					
	Low (L-AE)		Medium(L-AE)		High (L-AE)	
	TRAD	CCPMD	TRAD	CCPMD	TRAD	CCPMD
Density and Yield Data						
Density (trees/ha)	32		43		39	
Yield						
Manioc (kg/ha)	722.15	722.15	458.19	458.19	453.67	453.67
Beans (kg/ha)	132.89	132.89	228.31	228.31	185.38	185.38
Peanuts (kg/ha)	-	-	-	-	-	-
Cashew (kg/tree)	0.69	1.38	1.24	2.48	3.37	6.74
Price ($/kg)	------------------------$/kg--------------------					
Manioc	0.17	0.17	0.17	0.17	0.17	0.17
Beans	0.26	0.26	0.26	0.26	0.26	0.26
Peanuts	-	-	-	-	-	-
Cashew	0.38	0.38	0.38	0.38	0.38	0.38
Budget Items	---------------------------------- $ per Ha --------------------------------					
Gross Receipts	167.78	176.17	159.12	179.38	176.77	226.71
Operating Costs						
Purchased Inputs(excluding labor)	1.43	42.22	1.61	56.53	1.76	51.47
Purchased Services	27.93	25.89	10.16	12.31	0.00	1.96
	-------------------------------- man days per Ha ------------------------					
Total Labor Use	212.20	213.98	140.50	139.82	261.70	241.08
Performance Measures	---------------- $ per Ha and $ per AE labor day -------------------					
Net Returns to Land, Labor and Management per Hectare	138.42	108.06	147.35	110.54	175.01	173.29
Net Returns to Land, Labor and Management per Family AE Labor day	0.65	0.50	1.05	0.79	0.67	0.72

Source: Smallholder Cashew Production Technology Survey in Nampula, Mozambique, 1998/9.
TRAD stands for Traditional and CCPMD, for Chemical Control of PMD package.

Table 7-4 Financial Analysis of Cashew, Manioc, and Peanuts Enterprise under Existing and Improved Production Practices by Low, Medium and High L-AE Smallholder Cashew Farm Types in Surveyed Areas of Nampula, Mozambique, 1998/9

Parameters	Smallholder Cashew Farm Categories and Technology Packages					
	Low (L-AE)		Medium (L-AE)		High (L-AE)	
	TRAD	CCPMD	TRAD	CCPMD	TRAD	CCPMD
Density and Yield Data						
Density (trees/ha)	32		43		39	
Yield						
Manioc (kg/ha)	722.15	722.15	458.19	458.19	453.67	453.67
Beans (kg/ha)	-	-	-	-	-	-
Peanuts (kg/ha)	432.57	432.57	503.12	503.12	286.57	286.57
Cashew (kg/tree)	0.69	1.38	1.24	2.48	3.37	6.74
Price	-------------------- $ per kg --------------------					
Manioc						
Beans	0.17	0.17	0.17	0.17	0.17	0.17
Peanuts	-	-	-	-	-	-
Cashew	0.28	0.28	0.28	0.28	0.28	0.28
	0.38	0.38	0.38	0.38	0.38	0.38
Budget Items	-------------------- $ per Ha --------------------					
Gross Receipts	254.08	262.47	240.17	260.43	208.44	258.38
Operating Costs						
Purchased Inputs(excluding labor)	1.43	42.22	1.61	56.53	1.76	51.47
Purchased Services	0.00	1.60	2.07	3.98	1.17	2.73
	--------------------- man days per ha -------------------					
Total Labor Use	208.90	178.31	202.03	203.73	171.10	152.74
Performance Measures	----------$ per ha and $ per AE labor day--------------					
Net Returns to Land, Labor and Management per Hectare	252.66	218.65	236.49	199.93	205.51	204.19
Net Returns to Land, Labor and Management per Family AE Labor day	1.21	1.23	1.17	0.98	1.20	1.34

Source: Smallholder Cashew Production Technology Survey in Nampula, Mozambique, 1998/9.
TRAD stands for Traditional and CCPMD, for Chemical Control of PMD package.

CCPMD package breaks even, this technology increases the net return per labor day above the baseline value across farm categories. It is important to note that on average this package perform better in terms of net returns per labor day on this enterprise than it did on those examined earlier. This leads to the point made in Chapter Six about the relative profitability of cashew compared to marketable food crops such as peanuts. Although peanuts may not generate sufficient cash to be invested in cashew production, it is certainly a profit enhancing crop, and an alternative source of cash for the households. Besides, producing sufficient amounts of peanuts for household consumption is a good alternative to purchasing it in the market.

Finally, Table 7-5 presents the results for the cashew, manioc, beans and peanuts enterprise. These results also show that the chemical control package applied to an enterprise which include some marketable crops have the potential to increase household income. A comparison of net returns from this enterprise with those analyzed earlier, suggest that at least for farms in the medium and high L-AE categories, the net returns per labor day for this enterprise are higher compared to other enterprises. The low returns obtained by farms in the low L-AE category results from the fact that these farms used more labor than the average farm. This has depressed the net returns per labor day obtained from the enterprise. Note that cashew yields after the application of the technologies are still low for farms in the low L-AE farm category compared to those in the medium and high L-AE categories. The main reason seems to be the fact that scarcity of land on farms in the low L-AE category force these farms to cultivate cashew on the same piece of land for repeated years. This implies that these farms cannot plant younger

Table 7-5 Financial Analysis of Cashew, Manioc, Beans and Peanuts Enterprise under Existing and Improved Production Practices by Low, Medium and High L-AE Smallholder Cashew Farm Types in Surveyed Areas of Nampula, Mozambique, 1998/9

Parameters	Smallholder Cashew Farm Categories and Technology Packages					
	Low (L-AE)		Medium (L-AE)		High (L-AE)	
	TRAD	CCPMD	TRAD	CCPMD	TRAD	CCPMD
Density and Yield Data						
Density (trees/ha)	32		43		39	
Yield						
Manioc (kg/ha)	722.15	722.15	458.19	458.19	453.67	453.67
Beans (kg/ha)	132.89	132.89	228.31	228.31	185.38	185.38
Peanuts (kg/ha)	432.57	432.57	503.12	503.12	286.5	286.5
Cashew (kg/tree)	0.69	1.38	1.24	2.48	3.37	6.74
Price ($/kg)	------------------------------$ per kg-------------------------------					
Manioc	0.17	0.17	0.17	0.17	0.17	0.17
Beans	0.26	0.26	0.26	0.26	0.26	0.26
Peanuts	0.28	0.28	0.28	0.28	0.28	0.28
Cashew	0.38	0.38	0.38	0.38	0.38	0.38
Budget Items	------------------------------$ per ha ------------------------------					
Gross Receipts	288.90	297.29	299.99	320.25	257.01	306.95
Operating Costs						
Purchased Inputs(excluding labor)	1.90	43.17	2.15	57.60	1.76	52.64
Purchased Services	6.83	8.43	0.00	2.16	8.57	10.53
	------------------------- man days/ha -------------------------------					
Total Labor Use	269.60	241.18	100.60	109.04	108.60	123.99
Performance Measures	------------------$ per ha and $ per AE labor day-----------------					
Net Returns to Land, Labor and management per Hectare	280.17	245.69	297.84	260.49	246.09	243.78
Net Returns to Land, Labor and management per Family AE Labor day	1.04	1.02	2.96	2.39	2.27	1.97

Source: Smallholder Cashew Production Technology Survey in Nampula, Mozambique, 1998/9.
TRAD stands for Traditional and CCPMD, for Chemical Control of PMD package.

trees because it may overcrowd the land thereby reducing the land for food crop cultivation. As a result, trees on these fields may be relatively older than those owned by farmers in other L-AE categories. This may help explain the low yield per tree observed on low L-AE farms even after improvements are made. Note that cashew yield per tree increases as one moves from the low to the high L-AE farm category. The yield before the improvement as well as the production potential of the tree are crucial factors affecting the impact of the technologies. Yield level at the point when the package is applied is an important factor for the incremental effect that the technology has on returns to investments. As explained in Chapter Three, the technologies are applied at the tree level. Although it is difficult to determine the age and thus figure out the yield potential of a given tree, it is important to discover ways to know the status of the cashew tree before a technique is chosen.

Up to this point in the analysis we have compared net returns of the *CCPMD* technology package across cashew enterprises. A comparison of financial performance across available technologies could be important. Unfortunately, the impact of these technologies on yield and therefore on net returns have different time pattern. A simple comparison of net benefits in a given year is misleading, unless seen in a time-dynamic fashion. For instance, while the impact of a chemical control strategy is observable during the cropping season on the year of application, the effects of top-working on yield take about 18 months depending on soil type and rainfall pattern. Given that a time-dynamic whole farm analysis is not possible at this point, it is important to stress that packages such as the *TWCPMD* and the *ICM* are costly and potentially risky for some farmers, but they are also more comprehensive approaches to the low yield problem faced by farmers in Mozambique. Research work in Mozambique recognizes the widespread occurrence of PMD and the need for its control. PMD coupled with the ageing of the trees have reduced the productive capacity of the national cashew orchard. This means that there is a need not only to control PMD to prevent further spread and infection of new plantings, but also to replace the old and unproductive trees. These trees reduce land values thereby increasing its opportunity cost to land-constrained households. The *TWCPMD* and the *ICM* may be costly in the short-run, but in the long-run benefits may outweigh the short-run high cost of these investments.

In the section to follow, we use a whole farm approach to examine the impact of household resource constraints on the profitability of the chemical control package in a broader context of a single-year whole-farm analysis. A smallholder household linear programming model is the tool selected for this purpose. Later we proceed with the analysis using a capital budgeting approach to investments in the *TWCPMD* and *ICM* packages to stress the points made earlier about the time pattern of costs and benefits.

7.2 Modeling Smallholder Choices in Cashew Productivity Improvement

When farmers use resources at their disposal they pursue a strategy with multiple goals often including improve food and social security, improve risk management, and improve income generation (Saxena, Chambers, and Shah, 1989). For instance, depending on the type and nature of the tree, smallholders may plant trees as a risk reduction and management device to secure land tenure and user rights, or to even smooth seasonal flows of output and income, and demand on labor, as well as to provide a reserve of biomass products and capital available for use as a buffer in times of stress or emergency (Arnold, 1995). Farmers in the study area, have often mention households who cut down old cashew trees or have used their most distant cashew trees for charcoal production. This activity provides some cash when households face liquidity constraint under extreme and unusual circumstances.

A number of modeling approaches have been used to study cropping systems in order to analyze the effects of most of the factors examined above.[3] The methods used are known as whole-farm models and include farm budgeting, programming and simulation. Programming models are of particular interest for this study which include simplified linear or quadratic, non-linear or goal programing techniques. These models can be modified to include risk, or stochastic features (Ghodake and Hardaker, 1981). The choice of one particular model depends upon a number of important factors. These factors include (1) the capacity to handle many constraints and variables, the need for handling complexities in agricultural production, (2) the capacity to incorporate risk in a realistic manner, (3) the capacity to incorporate farmer's real goals and objectives, and (4) the need to introduce a criterion of degree of subjectivity, for if the system evaluation performed is to be accepted by scientists, extension workers and policy makers, they should depend no more than is absolutely necessary on subjective judgements by the analyst using the method. Complete objectivity is not attainable, but methods vary in the

[3] Detailed models and applications can be found in Barnard and Nix, 1973; Hardaker, 1974; Anderson, 1974; Dillon and Hardaker, 1980; and Ghodake, 1981.

extent to which they depend on judgements by the analyst. Furthermore, despite the assumption of farmer's profit maximizing behavior held in these models, programming models can be used in an environment where such behavior may not always be the case.

Linear programming (LP) models assume that (1) activities are linearly additive, (2) activities and resources constraints are divisible, (3) input and output units are homogeneous, (4) constraints or requirements on resources must be met, and (5) farmers know with certainty unique values of resource availability, input-output coefficients and prices. However, as Beneke and Winterboer (1980) report, there are several limitations of LP models that researchers need to be aware of, namely that (1) the assumptions of linearity and additivity are restrictive to a farm's real situation, (2) price expectation formation cannot be successfully incorporated nor can input-output coefficients be drawn from the LP model itself, and (3) decreasing cost activities are difficult to deal with in LP models.

In addition, LP model applications to development studies have been criticized for the fact that agricultural production systems typically involve technically feasible input substitution and not fixed coefficients as used in LP models. Changes in input-output coefficients are the primary objective of policies intended to affect production practices. Despite this criticism, LP models have been successfully used in several occasions

In Africa, pioneer application of an LP model is credited to Clayton (1961). Using a typical farm approach, Clayton evaluated the constraints to profitability and provided important insights on the relationship between perennial cash crops and annual crops in Kenya. Since then, most of the studies have focused on: (1) identifying constraints to smallholder farming; (2) estimation of cross-sectional frontier production functions; (3) deriving output supply and input demand functions; and (4) assessing the profitability of new alternative technologies. As Hopkins (1975) has argued, programming models are particularly appropriate to a changing environment where new crops and techniques affect not only farmer's incomes, but also imply repercussions in the pattern of farming activities and resource allocations too complex to be analyzed by conventional budgeting or other forms of farm planning tools.

Norman (1974) for instance, applied an LP model to evaluate crop profitability in Northern Nigeria under alternative scenarios that included adjustments in resource availability, change in crop prices, introduction of available technologies. Likewise, Heyer (1971) studied the Masai farmers resource allocation decisions in Southern Kenya. She incorporated risk and uncertainty in the model to study the effects of constraints on production practices under unfavorable conditions. Simler (1994) developed a set of simple linear programming models to simulate the effects of different policy scenarios on farm and sectoral agricultural production, resource use, and incomes for Malawi. Further applications of the technique extend to regional and national studies such as that of Spencer (1972) and normative supply responses in farm planning (Ogunfowora, 1970).

The previous section has calculated the net returns to family resources invested in different enterprises. Given that farmers make choices in an environment of constrained access to limited resources, these choices cannot be made on the basis of individual economic enterprise performance. The reasons for this is that even when all the enterprises are profitable, farmers may be forced to rank then as they cannot be undertaken simultaneously because of potential conflicts in shared resources. In addition, different enterprise requirements on constrained availability of land and labor may limit output expansion (Fotzo, 1983), or engaging in new activities. Furthermore, changes in the environment may not affect directly a given enterprise. However, inter-relationships through the use of common resources may require downsizing some operations in favor of others where resources yield a higher return. Thus an approach which provides both the economic value of scarce resources and their use in numerous alternatives simultaneously is required.

In this section a linear programming model is developed to simulate production outcomes based on different farm type situations. It evaluates the profitability of a technology package which includes chemical control of PMD and improved cashew management practices under current farm environment. The model will provide estimates of the marginal returns to resources, the opportunity cost of foregone income from enterprises not currently chosen due to restrictions in resource use, the cost of adoption of enterprises and the policy effect on the farmer's optimal crop mix and total and per capita net returns to resources.

7.2.1 The Smallholder Household LP Model

A simple deterministic single-period linear programing model is used to analyze smallholder cashew farm production decisions. The model focuses on constraints faced by smallholder cashew farmers and evaluates how these households respond to changes in cropping systems with introduction of a new technology with improved management practices in cashew production.

The primary reason for which a linear programming approach was chosen is the fact that the introduction of a new technology and improved management practices in cashew production will compete for the resources used in choices farmers usually make under the current situation. One technology package will be simulated and this requires additional use of some resources which might sacrifice its current use in alternative enterprises.

As an economic construct, the LP model helps to evaluate different options available to farmers. The model is set up to maximize a sum of net value of production (net returns to labor) of a set of cropping and non-cropping activities and earnings from off-farm activities, subject to a number of constraints on resource endowments, food security needs, and other conditions faced by three categories of smallholder cashew farmers in the Northern Province of Nampula.[4] The problem is stated such that:

$$Max \quad V = \sum_{j=1}^{a} c_j \, x_j \tag{1}$$

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[4] The three representative cashew producer household types modeled are primarily differentiated by land area per adult equivalent, as described in Chapter 4.

subject to resource constraints

$$b_i \geq \sum_{j=1}^{a} a_{ij} x_j \tag{2}$$

and non-negativity constraints

$$x_j \ldots x_n \geq 0 \tag{3}$$

where:

V = the net value of production per hectare (Gross value minus cost of purchased inputs), plus earnings from off-farm activities,

c_j = the per hectare net returns to family labor from the farming activities

x_j = the level of j^{th} activity providing c_j returns per farmer's working day

b_i = the amount of the i^{th} resource available to the farmer for the activity x_j, where i=1...m, as well as the amount of own food production to be consumed, and

a_{ij} = the per hectare amount of the i^{th} resource required in j^{th} activity, also known as technical or input-output coefficients.

In this framework, it is crucial to smallholder decision-making that the household meet its minimum food consumption needs, primarily from own production. As a result, the well known safety-first rule becomes more a binding constraint in the model which need to be met before any additional effort is allocated to maximizing returns to resources.

7.2.1.1 Model Activities

There are about 113 activities in the general model from a range of smallholder crop production, marketing, and off-farm labor demand and supply (Tables 7-6 and 7-7). Thirty of these activities are cropping activities under the current (traditional) practices, and 37 are new cropping activities in the household.[5] The remainder are purchasing activities (2), transfer activities (2), off-farm labor sales known as "*ganho-ganho*" (8), and hire in activities (8). Decisions about activity levels are assumed to be taken at the onset of the agricultural season and all parameters about input and output relations are assumed to be fixed during the period of analysis.

The new cropping activities are introduced by the technology reflecting the opportunities farmers have to change the current production state. The technology package can be applied to either a monocropped or a mixed cropped cashew field. The package is chemical control of PMD ($_i$*CCPMD*-j) with i=3,6,32,36,326, and either j=32,39, and 43 or j=44, 48 and 52 (Tables 7.6 and 7.7). The subscripts *i* indicates the crop or crop mixture and *j* the cashew tree density in the field where the technology

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[5] Each traditional cropping activity was classified into three types: low, medium and high yield and labor input. This follows from analysis in previous chapters which examined cropping and labor use patterns. It was found that there are differences in crop productivity which seemed to be associated with differences in levels of labor use and allocation strategies. As a result, all the possible and distinguishable crop mixtures and labor use relationships were assumed to be available to all farmers to reflect the fact that all farms operate under the same economic conditions, and decisions across farms differ only by resource endowments and constraints each farm category face.

Table 7-6 Model Activities and Definitions

Model Activities	Activity Definition
	Existing Practices
SOLE-6	Peanut production under monocropping
SOLE-3	Manioc production under monocropping
MAN-2	Manioc and Beans production under mixed cropping
MAN-6	Manioc and Peanuts production under mixed cropping
MAN-26	Manioc, Beans, and Peanut production under mixed cropping
SOLE-24	Cashew production under monocropping
CAJU-3	Cashew and Manioc production under mixed cropping
CAJU-32	Cashew, Manioc, and Beans production under mixed cropping
CAJU-36	Cashew, Manioc, and Peanut production under mixed cropping
CAJU-326	Cashew, Manioc, Beans, and Peanut production under mixed cropping
	New Cropping Activities
24CCPMD-44	Monocropping cashew field under Chemical Control of PMD with a density of 44 cashew trees
24CCPMD-48	Monocropping cashew field under Chemical Control of PMD with a density of 48 cashew trees
24CCPMD-52	Monocropping cashew field under Chemical Control of PMD with a density of 52 cashew trees
3CCPMD-32	Cashew cropping with manioc under Chemical Control of PMD with a density of 32 cashew trees
3CCPMD-39	Cashew cropping with manioc under Chemical Control of PMD with a density of 39 cashew trees
3CCPMD-43	Cashew cropping with manioc under Chemical Control of PMD with a density of 43 cashew trees
32CCPMD-32	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 32 cashew trees
32CCPMD-39	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 39 cashew trees
32CCPMD-43	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 43 cashew trees

2, 3, 6 and 24 stand for beans, manioc, peanuts and cashew when preceded by words such as sole, or when before the symbol designating enterprise or technology.

Source: Smallholder Cashew Production Technology Survey, Nampula, Mozambique 1998/9

Table 7-7 Model Activities and Definitions (con't...)

Model Activities	Activity Definition
32CCPMD-32	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 32 cashew trees
32CCPMD-39	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 39 cashew trees
32CCPMD-43	Cashew cropping with manioc and beans under Chemical Control of PMD with a density of 43 cashew trees
36CCPMD-32	Cashew cropping with manioc and peanuts under Chemical Control of PMD with a density of 32 cashew trees
36CCPMD-39	Cashew cropping with manioc and peanuts under Chemical Control of PMD with a density of 39 cashew trees
36CCPMD-43	Cashew cropping with manioc and peanuts under Chemical Control of PMD with a density of 43 cashew trees
326CCPMD-32	Cashew cropping with manioc, beans and peanuts under Chemical Control of PMD with a density of 32 cashew trees
326CCPMD-39	Cashew cropping with manioc, beans and peanuts under Chemical Control of PMD with a density of 39 cashew trees
326CCPMD-43	Cashew cropping with manioc, beans and peanuts under Chemical Control of PMD with a density of 43 cashew trees
SEL....	Sell either beans, manioc, peanuts or cashew
BY...	Buy either beans, manioc, peanuts, maize or inputs,
CREDINP	Credit for input purchase
CREDGEN	Credit for general purposes
OFFSEP...OFFAPR	Off-farm employment (*ganho-ganho*) in September to April
HIRLSEP...HIRLAPR	Hire in labor from September to April

2, 3, 6 and 24 stand for beans, manioc, peanuts and cashew when preceded by words such as sole, or when before the symbol designating enterprise or technology.

Source: Smallholder Cashew Production Technology Survey, Nampula, Mozambique 1998/9 package is to be applied. The lower density set is for the mixed cropped cashew fields, and higher density set is for the monocropped fields.[6]

7.2.1.2 Resource Constraints

The general model assumes that all households use a hand-hoe technology under the traditional practices, and the new technology and improved management practices are available to all farms. There are 65 constraints in total in the general model representing production situations faced by cashew farmers in the Northern Mozambique.

The first constraint (*Foodsec*) is food security. This safety-first constraint was constructed following findings from the NCD study which estimated that a household member in Monapo and Meconta districts consumed a daily amount of food of about 835 grams in 1995, of which 631 grams were from maize, manioc, beans, and peanuts. This is about 227.16 kilos per annum per capita (Rose et al., 1998) distributed as follows: 108.72 kgs of maize, 66.24 kgs of manioc, 36 kgs of beans and 16.20 kgs of peanuts per person per year. To account for risk and meet these food security requirements, the model imposes that a minimum amount (about 59 percent of each food crop requirement) should be met by own production, with exception of maize whose source is the market.[7]

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[6] These densities are actual, and are the same found in fields from smallholder cashew farmers (low, medium and high L-AE categories) as described in Chapter Four.

[7] The minimum amount to be produced for consumption was estimated by multiplying the food security requirements for each crop with the percentage (59 percent, from MSU/NCD data set) of retained staple food production per household. This percentage is an estimate for a typical household in Northern Mozambique (Strasberg, 1997; and Rose et al., 1999).

The second constraint, *Capstock* ensures that input purchases, hired labor and consumption expenses, and interest payments do not exceed beans, manioc, peanuts and cashew sales receipts and off-farm earnings. Input purchases and other expenses occur in three periods. In the first period from September to May is the period in which most of the cropping activities take place. During this period, farmers purchase agricultural tools, hire labor for food and cashew cropping activities under the traditional practices. Off-farm activities, and some sales as well as purchases of beans, manioc, peanuts and maize occur also during this period. Given that spraying must take place at a given period of time, the second period is determined by the need to have inputs on time for the spraying of cashew trees during June through August. Thus farmers purchase all the inputs required for spraying at the end of the first period. These purchases are financed by balances from first period sales and off-farm earnings, and borrowing for this specific spraying activity from the second period. Furthermore, in the third period farmers are allowed to hire more labor in connection with the spraying activities.

In recognition of credit market failures in rural areas, and in the study area in particular, a credit constraint (*Credit*) was included as the third constraint in the model. It is possible that smallholders engage in traditional credit schemes which allow them to reduce other resource constraints. It is also possible that more resourceful farmers, particularly those in the high L-AE category may resort to own equity to make investments. Lack of data on the magnitude of household savings/equity, and traditional credit schemes precluded inclusion in modeling efforts at this time. However, only formal credit was allowed in the model both for general purposes and for input purchases.

To make sure that credit made available for input purchases is not used by the household to finance living expenses, funds from formal credit were channeled to an input purchase fund in the model.

The fourth constraint in the model is land. Land is classified into three types: land in which households grow food crops with no cashew($Latype_I$), land on which cashew is grown sole($Latype_{II}$), and land with mixed cropped cashew($Latype_{III}$). Findings from previous research with part of sampled households in the study area (Mole, 1996) shows that most of the fields with sole cashew are not suitable for food crop cultivation in the short-run. This was the primary reason why cashew trees are currently standing alone in those fields. In addition, these fields are often located far from the house. In effect, fields far away from home represent a different land resource as compared to those close to the homestead. Nonetheless, for simplicity this distinction is not made in the model. In the long-run $Latype_{II}$ and $Latype_{III}$ may be substitutes, particularly if a farmer makes the decision to rehabilitate the entire stock of trees and replant with completely new trees. Since we are not examining this option in the model, these two types of land are not substitutes.

The fifth is a set of labor constraints. These were specified to reflect the timing of cropping activities (Tables 7-8 and 7-9). The critical aspect of timing in operations which is reflected in these tables is the fact that new investments in cashew will need additional labor and inputs. The labor requirements of these new investments will often conflict during specific periods of the year with the labor needs of other household cropping activities. This increases the opportunity cost of some resources, which makes

Table 7-8 Smallholder Cropping Calendar in Surveyed Areas of Nampula Province, 1998/99

Activities	Period 1												Period 2								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land Clearing	2 3 6	2 3 6	2 3										2 3 6	2 3 6	2 3						
Fire						3 6	2 3	2													
Plowing							3 6	2 3 6	2 3	2											
Seeding									2 3 6	2 3	2										
Weeding									3	3 6	3 6	2									
Pruning Trees												24									
Harvest	2 6	2 6	2		3 24	3 24	3 24	24	24			6	2 6	2 6	2		3 24	3 24	3 24	24	24
Marketing		2 6	2 6	2 6	2 6	2 3 6 24	3 24	3 24	24					2 6	2 6	2 6	2 6	2 3 6 24	3 24	3 24	24
Top-working											Cutting trees and grafting 24										
Thinning and Replanting	Thinning 24									Planting 24			Thinning 24								Plant 24
Spraying		1a 24	2a 24	3a 24	4a 24									1a 24	2a 24	3a 24	4a 24				
Sanitation	3r 24	4r 24								1r 24	2r 24	3r 24	4r 24								

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9.

Numbers are 2=Beans, 3=Manioc, 6=Peanuts and 24=Cashew; 1r= first round, 2r=second round, so on; 1a=first application, 2a= second application, and so on

Table 7-9 Labor Allocation by Periods of Activity and Crop Enterprises in Surveyed Areas in Nampula, 1998/9

Time period	Month in the Crop Calendar	Description of the Activity executed per Field
1	September	Harvest manioc cont. +Land clearing for Manioc, Beans and Peanuts+ harvest cashew+ market beans cont. + market peanuts
2	October	Burn in for Manioc and Beans + Plowing Manioc and Peanuts+Harvest and market manioc cont. + market cashew +Thinning and replanting cashew trees
3	November	Burn in and plowing for beans + Plowing for manioc and beans cont. + market manioc cont. + harvest and market cashew + Thinning and replanting cashew trees continued.
4	December	Plowing beans cont. + Seeding Beans and Peanuts +Planting and weeding Manioc+ Thinning and replanting cashew trees
5	January	Plowing for beans cont. +Seeding Beans cont. + Planting and weeding manioc cont. + Weeding Peanuts + 1st Sanitation of cashew trees
6	February	Seeding and Beans cont. +weeding beans + weeding Manioc cont. + Weeding Peanuts cont. + pruning Cashew trees+ 2nd Sanitation of cashew trees
7	March	Weeding Beans cont.+ pruning cashew trees cont. + Harvest peanuts +Top-working +Thinning and replanting cashew tress + 3rd Sanitation of cashew trees +Thinning and replanting cashew tress + 3rd Sanitation of cashew trees
8	April	Clear fields for new crops + Prune cashew trees cont. +harvest beans + harvest peanuts cont. + Top-working continued +Thinning continued + 4th Sanitation of cashew trees
9	May	Clear fields for new crops + Top-working continued +Thinning continued + Harvest beans cont. + harvest peanuts cont., and market + 1st spraying of cashew trees
10	June	Clearing beans fields cont. +harvesting beans cont., and market + market peanuts cont. + Top-working cont. +Thinning and replanting cashew cont. + 2nd spraying of cashew trees
11	July	Marketing beans + marketing peanuts cont. + 3rd spraying on cashew trees
12	August	Harvesting manioc+ marketing beans cont. + Marketing peanuts cont. + 4th spraying on cashew trees

Source: Smallholder Cashew Production Technology Survey, Nampula, 1998/9.

smallholder decision-making at planting time more complex, given the scarcity of these resources. We noted earlier that there are differences in resource endowments across farm types. In certain periods of the year physically demanding activities may require additional labor which may be met with casual hired labor, whereas family labor may be sufficient in periods of less demanding operations. However, for some households this option may not exist at all if their income levels do not allow any hiring of labor, and own labor must seek employment off-farm to meet cash needs for household own consumption. The model allows the household to hire in labor throughout the year, if cash is available.

Given these labor allocation complexities, the labor constraint is subdivided into 12 monthly labor periods spanning from September to August over the agricultural season (Table 7-8). Off-farm employment and hiring activities are allowed from October to May. These employment opportunities are what is known as "*ganho-ganho*" in the study area, reported in earlier chapters as casual labor. Given that most of the off-farm employment opportunities are in agriculture, these employment opportunities are often limited during the months of June to September. During this period most of the harvest has been already done for many crops, except cashew.

The last six constraints account for the limited supply of labor for off-farm activities. Off-farm activities are limited to a maximum of ten monthly adult-equivalent days per household the amount of family labor a household can allocate to work off-farm employment during on-farm high labor demand periods of October to March. Maximum limits for off-farm work varies for each farm category to account for differences in labor availability across L-AE categories.

7.2.1.3 Resource Stocks and Flows

The food security constraint is a safety-first requirement ensuring that the daily 631 grams(about 281 kgs/year, as reported by Rose et al., 1999) per household member be met if possible by own production of manioc, beans and peanuts from the different smallholder crop enterprises, and maize purchases.[8] That is, of total annual food requirements per household, the model imposes that at least 59 percent be produced on farm, and the reminder purchased in the market. Note that maize is acquired entirely through market purchases; cashew farmers in the area studied did not produce any maize.

The model restricts the capital stock at the beginning of the planning horizon to 35 percent of total net income per household. The net income per household was estimated using the NCD set. Data on the amount of potential credit available to each type of farmer is not available. Rural credit markets are rare to nonexistent. However, as mentioned above, there might be traditional schemes in which household engage in to remove their financial constraints. To allow household involvement in both credit and input market institutions, the model restricts the amount of credit available for general

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[8] Of the 227.2 kgs/year per household member required from these four food staples, 48 percent is from maize, 29 from manioc, 16 percent from beans, and seven percent from peanuts.

Table 7-10 Monthly Labor Supply by Farm L-AE Category and Time Period

Time Period	Smallholder L-AE Cashew Farm Categories			Typical Smallholder Cashew Farm
	Low	Medium	High	
January	26.10	23.44	19.29	23.15
February	26.10	23.44	19.29	23.15
March	26.10	23.44	19.29	23.15
April	26.10	23.44	19.29	23.15
May	26.10	23.44	19.29	23.15
June	20.88	18.74	15.43	18.52
July	26.10	23.44	19.29	23.15
August	26.10	23.44	19.29	23.15
September	20.88	18.74	15.43	18.52
October	26.10	23.44	19.29	23.15
November	26.10	23.44	19.29	23.15
December	20.88	18.74	15.43	18.52

Source: Smallholder Cashew Technology Survey, Nampula, Mozambique, 1998.

purposes to 25 percent of total living expenses, and to a 100 percent of the cost of required inputs for the technology packages. Credit for purchased input is subject to a 10 percent down payment and an interest rate of about eight percent equally applicable to credit for general purposes. No down payment is required for general purpose credit. Minimum living expenditures per household were set at the level of 33.6 percent of total expenditures per household. This percentage was obtained from the estimates of the NCD study which determined that the share of beans, manioc and peanuts in total food expenditures was about 66.4 percent. Given that these are the major food staples in the study area, we used the 33.6 percent estimate to calculate the right hand side value for the minimum living expenses constraint. These expenses include an allowance for education, health, and unexpected expenses.

The amount of labor available at each time period is presented in Table 7-10. These amounts are determined by the household size and composition. Household labor availability was estimated using conversion factors of age and gender into household adult male labor capacity equivalent. These estimates were in turn used to determine the labor stock available for on-farm activities. Each member is assumed to be available for cropping activities five days per week. An allowance is made for less working days in June, September, and December due to festivities and sickness reducing the number of working days in a week to four days.

7.2.2 Results and Discussion

7.2.2.1 The Baseline Model

One feature which characterizes LP models is the tendency for these type of models to select specialized enterprise alternatives as compared to traditional farmers' more diversified choices (Crawford, 1982; and Fotzo, 1983). Optimization models often allocate full resources to enterprises which are profitable from the economic stand point as opposed to more conservative choices some farmers may make in allocating their resources. One way to evaluate this is to compare current choices and resource allocation patterns with those suggested by the model. Although useful, this must be done with care given that the model may include practices which are not currently available on-farm.

The purpose of the study is exactly evaluating how and under what circumstances farmers are likely to adopt these practices.

The baseline model is initially run with the food security and labor constraints under the current cropping systems. At this point, new cropping activities are not included. Later, the chemical control and improved management practices package is introduced as a new cropping activity. Other constraints are either added or tested through sensitivity analysis. The baseline model excludes any type of formal or informal credit.[9] One must be cautious, however. While formal credit is not available to smallholder households, often farmers engage in mutual credit schemes when in need of cash to meet emergencies, or even small investments. As mentioned earlier, one must also recognize that some farmers may have sufficient own equity/savings to finance some level of investments. Later, when the cash constraint is relaxed, households are allowed to borrow both for general purposes and input purchases.

Tables 7-11 and 7-12 present the results of the baseline model. In Table 7-11 the model depicts the optimal cropping activities along with the current land allocation pattern under the traditional cropping system by farms in each L-AE farm category, and by a typical farm. In addition, total and per capita net income earned is presented. Farm

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[9] In most rural Mozambique formal credit to the smallholder households is non-existent. Only in few cases smallholders have received crop-specific credit lending. This is currently the case in cotton production whereby farmers receive inputs by joint venture companies with promise to future purchase of the output. This *concessionaire* scheme has also undergone changes. However, traditional schemes of farmer-to-farmer lending have been observed, although seldom and only to meet unexpected needs for cash. This source of borrowing is often inadequate to meet the needs for inputs purchases required for the technologies studied here.

Table 7-11 Linear Programming Results under the Baseline LP Household Farm Model for Low, Medium and High L-AE, and a Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
Cropping Activities	---- Ha planted ----			
Traditional				
Peanuts [1]	0.53 (0.13)	0.74 (0.13)	1.13 (0.05)	0.78 (0.10)
Manioc	- (0.09)	- (0.28)	- (0.40)	- (0.25)
Cashew [1]	0.49 (0.49)	1.36 (1.36)	1.22 (1.22)	1.01 (1.01)
Manioc and Beans	- (0.10)	- (0.17)	- (0.05)	- (0.14)
Manioc and Peanuts	- (0.07)	- (0.09)	- (0.28)	- (0.14)
Manioc, Beans and Peanuts [1]	- (0.05)	- (0.01)	- (0.06)	- (0.04)
Cashew and Manioc	- (0.29)	- (0.43)	- (0.35)	- (0.36)
Cashew, Manioc and Beans	- (0.41)	- (0.09)	- (0.67)	- (0.38)
Cashew, Manioc and Peanuts	- (0.22)	- (0.31)	- (0.08)	- (0.21)
Cashew, Manioc, Beans, and Peanuts [1]	1.23 (0.31)	0.98 (0.15)	1.27 (0.17)	1.16 (0.21)
Net Income	---- $ per Hh and $ per capita ----			
Total	248.54	306.80	365.57	305.92
Per capita	49.22	85.22	97.49	76.48

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.
Note: In parenthesis are current allocations of land.
1 These are high yield and labor input crops.

categories are as described in Chapter Four and used in previous sections of this chapter.

Under the safety-first food security constraint along with the cash constraint, farms in all categories allocate as much land as possible to sole traditional cashew and one or more food crops. For instance, low L-AE farms allocate all the 0.49 ha of land available to sole cropping of cashew using the traditional sole cropped cashew technology. Similarly, both medium and high L-AE farms allocate all the 1.36 ha, and 1.22 ha available to sole cropping of cashew to traditional sole cashew, respectively. This is also the case for the typical farm which allocates all the 1.01 ha of land available to sole cropping of cashew to traditional sole cashew. With respect to food cropping, farms across categories including the typical farm select the sole high labor input peanuts enterprise by allocating as much land as possible. Note that in Chapter Four it was shown that sole cropped peanuts were first in terms of cultivated area to food crop by low L-AE farms. In the medium L-AE category as well as for the typical farm, peanuts occupied the second largest land area allocated to single crops following manioc. Under the current cropping system, only farms in the high L-AE category allocated a very small portion of land to sole cropped peanuts compared to farms in other categories. Recall that in Chapter Six the highest net return per labor day from sole cropped peanuts was $0.92 by high L-AE farms which is close, but below the opportunity cost of labor assumed in the analysis.

The baseline results also show that net income per farm and per capita increases across farm categories. Farms in the low L-AE category earned the lowest net income both in total and in per capita terms. Net income differences are a direct result of differences in land owned. As pointed out earlier, there is a positive correlation between cultivated/owned land and income which makes land-scarce farms also poor in terms of income.

The land and labor endowment issues dealt with in Chapter Four, and a closer look at the selected cropping activities in Table 7-11 can explain these differences in farm income levels. Recall that in Chapter Four farms in the medium and high L-AE categories were found to have relatively more land per adult equivalent than those in the low L-AE category, but slightly less labor per adult equivalent than those in the low L-AE category. In fact, Table 7-11 shows that low L-AE farms allocated approximately the same amount of land area to marketable crops such as beans and peanuts as medium L-AE farms. Thus it might be the case that differences in net income between these farm categories are due both to land availability and access, and to on-farm productivity differences.

Table 7-12 also shows some of the differences across farms through labor allocation. For instance, farmers in the low L-AE category used about eight percent and 30 percent more family labor on on-farm activities than medium and high L-AE farms, respectively. In addition, low L-AE farms have taken about twice as much off-farm days of work employment than medium L-AE. Yet, farmers in the low L-AE category earned the lowest net income. The results also show that farms in the high L-AE category have used less total family labor while hiring more than twice as much labor as both low and medium L-AE farms. Nonetheless, the net income earned by these farms is higher than that earned by farms in the low and medium L-AE categories. Note that high L-AE farms

Table 7-12 Labor Use, Opportunity Cost of Land and Labor under the Baseline LP Household Farm Model for Low, Medium and High L-AE, and a Typical Smallholder Cashew Farm Categories

Indicators	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
Labor Use	----------------# of AE labor days ------------------			
Family	217.5	202.2	167.6	199.1
Hired	70.2	71.1	176.6	94.1
Off-farm	30.4	12.5	-	8.2
Total	**318.2**	**285.8**	**344.2**	**301.4**
Opportunity Cost				
Land	------------------------ $ per Ha ----------------------			
Food Crops only	151.80	151.30	146.50	148.20
Sole Cropped Cashew	17.20	17.10	15.00	15.20
Mixed Cropped Cashew	165.30	166.70	156.10	156.90
Labor(binding months)	----------------------- $ per AE day ----------------------			
January	1.18	1.18	1.18	1.18
February	1.18	1.18	1.18	1.18
March	1.18	1.18	1.18	1.18
April	1.14	1.14	1.18	1.14
May	0.80	0.80	0.84	0.84
September	-	-	0.84	0.84
October	0.80	0.84	0.84	0.84
November	0.80	0.80	0.84	0.80
December	0.84	0.84	0.84	0.84
Food Security	------------------------ $ per Kg ----------------------			
Beans		0.26		
Manioc		0.17		
Peanuts		0.28		
Maize		0.18		
Range of Land Area[1]	-----------------------Ha of land ------------------------			
Food Crops only	0.52 - 0.61	0.48 - 0.88	0.78 - 2.89	0.75 - 0.82
Sole Cropped Cashew	0.44 - 0.83	0.19 - 2.09	0.00 - 3.09	0.97 - 1.57
Mixed Cropped Cashew	1.21 - 1.29	0.85 - 1.12	0.74 - 2.77	1.15 - 1.25

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.
[1] Minimum and maximum land area by which baseline farm plan does not change.

have not allocated any labor to off-farm activities. Furthermore, under the baseline optimal plan these farms use about five percent more hired than family labor on farming activities. These results seem to suggest that while family labor is a scarce resource for farms in the high L-AE category, their ability to hire can compensate for the lack of household labor.

The pattern of land and labor allocation under the optimal plan across farms is also reflected by that of the typical farm. Land typically allocated to mixed cropping of food without cashew favored sole cropped peanuts while that used for food mixed cropped with cashew was entirely allocated to a combination of cashew with manioc, beans and peanuts. With respect to labor, under the optimal plan a typical farm is able to both hire and engage in off-farm activities. However, the amount of labor allocated to off-farm activities is fairly insignificant for the period of analysis. On one hand, this amount of labor allocated to off-farm activities by a typical farm shows to some extent the limited off-farm opportunities in rural areas and, on the other, constraints to household labor experienced by some farms in the study area.

Family labor was a constraint across farm types. However, shadow prices of labor suggest that labor constraints occurred at different time periods for different farms. For instance, Tables 7-12 and 7-13 show that during January throughout April family labor was equally valuable to all farms across L-AE categories. Table 7-12 shows that all farms faced the same labor shadow prices during this period, except in April where high L-AE farms seem to have experienced shortages in household labor as shown by shadow prices of about four percent higher than those faced by low and medium L-AE farm. This

Table 7-13 Labor Use Pattern under the Baseline LP Household Farm Model by Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Baseline Model						Typical Smallholder Cashew Farm	
	Low (L-AE)		Medium(L-AE)		High(L-AE)			
	Off-Farm	Hired-in	Off-Farm	Hired-in	Off-Farm	Hired-in	Off-Farm	Hired-in
Months	------------- AE labor days per Month -------------							
January	-	9.5	-	8.4	-	23.3	-	13.3
February	-	2.7	-	2.5	-	15.9	-	6.6
March	-	8.1	-	9.6	-	25.2	-	13.8
April	11.5	-	6.2	-	-	4.9	4.8	-
May	8.1	-	2.4	-	-	10.4	0.6	-
June	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-
August	-	31.8	-	31.3	-	39.3	-	33.9
September	-	-	-	-	-	6.2	-	0.1
October		0.9	-	3.2	-	15.9	-	5.6
November	9.9	-	3.9	-	-	6.7	2.8	0.1
December	-	18.0	-	16.1	-	28.9	-	20.7
Labor Ranges (binding months)	------------- AE labor days per Month -------------							
January	-185.4 - 35.6		-237.7 - 31.8		-291.8 - 42.5		-237.2 - 36.5	
February	-185.4 - 28.8		-237.7 - 25.9		-291.8 - 35.2		-237.2 - 29.8	
March	185.4 - 34.2		-237.7 - 32.9		-291.8 - 44.5		-237.2 - 36.9	
April	14.6 - ∞		17.2 - ∞		-291.8 -24.2		18.4 - ∞	
May	7.9 - ∞		21.0 - ∞		-415.9 -29.7		22.5 - ∞	
September	-		-		-419.8 -21.6		-345.7 - 18.6	
October	25.2 - 35.2		-341.8 - 26.7		-415.9 -35.2		-341.0 - 28.7	
November	16.3 - 26.3		19.6 - 27.6		-415.9 -25.9		20.3 - 28.3	
December	-275.0 - 38.9		-346.5 - 34.8		-419.8 -44.3		-345.7 - 39.3	

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique

was also the case during the months of May, September, and November. Table 7-13 shows that high L-AE farms were able to compensate for the lack of household labor with hired labor throughout the labor binding months. However, the amount of hired labor during some of these months were smaller, particularly during the months of April, September, and November. Recall from Table 7-10, from September to November households are engaged in plowing and land preparation activities for the seeding and planting of food crops occurring in December. Thus there might be less labor available for hiring by those households with some hiring ability. During the months of June, July and August off-farm employment was not allowed in the model. This is mostly harvesting period in the study area. Scarcity of household labor is also shown by labor ranges during the labor binding months. These ranges show the minimum and maximum amounts of household labor by which the baseline optimal plan does not change. Similar to land range values examined earlier, during the labor binding months of April and May the labor ranges show smaller intervals for farms in the high L-AE categories than is the case for low and medium L-AE categories. Given that April and May are the most critical months in terms of labor both for clearing new fields and harvesting cultivated fields, these findings suggest that small changes in available household labor time for cropping activities would have contributed more to high L-AE farm income than is the case for other farm categories. This was also explained by labor shadow prices which were shown to be relatively higher for high L-AE farms than for other farm categories throughout the labor binding months.

The pattern of labor use shown also suggests that households in the low L-AE category are more likely to work off-farm than those in the other categories whereas those in the high L-AE category are more likely to hire in labor. Given the resource constraints it seems that one would expect that households in the low L-AE category would have taken less off-farm employment opportunities in order to allocate family labor to on-farm activities. In fact, the amount of household labor allocated to off-farm activities by a typical farm is very small and this suggests that it may be the case that there are very limited off-farm employment opportunities. Nonetheless, by L-AE farm category some household members are taking more off-farm work than others because they have higher income earning opportunities off-farm. Working off-farm may have a higher pay-off which may help to ease some on-farm cash constraints. Note that heads of the household in this category are younger than those in other categories. Off-farm employment by resource-poor households raises some concerns with respect to household food security. If most productive household members choose to work off-farm because of their high income earning capacity, then on-farm productivity decline on these farms relative to resourceful farms can be explained by the low productivity of remaining household members (when there are hiring constraints). These members can be women and/or children. This issue has been explored by Alwang and Siegel (1999) in rural Malawi where they found that on-farm labor shortages on small holdings in Malawi were a result of, among other factors, the low returns to labor and land which contributed to household food insecurity. Land-poor households faced with consumption and production needs were forced to sell their labor thereby contributing to on-farm labor shortages to increase on-farm productivity and thereby secure food for own consumption. In the presence of food market failures, the effects of labor sales on on-farm productivity may be much stronger because during some critical agricultural periods households will need to work off-farm more often in exchange for food to compensate for the lack of food market purchases.

With respect to land, an important piece of information from the baseline results is the land shadow price. The shadow price for land under all categories is lower for farms in the low and medium L-AE categories than for farms in the high L-AE category. This reflects the relative scarcity (thereby a higher marginal value) of land for the low and medium L-AE farms. Recall that farms in the low L-AE category have the smallest land area for sole cropped cashew and that for food crops without cashew than farms in other categories. When productivity of crops grown on these land types rises, the marginal value of land used to cultivate sole cashew and crops without cashew will go up. Table 7-12 also provides the minimum and maximum land area by which the baseline farm plan does not change. The higher the marginal value of land the smaller this range is for a given farm type. These ranges are smaller for the farms in the low and medium L-AE categories compared to those in the high L-AE category. Although this reflects the LP right-hand side assumptions about land availability across farm categories, these land estimates indicate that low and medium L-AE farms have smaller land holdings relative to high L-AE farms.

The results presented above suggest that land endowment and on-farm productivity differences are the source of the income gaps across farm categories, particularly for those households with a smaller portion of land in which they have to crop to meet food security requirements. Furthermore, income per household seems to follow the cultivated land pattern across farm categories which indicates income is closely correlated with the amount of land cultivated by each farm. This land pattern seems to suggest that both land and labor are potential constraining factors in farmer's cropping choices. Households in the low and medium L-AE categories are more likely to grow mixed cropping of food crops with no cashew although they also allocate some land to both sole and mixed cropped cashew. On the other hand, high L-AE farms allocated more land to cashew cropping, both under sole and mixed cropped conditions, and to monocropped food crops. The introduction of new activities into the current farming system is likely to be affected by these resource constraints.

In the next section, we introduce the chemical control of PMD package for treatment of cashew trees into the set of current cropping activities to examine the conditions by which farmers are likely to select to improve cashew trees on both sole and mixed cropped cashew fields.

7.2.2.2 The *CCPMD* Package on Cashew Trees under Current Cropping Systems

Table 7-14 show the results of the household LP model with the introduction of the chemical control of PMD package into the current cashew cropping system by farms across L-AE categories, and the typical cashew farm. These results reflect farmer's choices of current cropping systems when an additional activity is made available to change the traditional cashew cropping system to control by means of spraying a widespread disease on cashew trees, the *oidium annacardii* disease. The results show that, under the prevailing conditions none of the farms in each farm L-AE categories would have chosen the *CCPMD* package to improve cashew trees. Note that the optimal plan obtained here is similar to the baseline plan examined earlier. The set of cropping activities selected, and the net income values obtained when the *CCPMD* package is made available to farmers are not different from those in the baseline model. This seems to suggest that the *CCPMD* package is not a profitable enterprise for farms across L-AE categories, a result found with the partial budgeting analysis conducted earlier in this chapter.

Table 7-14 Linear Programming Results for the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
Cropping Activities	---------------- Ha planted -------------			
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22 [2]	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, Peanuts [1]	1.23	0.98	1.27	1.16
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts[1]	-	-	-	-
Net Income	----- $ per Hh and $ per capita -----			
Total	248.53	306.80	365.57	305.92
Per capita	49.21	85.22	97.49	76.48

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.
1 These are high yield and labor input crops
2 About 53 percent of this land area was allocated to low labor and yield sole cropped cashew.

The lack of profitability of the *CCPMD* package was explained in the crop budget analysis as a result of the current low cashew yields and prices. With these low yields and prices, farmers could not increase current levels of labor investments in cashew, particularly for those trees under traditional sole cropping. Unless better incentives are in place to induce smallholders to invest more into cashew to improve yields, traditional cashew would always be an optimal selection. Investing more into this enterprise will require higher incentives to turn it into a more profitable enterprise relative to other crop mixtures. This is even more important for those trees under sole cropping conditions. In the following section we explore alternative change scenarios to this model with extensions which include changes in cashew prices and yields, food prices and relaxing potential labor and cash constraints.

7.2.2.3 Alternative Change Scenarios

Tables 7-15 through 7-21 show the results of the different change scenarios by farm category, and a typical farm. The percentage changes in each scenario are point estimates by which a given optimal plan shifts away from either the baseline or the immediate optimal plan within a given scenario by each smallholder L-AE farm category, and the typical farm. The results from each scenario are compared to the baseline optimal farm plan. Similar to results from section 7.2.2.2, results of each alternative change scenario are obtained from model runs which include the chemical control of PMD on cashew trees under the current cropping systems. Changes are as follows: in Table 7-15 the relative profitability of cashew is evaluated by increasing the prices of cashew up to 125 percent for different farm categories, including the typical farm. Next, Table 7-16 presents results from an alternative to increasing cashew prices. Here the impact of increasing cashew yields beyond the first technology impact assumed is evaluated. In Table 7-17 results are presented for a 30 percent increase in prices of crops grown on the farm on the baseline optimal plan. This scenario is extended in Table 7-18 by exploring the potential complementarity between cashew and food crops in the smallholder farming system. Then Tables 7-19 and 7-20 show the effects of relaxing the labor constraint. Table 7-19, the model assumes that a shock occurs and affects both demand and supply of labor resulting in a 30 percent reduction in the wage rate. Cashew prices are again increased along with the reduction in wages in Table 7-20. Finally, in Table 7-21 the cash constraint is relaxed by allowing households to borrow both for general purposes and for input purchases.

7.2.2.3.1 Relative Profitability of Cashew

Table 7-15 shows the impact of an increase in cashew prices under the current and improved management practices in the baseline optimal farm plan. It is expected that a sustained increase in the relative price of a cashew may induce smallholders to invest in improving cashew trees, particularly those under the monocropping system. This is where most trees are located. A sensitivity analysis is conducted by raising cashew prices to different levels and results are evaluated for each farm category. The results show that with an increase in cashew prices of up to 115 percent, medium L-AE farms would have applied the *CCPMD* package to improve about 41 percent of their trees on fields of 39 tree density, mixed cropped with manioc, beans and peanuts. Under this cropping system, farms in the low and high L-AE categories would have improved all and about 78 percent of the trees, if cashew prices had increased by 120 percent and 125 percent,

Table 7-15 Linear Programming Results for the Increased Cashew Prices Scenario under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm (121%)
	Low (L-AE) (120 %)	Medium (L-AE) (115%)	High (L-AE) (125%)	
Cropping Activities		------------------ Ha planted --------------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, Peanuts [1]	-	0.58	0.28	-
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	1.23	0.40	0.99	1.16
Net Income		----- $ per Ha and $ per capita -----		
Total	299.95	306.80	365.57	305.92
Per capita	59.39	85.22	97.49	76.48
Opportunity Costs		------------ $ per Ha --------- -----		
Land				
Food Crops only	147.73	150.99	143.09	146.46
Sole Cropped Cashew	49.79	50.23	47.77	49.71
Mixed Cropped Cashew	181.86	190.05	173.28	180.92

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.

1 These are high yield and labor input crops

Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

respectively. An increase in cashew prices of about 121 percent would have been required to induce a typical smallholder cashew farm to improve all of its cashew trees mixed cropped with manioc, beans and peanuts.

Note that under the current economic conditions when the *CCPMD* package was introduced in the set of current cropping systems, none of the L-AE farms, including the typical farm selected to improve any trees. Note also that even price changes of about 115-125 percent do not offer sufficient incentives for farmers to improve trees under the traditional sole cropped fields. An analysis of the typical farm optimal plan shows that improvements in the traditional sole cropped cashew field only occur at a 150 percent increase in cashew prices. At this price level, a typical farm would select to improve the 52 tree density fields with sole traditional cashew trees using the *CCPMD* package. These percentage changes in cashew prices imply nominal producer prices of about $0.82-$0.95 per kg of raw cashew nuts. These prices are very high compared to those farmers were able to obtain in the 1999-2000 cashew marketing season. Realistically, increased cashew prices of this magnitude will require profound changes in research and extension to improve cashew productivity, and substantial efforts in increasing competition in the cashew marketing which depend on more public investments to improve rural infrastructures to reduce transaction costs.

However, significantly higher cashew price levels seems to be one way to provide the necessary incentives for all L-AE farms to move away from sole traditional cashew cropping and consider the adoption of improved cashew management practices. Note that in this analysis we consider only one package. As pointed out earlier, there are other alternatives to the *CCPMD* package and these include the *TWCPMD* and the *ICM*. The *ICM* is an integrated technological package which includes top-working of a portion of trees which are old but have some potential for rejuvenation, pulling out of uneconomic trees replacing them with new and improved material, and spraying of the remaining trees. Regular pruning and cleaning adds to the package as it would be required for other packages. This is a more costly option, both in terms of inputs and labor requirements. However, given that its impact on yield is higher than that of the *CCPMD* package, it may be more attractive in the long run. We examine the *TWCPMD* and the *ICM* packages in later sections using a different approach.

Moving from the traditional cashew cropping into improved practices with adoption of spraying raises the shadow price of land available for cashew production across farm categories. A comparison between low and high L-AE farm categories show that shadow prices of land allocated to mixed cropped cashew are lower for the latter group. As explained earlier, this is due to the fact that land is relatively more scarce for farms in the low L-AE category than it is for high L-AE farms. Alternatively, as cashew prices rise and more diseased cashew trees are sprayed to control for the spread of PMD farmers become economically better off. The net income from these improved enterprises increase, making it worth the farmer's investment in land and labor. For instance, an increase in cashew prices of about 121 percent would have led a typical farm to improve all of its cashew trees mixed cropped with manioc, beans and peanuts. This change would have increased total household and per capita net income by 21 percent and 29 percent, respectively. Note that these results were not quite clear in the crop budgeting analysis where the *CCPMD* package was examined separately from the rest of the farming system. In the LP approach, as farmers are given the option to select from a wider range of available technical possibilities to choose from, the final choices seem to reflect better most of their farming constraints as compared to the crop budgeting analysis. As an optimization tool, the LP framework captures the smallholder resource constraints and provides with the best choice set of activities in which resources have their optimal use.

In summary, this scenario shows that farmers across all farm categories require significantly higher prices to adopt new management packages to improve cashew trees. These prices are much higher for high L-AE farms than they are for low and medium high L-AE farms. The main reason for these differences seems to reside on the relative scarcity of household labor, and on the low cashew yields which translate into low returns for some enterprises. On the other hand, households in the low L-AE category also seem to be affected by their relative land scarcity when making their cropping choices. While these households may not be labor constrained, they certainly could benefit more if they could use their relative labor abundance in larger land holdings. The analysis shows that under this setting, land scarcity leads to specialization on crops which meet first the food security requirements. Similarly, labor constraints seem to make it harder for some farmers to engage in improved, and profitable technologies. Thus relaxing labor constraints to smallholders would have a significant impact on technology adoption, particularly for farms in the high L-AE category. In the next section, we look at an alternative to increasing cashew prices to raise the likelihood of adoption of improved practices.

7.2.2.3.2 Further Increases in Cashew Productivity

An alternative or complement to increases in cashew prices may be yield improvement. If the impact on yield from alternative technologies and management practices could go beyond the mean yields assumed in the profitability analysis conducted in section 7.1, larger benefits could be realized compared to those obtained in the baseline model. Table 7-16 shows the impact of an increase in cashew yields beyond what was assumed when the *CCPMD* was first introduced as shown in Table 7-14. The results indicate that the critical points at which the optimal baseline plan changes, particularly when traditional cashew cropping is no longer profitable are much lower than was the case with cashew price changes. For instance, farms in the low and high L-AE categories would have adopted the *CCPMD* package to improve trees under mixed cropping, if cashew yields could be expected to rise by 100 percent. Changes in cashew yields of the same relative magnitude would also have been sufficient to stimulate a typical farm to adopt the *CCPMD* package on trees mixed cropped with manioc, beans and peanuts at the 39 tree density.

Farms in the medium L-AE category would have behaved similarly, if cashew yields had increased 15 percent more than that required by low and high L-AE farms. Note that it would have required an increase of up to 125 percent in cashew prices to achieve similar results. As in the case of price changes, moving from the traditional

Table 7-16 Linear Programming Results for the Increased Cashew Yields Scenario under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm (100%)
	Low (L-AE) (100 %)	Medium (L-AE) (115%)	High (L-AE) (100%)	
Cropping Activities		------------------ Ha planted --------------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, and Peanuts [1]	-	0.56	-	-
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	1.23	0.42	1.27	1.16
Net Income		----- $ per Ha and $ per capita -----		
Total	257.09	308.00	365.69	310.59
Per capita	50.90	85.55	97.52	82.8
Opportunity Costs		----------- $ per Ha --------------		
Land				
Food Crops only	147.73	148.15	143.49	146.46
Sole Cropped Cashew	15.11	15.56	12.94	15.02
Mixed Cropped Cashew	160.82	158.64	148.09	159.89

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.

1 These are high yield and labor input crops

Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

cashew cropping into improved with adoption of the *CCPMD* package raises the shadow price of land across farm categories. These increases in land shadow prices are higher for land- poor households than for relatively land-rich households. The net income from cashew enterprise improvement increases, which indicates the worthiness of making these investments in cashew. As cashew yields and prices rise, marginal land values also rise and faster for land-poor households. Similarly, the opportunity cost of labor rises for labor constraint households.

This scenario suggests that a possible alternative to increasing prices in order to raise smallholder net income would be to increase cashew productivity through yield. It is clear that the necessary percentage increase in yield to stimulate farmers to improve cashew trees from traditional cropped fields, and adopt improved management practices are much lower than those observed through price increases. Furthermore, these yield changes are also lower for farms who seem to enjoy relative labor abundance than for those facing labor constraints lending support to earlier findings about differences in on-farm productivity resulting from differences in labor and land endowments.

In the next section, we explore the potential complementarity between food crops grown on-farm and cashew, as a potential alternative (or complement) to raising cashew prices and yield to change smallholder's behavior toward investments in cashew improvements.

7.2.2.3.3 Complementarity of Food and Cashew Cropping

The following scenario explores the potential complementarity between cashew and food crops grown on the farm. Production of marketable crops provide farmers with cash to meet short term needs. Depending on the scale and productivity levels, receipts from sales may generate enough resources which can be used in making investments in other crop enterprises or purchases of household assets such bicycles and radio. In the study area peanuts play often this role. To evaluate whether food crops prices increase could be an alternative to cashew prices in providing the incentives to make more investments in cashew, prices of beans, manioc and peanuts were increased by 30 percent. Note that for simplicity, the price increases affect farmers both as sellers and buyers of these crops. While increased prices benefits farmers as sellers of food crops, they also are affected when they fall short of these crops for their own consumption. The net effect is evaluated by either increase or decrease in net income relative to the baseline model results.

The results from this scenario are presented in Tables 7-17 and 7-18. Note from Table 7-17 that the changes in food crop prices are not sufficient for farmers to move away from the traditional cropping of cashew. When the *CCPMD* package is available, as the prices of food crops increase, none of the L-AE farms, including the typical farm select to improve cashew trees under both cropping systems. All the farms remain in the baseline solution. Higher food prices increase the marginal value of cultivated land to signal its increased demand for cultivation. Results from the typical farm show that land

Table 7-17 Linear Programming Results for a 30 Percent Increase in Food Prices Scenario under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
Cropping Activities		---------------- Ha planted -------------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, and Peanuts [1]	1.23	0.98	1.27	1.16
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	-	-	-	-
Net Income		----- $ per Ha and $ per capita -----		
Total	310.91	384.89	491.39	393.10
Per capita	61.57	106.91	131.04	98.28
Opportunity Costs		----------- $ per Ha -------------		
Land				
Food Crops only	221.45	220.96	214.49	217.91
Sole Cropped Cashew	17.07	17.07	13.39	15.22
Mixed Cropped Cashew	247.67	247.67	232.49	237.85

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.

1 These are high yield and labor input crops

Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

shadow prices increased about 47 percent for land under food crop cultivation without cashew and about 51 percent for that under food crops and cashew.

To avoid that improvements in food crops make it harder for farmers to increase attention for cashew, the model allows for proceeds from sales of marketable food crops be invested in cashew improvement activities. In this way, earnings from food feed into an operating capital stock which could be used to purchase inputs to improve cashew. The results, however, suggest that earnings from sales of marketable food crops could not make up for low cashew yields and prices.

Table 7-18 shows the results of an extension of the scenario presented in Table 7-17. Here food prices increases are complemented with increases in cashew prices. When food crop prices change farmers do allocate more labor into these enterprises. Although the additional labor may benefit cashew trees, it is not sufficient for farmers to engage in cashew improving technologies and management practices in all the cashew trees. For instance, it is shown that with a 30 percent increase in marketable food crops and an increase in cashew prices of 145 percent (about $0.93 per kg), farms in the low and medium L-AE farms adopt the *CCPMD* package to improve about 74 percent and about 43 percent of the cashew trees mixed cropped with manioc, beans and peanuts at a density of 39 trees, respectively. A price of about $0.99 per kg would be required by farms in the high L-AE category to improve about 78 percent of the trees under the same cropping system. A look at the typical farm shows that a price of about $0.95 per kg would be sufficient to improve all the trees mixed cropped with manioc, beans and peanuts. However, farmers across categories still keep all the traditional sole cropped

Table 7-18 Linear Programming Results for a 30 Percent Increase in Food Prices Scenario along with Increased Cashew Prices under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm (150%)
	Low (L-AE) (145 %)	Medium (L-AE) (145%)	High (L-AE) (160%)	
Cropping Activities		---------------- Ha planted -------------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, and Peanuts [1]	0.32	0.56	0.28	-
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	0.91	0.42	0.99	1.16
Net Income		----- $ per Ha and $ per capita -----		
Total	369.69	471.22	594.75	471.08
Per capita	73.20	130.89	158.60	125.62
Opportunity Costs		----------- $ per Ha -------------		
Land				
Food Crops only	218.63	218.15	210.26	216.13
Sole Cropped Cashew	57.20	57.29	54.29	57.25
Mixed Cropped Cashew	269.54	270.01	260.15	267.27

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.

1 These are high yield and labor input crops

Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

cashew trees untreated in their portfolio. Increases in both cashew and food crop prices raise net income and land shadow prices across farms. These increases in prices raise the value of land allocated to all crops relative to the baseline results. Note that these land values are still relatively higher for relatively land-poor farms.

Further increases in food prices could be allowed in the model to make it comparable to changes in cashew prices. Given that we are searching for switching points at which we observe adoption of new technologies and management practices, a simple comparison of effects of individual changes may be misleading. While prices cannot increase continuously, a combination of strategies may be necessary to produce the effects that individual approaches provide to raise incentives to smallholders. Farmers cannot invest in cashew trees unless cashew prices can provide a signal that labor invested in cashew will earn a high return. Nonetheless, one cannot minimize the potential effects of food crop productivity improvements which ultimately may be reflected in food crop price changes and may spillover to cashew improvement activities. In the next section we examine the effects of smallholder labor constraints on choices of alternative cashew management practices.

7.2.2.3.4 Labor Constraints to Cashew Production

In addition to land and food security constraints, the models include monthly labor constraints over the cropping season. Given that in the short-run both land and family labor stocks cannot be increased, this section explores the effect of changes in the

Table 7-19 Linear Programming Results for a 30 Percent Reduction in Wages Scenario under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
<u>**Cropping Activities**</u>	---------------- Ha planted ------------			
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, and Peanuts [1]	1.23	0.98	1.27	1.16
<u>**New Technologies and Improved Management Practices**</u>				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	-	-	-	-
<u>**Net Income**</u>	---- $ per Ha and $ per capita ----			
Total	254.95	317.78	408.09	324.49
Per capita	50.49	88.27	108.82	86.53
<u>**Opportunity Costs**</u>	---------- $ per Ha ------------			
Land				
Food Crops only	179.21	178.86	173.41	179.72
Sole Cropped Cashew	20.48	20.40	16.91	19.11
Mixed Cropped Cashew	206.02	205.63	192.43	198.76

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.
1 These are high yield and labor input crops
Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

labor constraints of the model by assuming a shock in the local supply and demand for hired labor which reduces the wage rates by 30 percent. By reducing the wage rate we intend to provide farmers with the opportunity to relax the labor constraint by hiring more labor. We anticipate that, in order for farms to hire more labor, they must either face lower wages and/or increased returns to on-farm activities. In fact, the results presented in Tables 7-19 reflect only the reduction in wage rates whereas those in Table 7-20 include both lower wages and increased returns to cashew through higher cashew prices.

Table 7-19 shows that a 30 percent reduction in wages is not sufficient for farms across L-AE categories to adopt the *CCPMD* package to improve cashew trees under the traditional cropping system. Results in Table 7-19 show the net effect of reduced wage rates on net income from selected set of cropping activities. Note that reduced wage rates lower production costs, but lower wage rates affect also earnings from off-farm employment. The effect of lower wages might be more negative for labor-abundant households who do more off-farm work than they hire in labor, relative to labor-scarce households. The end effect may be difficult to ascertain because of the relation between land and labor availability. Complexities within this relationship may obscure the effect of reduced wages on cropping choices. Labor abundant farmers may be undertaking relatively more off-farm employment because of land scarcity whereas land-rich farmers may benefit more from reduced wages due to lack of household labor and thus reliance on hired labor. Under these circumstances, reduced wages will make the first group worse-off.

In fact, results in Table 7-19 show that a 30 percent reduction in wage rates does not stimulate farms across categories to adopt the *CCPMD* package to improve cashew trees. It is possible that further decreases in wage rates could effect on farm's plans, particularly at specific period of the year when farmers faced labor constraints for given operations. The reduction in wages increases the shadow price of land as farms seek to employ more labor to increase returns to land on food crops. Note however, that despite the reduction in production costs and increase in the likelihood for farmers to engage in improved management practices, this did not translate into substantially high net incomes compared to the baseline. Net income per household increased about three percent for low L-AE farms, about four percent for medium and 12 percent for high L-AE farms. This is about six percent increase in net income for the typical cashew farm. This suggests that in fact while reduced wages helped more to relatively labor scarce farmers, relatively labor-abundant farmers were made worse-off due to reduced earnings from off-farm employment.

In Table 7-21 we complement the reduction in wages with increases in cashew prices. We are looking for the switching points at which farmers would adopt cashew productivity enhancing practices. For instance, under this scenario an increase in cashew prices up to 105 percent is sufficient to alter the baseline solution for farmers in the low and medium categories. At this price level, these farms select to improve all the cashew trees at the density of 39 on the mixed cropped field with manioc, beans and peanuts by adoption of the *CCPMD* package. Improvements of cashew trees under this cropping

Table 7-20 Linear Programming Results for a 30 Percent Reduction in Wages Scenario along with Increased Cashew Prices under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm (105%)
	Low (L-AE) (105 %)	Medium (L-AE) (105%)	High (L-AE) (115%)	
Cropping Activities		------- Ha planted -------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, and Peanuts [1]	-	-	-	-
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	1.23	0.98	1.27	1.16
Net Income		---- $ per Ha and $ per capita ----		
Total	299.93	381.94	485.79	381.06
Per capita	59.39	106.09	134.94	95.27
Opportunity Costs		------- $ per Ha -------		
Land				
Food Crops only	176.38	175.88	171.33	175.48
Sole Cropped Cashew	49.19	49.16	47.50	49.13
Mixed Cropped Cashew	221.20	220.85	217.14	220.55

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.

1 These are high yield and labor input crops

Note: Numbers in parenthesis are percentages by which a given farm selects to improve cashew trees using the chemical control of PMD package.

system by farms in the high L-AE category occur when cashew price changes are about 115 percent.

Net income per household generated under this scenario seems to be higher than that obtained under the relative profitability of cashew scenario for farms in the medium and high L-AE categories in Table 7-15. Note that these are the farms which benefit more from reduced labor costs, as shown above. Increased cashew prices reinforce the benefits of reduced labor costs. This effect seems to be stronger for the labor scarce farms in the high L-AE category than is the case in other farm categories. Note also that saving on production costs through wage reduction benefit farmers on investments already made in cashew, but it does not provide the necessary incentives for new investments (see Table 7-19). Farmers require changes in cashew prices in order to improve upon traditional practices (Table 7-20). As it was shown, complementing these cost savings with increased cashew prices seems to have a greater impact than that provided by increases in food prices. The reason for this is that in the latter there is a potential for food crops competing for land with cashew which may make it harder for cashew to receive more care.

In the next scenario, the cash constraint is relaxed by allowing borrowing for both general purposes and for input purchases. Note that the model distinguishes these two sources of finances and their uses. Unlike funds for general purposes, funds for input purchases cannot be used for living expenses, but may be complemented with receipts from sales of food crops.

7.2.2.3.5 Relaxing the Cash Constraints

In Table 7-21 we introduced borrowing into the model for both input purchases, and general household living expenditures. Borrowing had no effect on the baseline solution. That is, borrowing activities did not enter into the optimal solution. The likely explanation was that input costs were to low to require credit.

The credit issue, however, it is of extreme importance for new technologies and improved management practices such as the *TWCPMD* and the *ICM* packages whose impact have a time dimension. While the benefits from spraying cashew trees can be obtained from the initial of its application, those from the *TWCPMD* and the *ICM* packages have a gestation period with at least two to three years of negative returns. This waiting period is likely to be a constraining factor to adoption for resource-poor farmers. As a result, credit can become an important resource for farmer's adoption of these technologies.

It is important also to keep in mind that even in the case of adoption of the *CCPMD* package credit may be important, particularly in the presence of failures in the food and labor markets. Farmers may fail to produce sufficient surplus of marketable food crops or farmers may stay longer periods without engaging in off-farm employment opportunities. These factors may reduce their ability to accumulate sufficient income and therefore fail to secure funds to finance the required inputs, in a given year. Another important issue is availability of inputs such as fungicides, oil, petrol and blower services in local markets. This is also likely to prevent farmers from adopting the new technologies and improved cashew management practices. Nonetheless, the results show

Table 7-21 Linear Programming Results for the Relaxed Cash Constraint Scenario under the Current and Improved Management Practices for Low, Medium and High L-AE, and Typical Smallholder Cashew Farm Categories

Optimal Smallholder Choices	Smallholder L-AE Farm Categories			Typical Smallholder Cashew Farm
	Low (L-AE)	Medium (L-AE)	High (L-AE)	
Cropping Activities		---------------- Ha planted -------------		
Traditional				
Peanuts [1]	0.53	0.74	1.47	0.78
Manioc	-	-	-	-
Cashew [1]	0.49	1.36	1.22 [2]	1.01
Manioc and Beans	-	-	-	-
Manioc and Peanuts	-	-	-	-
Manioc, Beans and Peanuts [1]	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans, Peanuts [1]	1.23	0.98	1.27	1.16
New Technologies and Improved Management Practices				
Chemical Control of PMD on Cashew Trees under:				
Cashew	-	-	-	-
Cashew and Manioc	-	-	-	-
Cashew, Manioc and Beans	-	-	-	-
Cashew, Manioc and Peanuts	-	-	-	-
Cashew, Manioc, Beans and Peanuts [1]	-	-	-	-
Net Income		----- $ per Ha and $ per capita -----		
Total	248.53	306.80	365.57	305.92
Per capita	49.21	85.22	97.49	76.48

Source: Smallholder Cashew Production Technology Survey, Nampula 1998/9, Mozambique.
1 These are high yield and labor input crops
2 About 53 percent of this land area was allocated to low labor and yield sole cropped cashew.

that farmers may have the financial resources to afford the input costs provided these inputs are available and they have sufficient confidence that cashew can yield a return worth the investments they may decide to make.

In the forthcoming section we elaborate on the dynamics of cashew investments with particular reference to time pattern of costs and benefits using the *TWCPMD* and *ICM* packages as an example to highlight risk and credit considerations.

7.3 Timing of Cashew Investments and Cash Flow Issues

The purpose of this section is to complement the analysis undertaken in previous sections through a discussion of the importance of time pattern of costs and increased yields for two technological packages: *TWCPDM* and the *ICM*. Recall that *TWCPDM* package includes top-working in combination with chemical control of PDM, and the *ICM* package is a bundle of top-working, chemical control of PDM and thinning/replanting of cashew trees. Both packages also include improved husbandry of cashew fields such as regular pruning and weeding. In previous sections we used a simple deterministic single-period linear programing model to analyze smallholder cashew farms production decisions. The model focused on constraints faced by smallholder cashew farmers and evaluated how these households would have responded to changes in cropping systems with introduction of the *CCPMD* technology package on cashew trees with improved management practices.

However, the perennial nature of cashew trees and the long term characteristics of benefits and costs of new investments embodied in the *TWCPMD* and the *ICM* packages

Table 7-22 Tree Characteristics by Cashew Varieties

Tree Characteristics	Cashew Tree Variety	
	Common (Traditional)	Dwarf
	------------- meters ---------	
Height	6.00	3.00
Canopy Diameter	13.00	6.00
	-------------years------------	
Time for initial production	3rd	1st
Time to economic production	8th	3rd
Time to stable production	15th	7th
	---------trees per ha, and kg per ha------------	
Density (trees/ha)	44-150	200-416
Mean yield (kg/ha)	900.00	1300.00

Source: Prasad, M., José Camões, and Pedro Cuhia "Cultura do Cajú: Manual Prático" SEC.

require a multi-period framework to take into account lags and risk involved in the cashew production process. A certain period of time is required for full implementation of investment decisions which result in stocks of resources that last for several periods of time (Merrill, 1987). These lags in production introduce periods in which benefits are below costs. This raises some concerns with respect to incentives to adoption of improved practices. As Table 7-22 shows, time lags in cashew production are basically defined by choices of cashew variety along with climatic conditions. For instance, dwarf varieties begin production in the first year after planting, reaching economic production on the third year and stabilizing production on the seventh year. Alternatively, the common variety produces its first nuts on the third year, reaching economic levels on the

8th year to stabilize on the 15th year after. Nonetheless, biological factors together with climatic conditions can, in effect, shorten these periods. In this regard, technology options such as top-working can offer a faster response compared to planting a completely new stock of cashew trees. That is, when an rooting system of an old and traditional tree is used (as it is the case of top-working) to graft on improved material, the initial production period can be expected to be earlier than it would have been if a new seedling was planted. Research work by WV and the CRP in Nampula has shown that when canopies of traditional cashew trees are top-worked with superior material, production can start within 18 months. The response varies across geographical locations, but the most important factor for this response is soil fertility. Poor performance was also and mostly observed in less fertile soils and poorly managed cashew orchards (Eliezer, 1999, personal communication).[10]

As in all production processes time lags introduce considerable risk to farmers because of yield and price variations over the time. This in turn may reduce the returns to smallholder's investments for a period of time and thereby create a disincentive for farmers to invest in different technologies to expand production and improve quality. Under these circumstances, a richer approach to farmer's cropping choices would have been a dynamic linear programming model which has been particularly successful in capturing the long term nature of perennial crops integrated with annual crops and other household activities. However, the use of a multi-period approach is more complex and

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[10] In Chapter 5, we noted that loamy sandy soils with moderate moisture levels had a positive effect on yield.

data demanding. The data available in Mozambique at this point prevented the use of a dynamic linear programing. Of critical importance is data from agronomic research on the impact of the new technologies and improved cashew management practices on yield, and the time pattern of costs. As mentioned earlier, 'steady-state' yield data used in previous sections was based on estimates from other countries. Yield data to construct a 'cashew yield curve' from different technology packages does not exist for Mozambique.

Given that a multi-period linear programming could not be pursued, we attempt to use a capital budgeting approach in recognition of the caveats of the single period model used in section 7.2, above. Here we construct first a hypothetical 'cashew yield curve' for the *TWCPMD* and *ICM* packages based on estimates of yield from secondary sources. The yield curve is constructed under very restrictive assumptions. The purpose is to show and to stress the importance of time pattern of costs and likely increased yield in modeling farmer's investment decisions for a perennial crop such as cashew. This exercise allows us to discuss critical issues such as risk and cash flow and their relationship with the potential adoption of new technologies and improved management practices. The analysis is undertaken for a typical smallholder cashew farm and refers to cases in which both the *TWCPMD* and the *ICM* packages are applied under monocropping and mixed cropping conditions. Under mixed cropping conditions, field level data for existing practices refers to cashew trees cropped with manioc, beans and peanuts. Note that farmers grow cashew trees in different combinations with food crops. The choice of a mixed cropped cashew field with manioc, beans and peanuts reflects the importance of the most widely grown food crops in study area in the profitability of enterprises which include cashew.

There are crucial assumptions that the performance indicators depend upon for the new technology and improved cashew management practices presented in Tables 7-23 through 7-26. These are: (1) as Topper et al., (1999) found in Monapo District, spraying can increase the current yield up to double in the first year of its application;[11] (2) Brazilian data provides estimates of potential yields under a mix of top-working, thinning, and replanting which vary from the low 0.41 kg/tree in the second year to the high of about 7 kg/tree in year eight. These are the estimates used to construct a hypothetical yield curve to examine the two *TWCPMD* and the *ICM* packages on a mono- and mixed cropped cashew field, as shown in Tables 7-23 throughout 7-26. We discuss first results for the *TWCPMD* package in Tables 7-23 and 7-24, and then those for the *ICM* package in Tables 7-25 and 7-26.

7.3.1 The *TWCPDM* and *ICM* Packages under the Current Cropping Systems

Table 7-23 shows capital budgeting results for a hectare of monocropped cashew trees under the *TWCPMD* package by a typical smallholder cashew farm. Results show that at the assumed input and output prices an investment in the *TWCPMD* package is not

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[11] Note that this result depends on the current potential of the tree. Whether a tree, after treatment through spraying, can produce a yield of this magnitude depend on its current potential to which age and disease incidence are critical factors. Whereas disease incidence may be ease to determine, age of the tree is more complex, but critical to farmer's investment in improvements.

Table 7-23 Capital Budgeting for One Hectare of Monocropped Cashew Trees for a Typical Smallholder Cashew Farm under the Top-working and Chemical Control of PMD (*TWCPMD*) Package

Budget Item	Years (Improved Practices) -------->								
	Existing Practices	1	2	3	4	5	6	7	8
Yield Information			-----------------------------kg/per tree-----------------------------						
Sprayed trees	1.12	2.24	3.36	4.48	5.60	6.72	7.84	8.96	10.08
Top-worked trees	--	--	5.98	8.80	10.33	11.80	12.30	16.08	16.08
Yield per Ha (Kg/ha)	53.76	77.41	161.28	215.04	268.80	322.56	376.32	430.08	483.84
Density (trees/ha)	48	48	48	48	48	48	48	48	48
Cashew Price (US$/kg)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Revenues (US$/ha)	20.43	29.42	61.29	81.72	102.14	122.57	143.00	163.43	183.86
Operating Costs			------------------------------ US $ per Ha --------------------------						
Purchased Inputs(excluding labor)	0.51	62.66	62.44	62.44	62.44	62.44	62.44	62.44	62.44
Total Labor Cost	28.00	62.91	22.68	51.65	48.84	51.65	48.84	51.65	48.84
Tractor Services	--	6.51	2.84	3.27	2.84	3.27	2.84	3.27	2.84
Total Costs	28.51	132.07	87.95	117.36	114.11	117.36	114.11	117.36	114.11
			------------------------------- US $ per Ha --------------------------						
Net Returns	-8.08	-102.66	-26.66	-35.65	-11.97	5.21	28.89	46.07	69.74
Incremental Net Returns		**-94.58**	**-18.58**	**-27.56**	**-3.89**	**13.29**	**36.97**	**54.15**	**77.82**
At 10% NPV	**-31.49**	**(US$/ha)**							
IRR	**4.3%**								

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9. Other data sources include Topper et al., 1999; Prasad et al., 1996; Embrapa, Brazil.

attractive under monocropping conditions. A typical smallholder cashew farm would have earned a low four percent rate of return, if the farmer had top-worked about 28 percent of the trees at the current cashew density of 48 trees, and sprayed all the reminder on a sole cropped cashew field.[12] At a 10 percent discount rate, this internal rate of return mean a negative net present value of about 31.5 USD per hectare.

In Table 7-24, results show a better picture for the package when it is applied to a mixed cropped field. Here, the internal rate of return is about 42 percent, and the net present value is about 138 USD per hectare. Recall that the differences in profitability across cropping systems are a result of two factors explored earlier: (1) low cashew yields in monocropped cashew fields due to, among other factors, less labor allocated to management of the trees, and (2) higher density in sole cropped cashew fields. Cashew yields per tree on sole cropped fields on average is about 6 percent lower than that on mixed cropped fields. Furthermore, sole cropped cashew fields have about 26 percent more trees than those mixed cropped. As a result of less care, the proportion of trees showing some signs of disease is about 15 percent higher on sole cropped cashew fields than those on mixed cropped fields. These factors contribute to a large extent to the differences in the baseline yield from which impact of the technologies is examined.

Sensitivity analysis on price changes shows that a seven percent change in the current price of $0.38 per kg from the third year of adoption of the *TWCPMD* package on

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[12] For details on proportions of trees subject to different technologies in a given field, see Chapter Three.

Table 7-24 Capital Budgeting for One Hectare of Mixed Cropped Cashew Trees for a Typical Smallholder Cashew Farm under the Top-working and Chemical Control of PMD(*TWCPMD*) Package

Budget Item	Years (Improved Practices) -------->								
	Existing Practices	1	2	3	4	5	6	7	8
Yield Information					--kg/per tree--				
Sprayed trees	1.22	2.44	3.66	4.88	6.10	7.32	8.54	9.76	10.98
Top-worked trees	--	--	5.98	8.80	10.33	11.80	12.80	16.08	16.08
Yield per Ha (Kg/ha)	46.36	66.76	163.76	227.15	276.81	325.81	364.53	438.12	471.50
Density (trees/ha)	38	38	38	38	38	38	38	38	38
Cashew Price (US$/kg)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Revenues (US$/ha)	17.62	25.37	62.23	86.32	105.19	123.81	138.52	166.49	179.17
Operating Costs					-- US $ per Ha --				
Purchased Inputs(excluding labor)	2.14	50.78	50.61	50.61	50.61	50.61	50.61	50.61	50.61
Total Labor Cost	32.61	49.80	17.95	40.89	38.67	40.89	38.67	40.89	38.67
Tractor Services	--	5.15	2.25	2.59	2.25	2.59	2.25	2.59	2.25
Total Costs	34.75	105.74	70.81	94.09	91.52	94.09	91.52	94.09	91.52
					-- US $ per Ha --				
Net Returns	-17.13	-80.37	-8.58	-7.77	13.67	29.73	47.00	72.40	87.65
Incremental Net Returns		**-63.24**	**8.56**	**9.36**	**30.80**	**46.86**	**64.13**	**89.53**	**104.78**
At 10% NPV	**137.77**	**(US$/ha)**							
IRR	**42.4%**								

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9. Other data sources include Topper et al., 1999; Prasad et al., 1996; Embrapa, Brazil.

a monocropped cashew field, throughout year eight would have been sufficient to yield an internal rate of return of about 11 percent with a net present value of about 5 USD. These estimates are still very low as incentives to farmers, but they show the potential of these investments at different prices levels.

Tables 7-25 and 7-26 show profitability measures assessing the attractiveness of the *ICM* technology package for a typical smallholder cashew farm in the study area. The results are similar to those examined for the *TWCPMD* package in terms of the cropping system in which profitability is the best. Table 7-25 shows that an investment in an integrated cashew management package (meaning top-working, thinning and replanting, and spraying) is not attractive for a typical smallholder cashew farm under monocropped conditions. At the prevailing yields, input and output prices a typical smallholder cashew farm would have earned a negative rate of return of about 29 percent with adoption of the I*CM* package on a sole cropped field with a density of 48 trees. The application of the technology would have affected 28 percent of trees with top-working, an equal percentage of trees subjected to thinning and replanting, and the reminder chemically sprayed.[13] The investment would have yielded a negative net present value of about 258 USD per hectare. However, the adoption of the *ICM* package on a mixed cropped field shows an internal rate of return of about 16 percent with a net present value of about 38 USD per hectare.

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[13] For details on proportions of trees subject to different technologies in a given field, see Chapter Three.

Table 7-25 Capital Budgeting for One Hectare of Monocropped Cashew Trees for a Typical Smallholder Cashew Farm under the Integrated Cashew Management(*ICM*) Package

Budget Item	Existing Practices	1	2	3	4	5	6	7	8
		Years (Improved Practices) -------->							
Yield Information			--------kg/per tree--------						
Sprayed trees	1.12	2.24	3.36	4.48	5.60	6.72	7.84	8.96	10.08
Top-worked trees	--	--	5.98	8.80	10.33	12.30	16.08	16.08	16.08
Newly Planted Trees	--	--	0.40	2.73	3.84	4.44	5.02	5.22	6.70
Yield per Ha (Kg/ha)	53.76	47.31	91.70	154.35	200.60	240.00	279.13	313.15	364.38
Density (trees/ha)	48	48	48	48	48	48	48	48	48
Cashew Price (US$/kg)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Revenues (US$/ha)	20.43	17.98	34.85	58.65	76.23	91.20	106.07	119.00	138.46
Operating Costs			-------- US $ per Ha --------						
Purchased Inputs(excluding labor)	0.53	62.66	62.44	62.44	62.44	62.44	62.44	62.44	62.44
Total Labor Cost	28.00	134.71	47.21	48.05	45.24	48.05	45.24	48.05	45.24
Tractor Services	--	7.50	2.84	4.26	2.84	4.26	2.84	4.26	2.84
Total Costs	28.53	204.86	112.48	114.75	110.51	114.75	110.51	114.75	110.51
			-------- US $ per Ha --------						
Net Returns	-8.11	-186.88	-77.64	-56.09	-34.29	-23.55	-4.44	4.25	27.95
Incremental Net Returns		**-178.78**	**-69.53**	**-47.99**	**-26.18**	**-15.44**	**3.66**	**12.36**	**36.05**
At 10% NPV	**-258.29**	**(US$/ha)**							
IRR	**-28.8%**								

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9. Other data sources include Topper et al., 1999; Prasad et al., 1996; Embrapa, Brazil.

Table 7-26 Capital Budgeting for One Hectare of Mixed Cropped Cashew Trees for a Typical Smallholder Cashew Farm under the Integrated Cashew Management Package

Budget Item		Years (Improved Practices) -------->							
	Existing Practices	1	2	3	4	5	6	7	8
Yield Information			-------kg/per tree-------						
Sprayed trees	1.22	2.44	3.66	4.88	6.10	7.32	8.54	9.76	10.98
Top-worked trees	--	--	5.98	8.80	10.33	11.80	12.30	16.08	16.08
Newly Planted Trees	--	--	0.40	2.73	3.84	4.44	5.02	5.22	6.70
Yield per Ha (Kg/ha)	46.36	40.80	129.08	204.27	252.76	295.18	327.07	389.82	425.96
Density (trees/ha)	38	38	38	38	38	38	38	38	38
Cashew Price (US$/kg)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Revenues (US$/ha)	17.62	15.50	49.05	77.62	96.05	112.17	124.29	148.13	161.87
Operating Costs			------- US $ per Ha -------						
Purchased Inputs(excluding labor)	2.14	51.32	51.14	51.14	51.14	51.14	51.14	51.14	51.14
Total Labor Cost	37.93	106.64	37.37	38.04	35.81	38.04	35.81	38.04	35.81
Tractor Services	--	5.94	2.25	3.37	2.25	3.37	2.25	3.37	2.25
Total Costs	40.06	163.89	90.76	92.55	89.20	92.55	89.20	92.55	89.20
			------- US $ per Ha -------						
Net Returns	-22.45	-148.39	-41.71	-14.93	6.85	19.62	35.09	55.58	72.66
Incremental Net Returns		**-125.95**	**-19.27**	**7.52**	**29.29**	**42.06**	**57.53**	**78.02**	**95.11**
At 10% NPV	**38.23**	**(US$/ha)**							
IRR	**15.7%**								

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9. Other data sources include Topper et al., 1999; Prasad et al., 1996; Embrapa, Brazil.

Note that these calculations are made using current cashew prices. With increased competition between exporters and domestic processors, as the world market for processed cashew improves, producer prices can be expected to increase. An expected increase in cashew producer price of about 80 percent over the period of analysis would be required to turn the improved sole cropped cashew trees into a profitable enterprise using the *ICM* package. This would have earned a rate of return of about 11 percent with a net present value about $USD 9 per hectare. Note that it is expected that the 1999-2000 producer prices will average $0.53 per kg (CWG, 1999 Statistical report). This price is about 39.5 percent above that in 1997/8 season, but it is still very low compared to the required price change shown above. It is unlikely that prices will increase up to 80 percent in the short-run. As mentioned earlier, a diversified incentive structure is needed to encourage greater adoption of improved cashew technologies. This would include changes in cashew producer prices, yields and input costs to make improved cashew technologies profitable for farmers.

7.3.2 The Time Pattern of Benefits and Costs of Investment

An important consideration in the analysis above is the time pattern of benefits and costs and its impact on potential adoption of the technologies and improved management practices. As shown in Tables 7-21 throughout 7-24, it takes about three to five years for farmers to realize positive net returns, depending on which cropping system cashew trees are chosen to be improved upon. Adding this fact to the uncertainties in cashew marketing, investments in cashew tree improvement can be perceived as too risky, particularly for farmers who face already several constraints, including liquidity constraints.

These issues bring about the need to consider credit as part of the improvement packages. In our previous single-period analysis we found that credit seemed to be of a lesser concern. This however, did not mean a complete dismissal of a such an important resource to farmers. When returns and costs are spread over time, the need for alternative sources to finance investments become more evident as shown in the capital budgeting presented in this section. For instance, if farmers are to adopt these technologies, the packages will need to consider credit as part of the inputs required. As pointed earlier, during the first three to five years farmers will realize returns below costs. This is a long period to wait, and may well be sufficient to prevent farmers from investing in cashew improvements.

7.4 Conclusions

This chapter has (1) estimated (under current smallholder cashew cropping conditions) the costs and returns per labor day for the chemical control of PMD package, (2) compared estimated results with those from Chapter Six on traditional cashew cropping practices, (3) used the generated information in developing a smallholder cashew household linear programming model to evaluate the chemical control package in the context of a smallholder whole farm system, and (4) developed a capital budgeting model for the top-working technology bundled with chemical control of PMD and the integrated cashew management packages to examine the time pattern of costs and returns to farmer's investments. In addition, the chapter has generated specific insights about the relative sensitivity of a farmer's profit to the potential adoption of new technologies and to changes in profit determinants. Another way to look at this is to ask what is the relative magnitude of changes in output price, yield or input cost needed to make improved cashew technology profitable.

A number of important results emerged from the partial profitability analysis of the chemical control of PMD. First, under the prevailing input and cashew prices the *CCPMD* package was not profitable for sole cropped cashew across all farm categories. The net returns per labor day were negative across L-AE farm categories. The main reason seems to be the extremely low cashew yields and prices. In addition, the ageing of the cashew trees and less care, as found in Chapter Five seems to be at the foundation of these results. Second, under mixed cashew cropping conditions the impact of the *CCPMD* package on net returns could be unambiguously labeled as an improvement over the traditional practices only when it was applied to cashew trees located on manioc and peanuts fields by farms in the low and high L-AE categories.

Unusual amounts of labor allocated to certain crop mixes compared to those by a typical smallholder cashew farm, and low cashew yields and prices explain the lack in profitability of cashew in most crop mixtures. Nonetheless, one cannot minimize the importance of the relative effects of the *CCPMD* package on yield. Recent research findings (Topper et al., 1999) in Nampula have shown that high potential trees once sprayed can double their current low yield. The financial analysis conducted here shows that there are potential gains from spraying cashew trees, particularly those on fields which include some marketable crops. Furthermore, spraying could have a greater impact on yield if farmers were able to determine which trees have high yield potential as opposed to an indiscriminate spraying which include uneconomic trees. Note that at the present state of the cashew orchard, it may not be worth top-working some trees or thinning and replanting some without controlling for the powder mildew disease (PMD). In the short-run farmers may select to spray their trees and neither top-work nor thin, but the effects although significant, may not be substantial enough due to the aging of the trees and the quality of the planting material that farmer have in the fields. It is thus important for farmers to ascertain which trees require different treatment to avoid uneconomic spraying, but improve efficiency of application. That is, farmers must be able to select which trees must be subject to a given technique to maximize spraying benefits on those trees which are economic to treat.

The results of the household model provide other insights when the *CCPMD* technology is examined from a whole-farm system perspective. First, land scarcity is reflected mostly by the tendency of farmers in the low L-AE category to grow mixed food crops with no cashew while allocating a small portion of land to both sole and mixed cropped cashew. On the other hand, farms in the medium and high L-AE categories allocated more land to cashew cropping under both sole and mixed crop conditions, and to monocropped food crops.

Second, given the current low prices for cashew, the model results show farmers selecting to improve only some of their cashew holdings. For instance, with an increase in cashew prices of up to 115 percent, medium L-AE farms would have applied the

CCPMD package to improve about 41 percent of their trees on fields of 39 tree density, mixed cropped with manioc, beans and peanuts. Under this cropping system, farms in the low and high L-AE categories would have improved all and about 78 percent of the trees, if cashew prices had increased by 120 percent and 125 percent, respectively. Note that, even price changes of about 115-125 percent do not offer sufficient incentives for farmers to improve trees under the traditional sole cropped fields. This result was also predominant in the partial budgeting undertaken above.

Third, the results show persistently that farmers across categories select the traditional sole cropped cashew in their optimal plan. This results from the fact that (1) when relatively low cashew prices persist, farmers do not increase their current work effort on sole cropped cashew because labor allocated to marketable food crops is relatively more profitable, which also suggest that (2) food security is receiving higher priority in resource allocation, particularly with respect to household labor, which seems to be a constraining factor for some households. While these findings may call for increases in both cashew and food prices, profitability may also call for improvements in yield in both areas. That is, complementarity between cashew and food may require technologies which improve upon yields or reduce costs to farmers in production of cashew and food crops.

Fourth, the results also suggest that differences in crop productivity is one source of the wide gap in the net income earned across farm categories, particularly for those households with a smaller portion of land in which they have to crop all they need to meet food security requirements.

The analysis of alternative scenarios show that farmers across all categories require high prices to adopt technology packages to improve cashew trees. For example, estimates from the analysis of the typical farm optimal plan show that improvements in the traditional sole cropped cashew field only occur at a 150 percent increase in cashew prices. At this price level, a typical farm would select to improve the 52 tree density fields with sole traditional cashew trees using the *CCPMD* package. These percentage changes in cashew prices imply nominal producer prices of about \$0.82-\$0.95 per kg of raw cashew nuts. These prices are very high compared to those farmers were able to receive (about \$0.53 per Kg) in the 1999-2000 cashew marketing season. Realistically, increased cashew prices of this magnitude will require profound changes in research and extension to improve cashew productivity, and substantial efforts in increasing competition in the cashew marketing which depend on more public investments to improve rural infrastructures to reduce transaction costs.

Across L-AE farm categories, the required changes in prices are much higher for farms in the high L-AE category than they are for low and medium L-AE farms. The main reason for these differences seems to reside on the relative scarcity of labor across farms as shown by the labor shadow prices. Farms in the high L-AE category faced binding labor constraints in most of the months in the agricultural season. These constraints are reflected by higher shadow prices compared to those faced by farms in the low and medium categories for which labor constraints were not as binding. The high labor shadow prices for high L-AE farms are consistent with high cashew prices and yield changes which these farmers required to adopt alternative yield improving technologies and managements practices.

Finally, the results shows that the low net income earned by farms in the low L-AE category may be due to limited access to land for cultivation which may be forcing more productive household members to take more off-farm work in detriment of increased on-farm productivity.

The analysis from the smallholder household model show that the success in changing farmer's current behavior towards improving cashew trees can be achieved with a diversified incentive structure. Farmers can invest in cashew trees, but require that cashew prices provide a signal that investments in cashew, particularly in labor will earn a high return. However, while higher cashew prices could provide that incentive, the required price changes are well beyond what the market could provide in the short-run. An alternative to cashew prices is further increases in cashew yields.

Sensitivity analysis indicated that required percentage increases in yield are much lower than those required by price changes. For instance, an increase in cashew yields of about 100 percent would have led farms in the low and high L-AE categories to adoption of the *CCPMD* package to improve trees under mixed cropping. Changes in cashew yields of the same relative magnitude would also have been sufficient to stimulate a typical farm to adopt the *CCPMD* package on trees mixed cropped with manioc, beans and peanuts at the 39 tree density. Similar behavior would have been observed on farms in the medium L-AE category, if cashew yields had increased 15 percent over and above that required by low and high L-AE farms. Price changes of up to 125 percent would be required to achieve similar results.

Yet, changes in yield will require efforts from several fronts, including research and extension in developing the best technologies. Examination of other possibilities to improve smallholder incentives include (1) improved productivity and prices of food crops, particularly marketable food crops, and (2) production costs savings through lower wages rates. However, as the analysis of these alternatives has shown, greater impact is obtained when a combined package of incentives is in place, particularly those which save on production costs and increase cashew productivity.

The analysis from the capital budgeting model of the *TWCPMD* and *ICM* packages conducted in section 7.3 provides similar insights. Results show clearly that these alternative technologies to single spraying of cashew trees also require both improvements in prices and yields as incentives to adoption. As shown, an expected increase in cashew producer price of about 80 percent over the period of analysis would have been required to turn the improved sole cropped cashew trees into a profitable enterprise using the *ICM* package. In contrast, a seven percent change in the current price of $0.38 per kg from the third year of adoption of the *TWCPMD* package on a monocropped cashew field, throughout year eight would have been sufficient to yield an internal rate of return of about 11 percent. These estimates show the potential improvements these investments can make at different prices levels. Again, we note that it is unlikely that prices will increase up to 80 percent in the short-run. As a result, a diversified incentive structure is needed to encourage greater adoption of improved cashew technologies. This would include changes in cashew producer prices, yields and input costs to make improved cashew technologies profitable for farmers.

Time lags in the production introduced by these technologies before benefits accrue to farmers resources will require additional incentives for adoption. When costs are above returns as it is the case for these two technology packages in the first years of implementation, farmers face additional constraints when considering adoption. In this case there is a need for support for willing adopters as an incentive for farmers to cope with the negative returns of the first years of implementation. Availability and easy access to credit resources will be very important factors in farmers' decision making. Nonetheless, the need for improved yields and prices cannot be dismissed even when credit is made available because credit is a costly resource and needs to be repaid.

In the next chapter we turn to the implications of these findings for policy, research and extension interactions.

CHAPTER 8

SUMMARY OF FINDINGS AND IMPLICATIONS FOR POLICY, RESEARCH AND EXTENSION EFFORTS

8.0 Re-stating the Research Problem, Objectives and Methods

As the economy of Mozambique moves forward, more challenges emerge and sustainable strategies are required to address the issues of sustainable economic growth, particularly in rural areas. Clearly, strategies and opportunities for those who constitute the majority in agricultural production should be placed among the country's list of priorities for development. Part of this community of agricultural producers are cashew growers in the Northern Province of Nampula where more than half of the national cashew output is produced and marketed every year.

As stated earlier, cashew production has declined over the years, both in quantity and in quality. Factors cited as the main causes of this decline in productivity are among others, the neglect of many of the cashew trees after independence as a result of war, economic crisis which reduced the incentives to farmers to invest in cashew, and reduced funding for agronomic research and effective extension efforts. Although these factors seem to be well understood, important challenges remain. Lack of farm level data makes it difficult for policy makers, researchers and extension workers to address effectively smallholder constraints or to evaluate alternative policies targeting this important segment of the economy. For instance, it is currently a great challenge to figure out the relative importance of factors responsible for the productivity decline at the farm level, and to find ways to solve the problems to facilitate economic development of the cashew industry as a whole.

Yet, in the midst of all these problems the country is in desperate need to reverse the declining trend in cashew production, an important cash crop for about a million smallholder farmers. At the moment, leaders in the sector face a fundamental and complex policy challenge. That is, how to structure available technological options to smallholder cashew producers, market rules and industry coordination arrangements so as to provide policy induced incentives and improve capabilities for smallholder cashew producers to increase both quantity and quality produced from either existing or newly planted cashew trees. The challenge extends to the domestic cashew processing industry as well, calling for an adjustment and restructuring to improve productivity and management in order to be able to compete internationally.

The main objective of this study was to understand these challenges at the smallholder production level by obtaining comprehensive farm level insights, evaluating returns to smallholders' resources, particularly labor time allocated to different competing enterprises, under alternative crop production technologies and institutional arrangements. The study utilized to the extent possible existing data and generated additional micro data on smallholder cashew production in order to answer the following research questions under what conditions: is it profitable for Mozambican smallholder cashew farmers to expand production and improve quality of cashew nuts? If profitable, what are the investment decisions and available alternative technological options smallholders need to consider in order to achieve the expected cashew production increases and quality improvements? What incentives and institutional support will be required for smallholders to adopt these alternative productivity enhancing technologies in a farming system environment where cashews are not the main crop?

As Reardon et al, (1988) have pointed out, when farmers decide on where to invest money or labor they make an evaluation of earning potential of these resources across a number of activities both on- and off-farm. The opportunity cost of household resources to various activities need to be taken into account when on-farm choices are made[14].

To address the research questions of this study, insights and findings are drawn from three analytical methods. Following prior findings about the relationship between land and cashew trees (Marrule et al, 1998; Strasberg, 1997; Strasberg, Mole and Weber, 1998; and TIA/96) a survey with a small sample of smallholder cashew producers was undertaken in three districts of Northern province of Nampula. This survey gathered in-depth data for the 1997/8 food cropping season and 1998/9 cashew marketing season. In addition demographic data and smallholder resource allocation data with particular attention to land and labor, cropping system patterns were recorded.

Based on patterns found in this basic data, a typology of smallholder cashew producers was constructed based on categories of household-level land area available per adult equivalent. Marrule (1997) provided evidence of land being a constraint for some

[14] Eicher and Baker, 1982 found that 25 to 50 percent of household's labor time on smallholder farms in Africa was typically spent on non-agricultural activities.

households in the study area. In addition to land, labor is the other most important household resource. Constraints to these two resources may determine the pattern of on-farm decisions regarding choices of alternatives to improve current cropping systems.

The information from the typology is the base for all the analysis undertaken in this dissertation. Caveats resulting from the small sample size are recognized. The analysis of key issues from the perspective of the typology are always complemented with an examination of a typical smallholder cashew farm behavior, which to the extent possible, is compared also with available data from other research. Survey data was further used in estimating an econometric model of the determinants of cashew productivity at the tree/farm level, and to construct partial crop budgets which evaluated the profitability of different cropping mixtures of cashew and food crops. However, crop budgeting assumes no inter-relationship among activities on-farm, certainty about outcomes, and no long-term effects beyond the budgeting period (Swinton and DeBoer, 1998). Thus whole smallholder farm impact model was developed to examine the profitability of current cropping systems in conjunction with cashew productivity enhancing technologies and management practices. Only chemical control of PMD was tested in the whole farm approach using a simple single-period linear programing framework. Top-working and integrated cashew management packages were then analyzed using a capital budgeting model due to lack of detailed data to construct a time-dynamic whole farm model.

The next sections summarizes of findings from the analytical tools used. Then their implications for policy, research and extension discussed, and areas of future research are outlined.

8.1 Summary of Findings

8.1.1 Cashew Development Strategies to Consider

In chapter three we explored the state of knowledge about available smallholder investment and technical decisions with respect to technologies and management practices to increase cashew production. Feasible alternatives to increase cashew production were presented, taking into account the characteristics of the current cashew farming systems in Mozambique. These alternatives focused on provinces and districts where cashew is currently been grown, by existing cashew farmers and in existing fields. One important consideration from this analysis is that, given the heterogeneity in cashew tree status or potential, and the high cost to ascertain the tree potential, the best available knowledge suggest that in general farmers and researchers should consider the following strategies: (1) all unproductive cashew trees that are older than 25 years should be eliminated through thinning and replanting of improved material selected from either local mother trees with proved tolerance to diseases, and with high yielding capacity, or adapted material from other countries; (2) all the cashew trees that are unproductive and less than 25 years old should be top-worked; and (3) diseased cashew trees with reduced productive capacity should be subject to sanitation, and improved management practices. However, given the different labor requirements of these options, and different labor and land availability among smallholder farmers, further analysis of the farming systems in which these strategies might be applied is necessary. The analysis of the farming systems should provide insights about the potential for adoption of these techniques and the likelihood of success for the diverse group of farmers in the smallholder sector in Northern Mozambique.

8.1.2 Typology of Smallholder Cashew Farmers

Chapter Four provided background information on typical cashew producing households in the study area. A description of the farming system in the cashew producing zones of Nampula was presented and provided sufficient information to develop a framework of analysis of the smallholder cashew sector. This framework grouped farmers based primarily by available land area per household adult equivalent and described differences across groups in resource endowment, including the number of cashew trees by cropping system. This analysis suggested that there seems to be significant micro level diversity among smallholder cashew farming households, and taking these differences into account will have likely important advantages for policy making and improvement of strategy design for the smallholder sector as a whole. It was found that there is a skewed distribution of farmer's income, resulting particularly from a non-uniform access to productive assets such land and cashew trees. It was thus suggested that a recognition of this diversity and an open mind to the fact that there are no likely universal solutions, would help in devising a range of policy targets and technology options which would possibly avoid the exclusion of some farmers due to ignoring their specific constraints. The typology clearly show that households in the low land per adult equivalent category had a relatively larger household size and potential for a bigger labor force. However, more members to feed for the same number of adults as other categories, implies that these households have a high dependency rate. As a result, with less land and fewer cashew trees, these farmers were likely to be more vulnerable and less capable to engage in riskier activities.

8.1.3 Determinants of Cashew Tree Productivity

Chapter Five examined key determinants of cashew tree productivity under on-farm conditions in Northern Mozambique. Apart from the genotype factors found to be significant in explaining yields, red sandy loam soils, tree density and variations in farm type characteristics seems to also significantly influence tree yields. The most important finding, however, was the negative although statistically insignificant effect of labor on cashew yield. This result provided insights about the current incentive structure to invest more labor in cashew, particularly for labor to be used at the right time of the growing cycle. It was noted that the current approach to improved tree management and disease control calls for labor to be used when it conflicts to a large extent with activities needed on food crops. As rural food markets are unreliable for many smallholders, the lack of cash earnings opportunities, and the low economic incentives for cashew producers force farmers to set priority for food cropping activities, and shift labor for cashew activities to be done later in the agricultural season. Since some of the recommended cashew activities with a potential strong impact on yield cannot be done later in the year, they are simply not executed. This has been done for a long of period of time and has led to the current high incidence of disease spread incidence and declining cashew productivity at the farm level.

These findings provide insightful information on research needs and therefore help to inform questions about supply response in the cashew policy debate. It seems that lowering disease incidence levels, improving the current genotype material, and creating an environment for improved incentives to increased smallholder farm investments in cashew production, particularly labor use are urgent issues in the forefront of the cashew industry success requirements.

8.1.4 Cashew Profitability

Chapter Six pursued further the issue of productivity. Given the low cashew productivity levels explored in the previous chapters, the analysis looked at cashew from an enterprise perspective asking the question of profitability for smallholder farms across L-AE farm categories. Despite the partial nature of the crop budgeting method used, important insights were obtained. Farms across categories held a crop portfolio which included the most commonly grown crops in the study area. The financial analysis show that differences in profitability across enterprises and/or farm categories were driven by differences in crop productivity, but also by differences in labor applied per unit of land. For instance, it was shown that farms in the low L-AE category allocated significant labor resources on fields where manioc and peanuts were the most important crops compared to farms in other L-AE categories. This apparent crop orientation was a result of relative scarcity of land in the low L-AE farm category which forces farms to more diversification among food crops, rather than concentrating more on cashew as compared to farms in other L-AE categories. This finding provides insights about low L-AE smallholder farm's risk attitude which result from land constraints and the need to produce sufficient food for the households own consumption. The low levels of labor use observed in sole cashew cropping across smallholder cashew farm categories also provide insights about perceived effects of the current economic conditions on farmer's incentives to take care of existing cashew trees. It seems that the cost of dropping cashew production from the farms crop portfolio by clearing the fields from potential uneconomic cashew trees to allow profitable crops cultivation is high. This explains, in part, farmer's reluctance to get rid of unproductive cashew trees present on much of the household's needed land. In Chapter Seven, we analyzed alternatives ways to help farmers improve upon these uneconomic trees and to thus increase returns to the land, which is worthless under the current cashew cropping system.

8.1.5 Cashew Technologies, Profitability, and Other Results

Chapter Seven examined three cashew productivity enhancing technologies and improved management practices packages: (1) chemical control of PMD(*CCPMD*); (2) top-working in combination with chemical control of PMD(*TWCPMD*); and (3) a bundle of these two packages with thinning and replanting(*ICM*) of some cashew trees in a given field. Data limitations required the use of different tools of analysis for these three packages on current cashew cropping systems. First the *CCPMD* package was evaluated from the stand point of its individual profitability using crop budgeting analysis, and results were compared to current traditional practices. Second, the information from the crop budgeting analysis was fed into a smallholder cashew household LP model developed to evaluate the *CCPMD* technology in a context of a whole-farm system. Finally, given the importance of the time pattern of costs and yield impacts of the *TWCPMD* and *ICM* investments, a multi-period capital budgeting model was used to stress risk considerations and the need to put in place strategic support services to increase the likelihood of farmer's adoption.

The findings show that, with prevailing input and cashew prices, the *CCPMD* technology analyzed was not profitable under sole cashew cropping conditions across all farm categories. The net returns per labor day were all negative. Under mixed cashew cropping conditions, the impact on net returns proved to be unambiguously an improvement over the traditional practices only when the package was applied to cashew trees on manioc and peanuts fields by farms in the low and high L-AE categories.

The results of the household model provide other insights based on the whole-farm system perspective. First, land constrained farmers in the low L-AE category tend to grow more mixed food crops with no cashew, while allocating a small portion of land to both sole and mixed cropped cashew. In contrast, farms in the medium and high L-AE categories allocated more land to cashew cropping under both sole and mixed crop conditions, and to monocropped food crops.

Second, at the current low price levels for cashew, the model results show that farmers select to improve only some of their cashew trees. As found in the partial budgeting analysis, these trees tend to be in those fields where cashew is mixed cropped. For example, an increase in cashew prices of up to 115 percent, led to medium L-AE farms selecting the *CCPMD* package to improve about 41 percent of their trees mixed cropped with manioc, beans and peanuts, at 39 tree density. Under this cropping system, farms in the low and high L-AE categories would have improved all and about 78 percent of the trees, if cashew prices had increased by 120 percent and 125 percent, respectively. However, price changes of about 115-125 percent do not offer sufficient incentives for farmers to improve trees under the traditional sole cropped fields.

Third, the results show persistently that farmers across categories leave the traditional sole cropped cashew in their optimal plan. Two possible explanations for this result are (1) persistence of low cashew prices lead to low investments in labor to cashew because of the higher relative profitability of marketable food crops, and (2) when farmers allocate resources to various household activities give high priority to food security. The latter is particularly true for resources such as household labor which seems to be a constraining factor for some households.

Fourth, differences in crop productivity were found to be one source of the wide gap in the net income earned across farm categories, particularly for those households with a smaller portion of land in which they have to crop to meet food security requirements.

Fifth, alternative scenarios compared to the baseline model results show that farmers across all categories require relatively high prices or alternatively large increases in cashew yields to adopt more new technological packages to improve cashew trees. For example, for a typical farm optimal plan improvements in the traditional sole cropped cashew field only occur at a 150 percent increase in cashew prices. With price changes of this magnitude, a typical farm would have selected the *CCPMD* package to improve the 52 tree density fields with sole traditional cashew trees. These percentage changes in cashew prices correspond to nominal producer prices of about \$0.82-\$0.95 per kg of raw cashew nuts. These prices are very high compared to about \$0.53 per Kg received in the 1999-2000 cashew marketing season. It is therefore to expect that increased cashew prices of this magnitude will require profound changes both in research and extension to improve cashew productivity, and substantial efforts in increasing cashew marketing competition. This will in turn depend on more public investments to improve rural infrastructures to reduce transaction costs.

Alternatively, the results show that changes in current cashew yield would have resulted in adoption of improved technologies. For instance, farmers in the low and high L-AE categories would have adopted the *CCPMD* package to improve trees under mixed cropping, if cashew yields had increased by about 100 percent. Changes in cashew yields of the same relative magnitude would also have been sufficient to stimulate a typical farm to adopt the *CCPMD* package on trees mixed cropped with manioc, beans and peanuts at the 39 tree density. Similar behavior would have been observed on farms in the medium L-AE category, if cashew yields had increased 15 percent over and above that required by low and high L-AE farms. The main reason for differences in the magnitude of changes both in cashew prices and yields required for adoption of improved technologies seems to reside in the relative scarcity for labor across farms as shown by the labor shadow prices.

As shown, farms in the high L-AE category faced binding labor constraints in most of the months in the agricultural season. These constraints are reflected by higher labor shadow prices compared to those faced by farms in the low and medium L-AE categories for which labor constraints were not as binding. The high labor shadow prices for high L-AE farms were consistent with high cashew prices and yield changes which these farmers required to adopt alternative yield improving technologies and managements practices. Therefore, high L-AE farms were labor constrained households.

Sixth, it was also found that farmers in the low L-AE category were land-poor. This was reflected in consistently high land shadow prices these farms faced compared to farms in other categories.

Finally, the analysis concludes that success in changing farmer's current behavior towards improving cashew trees could be better achieved through a diversified incentive structure which includes price incentives, but also includes yield improving strategies and production cost saving practices. This called for directing efforts in three main areas: (1) changes in technology to raise incremental output, (2) lowering costs of production through changes in cashew technology, and (3) improving markets to improve prices to farmers. These three areas are critical to move the smallholder cashew sector forward. However, the first of the three areas seems to require long term efforts in research and extension to provide farmers with adequate technologies to improve current yields at low cost. The third area is where short-term results may more likely be achieved. To date liberalized cashew marketing seems to have shown a potential for raising producer prices. Prices during the 1998-9 and 1999-2000 cashew marketing seasons provide an example.

However, further efforts need to be undertaken. In the sections to follow we elaborate more on these issues.

8.2 Policy Implications and Recommendations

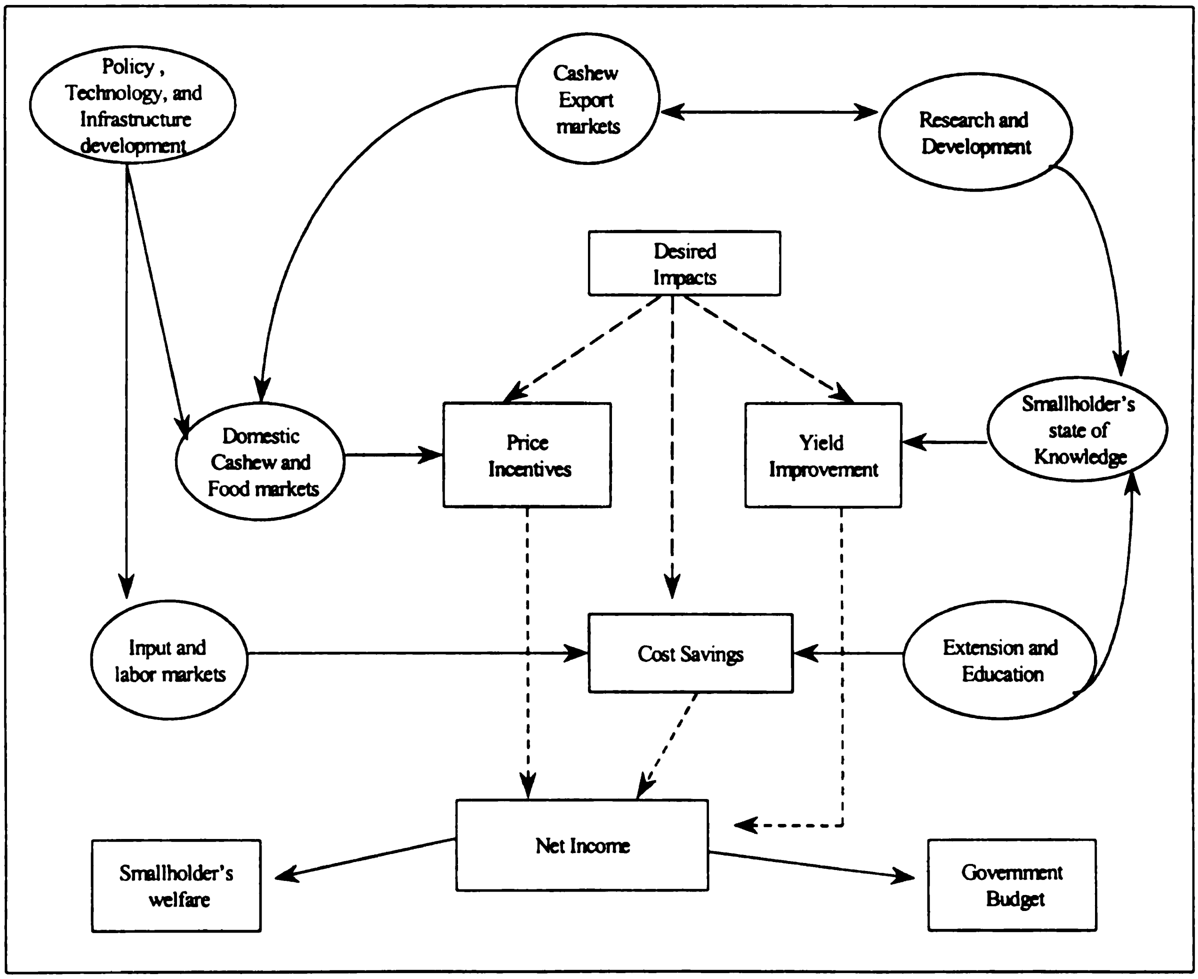
Many of the causes of declining productivity in the smallholder cashew sector have been well discussed on several occasions. The real challenge is facing these factors in a way that develops cashew as a smallholder crop that continues to provide broad based benefits to rural growth.

Findings from this research show that there are at least two groups of smallholder cashew farmers. Those with relatively less land and cashew trees, and those with relatively more land and cashew trees. It was shown that these groups require different levels of incentives to improve and maintain cashews trees. These incentives are likely to affect decisions about which alternative technology smallholders may choose to improve their cashew trees. It is important to recognize that not all the farmers with many trees will have the same incentive, and probably the means to improve the cashew trees. Cashew came to many households through different sources (heritage, own decision, and/or mandatory policy) and they have different levels of motivation to continue producing cashew. These farmers will likely need different approaches to induce them to invest in cashew.

On the other hand, this study has presented empirical evidence on the determinants of cashew productivity at the farm level, studied profitability challenges and smallholder strategies to increased cashew production. Building on this knowledge and the information on characteristics of household cashew producers in the smallholder sector, a number of policy implications can be derived from the findings of this research. We examine these implications with the help of the diagram in Figure 8-1.

There are three important types of impacts to examine: (1) impacts of raising cashew yields, (2) impacts of raising cashew prices, and (3) impacts of lowering costs of cashew production. These impacts result from policy, research, and extension, and will net out on income earned by farmers.

Figure 8-1 Framework for Analysis of Policy, Research and Extension Implications of Alternative Technologies and Improved Management Practices in Cashew Production



Price incentives, and yield improvement ---the goal of the alternative technologies and improved management practices ---examined in this research are the two major components of the declining cashew productivity problem in Mozambique. Not long ago, agricultural prices were liberalized, including those of cashew nuts. With relatively free export of raw cashew nuts, it was expected that smallholder cashew producers would benefit from increased competition between traders/exporters, and the domestic processing industry. Although some of the effects of these changes started to work their way down to farmers, more needs to be pursued to assure continuity and to overcome remaining bottlenecks in the process. For instance, rural markets for cashew and other crops are still underdeveloped. Poor marketing infrastructures including transport and lack of better roads to cashew producing areas reduce farmers' profit from sales of surplus production. Despite increased effort to make market information available, dissemination is still far from sufficient to make farmers aware of better selling opportunities. Market information cannot yield the full benefits with lack of communication between rural communities. In addition, during the marketing season, raw cashew export demand signals reach farmers in rural areas distorted because high transport/transaction costs tend to depress farm level cashew prices. These transaction costs also increase on-farm costs of production.

Furthermore, constrained access to credit at the onset of the cashew marketing season prevents a larger segment of the cashew industry from participating in marketing, so as to improve competition in buying at the farm level. This has led to concentration and lower cashew producer prices in some areas. Lack of enforceable grades and standards prevent also farmers from getting a premium from high quality nuts.

In summary, export markets whether they are for raw or processed kernels are an important window for smallholder cashew producers for the price discovering process, and a good mechanism to improve domestic prices. Export market signals can only be transmitted to them through more developed local markets both for cashew and food crops. For this to happen, liberalized markets may not be sufficient, if rural infrastructure is still resulting in high transaction costs to traders/exporters and domestic processors. Cashew marketing agents/participants want to maximize margins, and without sufficient competition will depress prices paid to farmers. Marketing infrastructures must be improved if continuous price transmission from the export market demand can be expected to reach farmers in cashew producing areas. This is true for both cashew, inputs and food and non-food goods sold in most remote areas of rural Mozambique and, in particular, in cashew producing areas.

One important factor in low productivity in Mozambique smallholder cashew sector is lack of access to improved technologies, particularly disease resistant/tolerant cashew material. Although some adaptive research and testing is taking place by either the public or NGO/private sectors, this effort is still below the needs of the smallholder sector. While the most critical cashew research institution (INIA) has very few trained cashew researchers, the policy making institute (INCAJU) was recently created and still lacks resources to finance and coordinate activities in cashew producing areas. Research undertaken by NGOs and the private sector is concentrated in a few provinces and cannot meet the broad demand of cashew producers. Where new technologies are identified, delivery mechanisms are either weak or absent. Furthermore, investment in these new technologies are risky. An environment in which public, NGOs and private sectors collaborate on concrete actions could reduce the risk to both these participants and to adopting farmers.

On the other hand, cashew production must be seen in conjunction with food crop production. Promoting cashew productivity increases along with food productivity changes is the most desirable path. Furthermore, creation of off-farm employment opportunities, particularly those of labor intensive nature (ex. local processing of cashews) would provide a great impact on incentives to farmers invest more in cashew. Development of local cashew marketplaces as opposed to "selling in the store" could provide incentives to on-farm storage and the development of larger markets with economies of scale. This would also help prevent a few resourceful and "monopoly like" trader groups or individuals from colluding to pay lower prices.

The perceived notion that taxing exports will redirect raw nuts supply to domestic processing must be seen with caution. As mentioned earlier, the export market offers an opportunity window for farmers to receive incentive signals from a wider market for their product. Whether farmers can get these signals depend on the structure of the domestic market. This includes the members and type of traders and processors who bid for smallholder's cashew surplus. Fewer traders and processors will not likely guarantee a competitive environment to raise producer prices. More traders and processors may increase the likelihood that such an environment is created, but more resources need to be directed to areas such financing, market information and infrastructures.

Concurrently, reforms on the land tenure system would allow land-poor and relatively labor abundant households to acquire more land, and to invest their labor to on-farm production activities with a potentially significant positive impact on smallholder's income and food security conditions.

These seem to be the conditions conducive to a broad-based approach to rural development which could be more favorable to the expansion and improvement of cashew production while improving smallholder's welfare and yet staying within the government budget.

8.3 Research and Extension Implications and Recommendations

Yield increases require improved capacity in research and development of new cashew varieties with high yielding potential, as well as well supported extension and education services programs. For instance, in the short-run farmers may select to spray their trees and neither top-work nor thin. But the effects, although significant, may not be substantial enough due to the aging of the trees and the quality of the planting material that farmer have in the fields. So an implication is that more research and effort is needed to try to discover ways that would work for farmers to better judge what kind of tree they are dealing with, and which treatment might best apply. This is important to avoid uneconomic spraying, but reduce risk and improve efficiency of application.

Extension and education services and programs affect the smallholder state of knowledge of available technologies and management practices as alternatives to the traditional management systems under which cashew has been produced for many years. Improvement here to suit the needs of cashew producers requires consistent planning and carefully set priorities by governments, private companies and NGOs involved in cashew research and extension.

Research and development are crucial. As of today, efforts in this area are undertaken by either INIA, and a few ONGs and private companies on limited number of nurseries in some cashew producing areas.[15] Although this is an important step, ill-funded government research institutions cannot, in the long-run, fulfill cashew research and development needs when priorities often are set on crops with direct impact on food security of the smallholder sector as a whole. The development of new varieties and adaptation of others require funds for infrastructures and scientific research and training. Furthermore, research findings on improved technologies and alternative management practices need to be disseminated. This requires a functional and reliable extension service network which can reach farmers with the right message. Scattered efforts by different actors while making some contributions, cannot have the desired impact on smallholder's state of knowledge in cashew production across the nation. This requires a coordinated effort and a long-term institutional commitment from the government with

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[15] INIA is the acronym for Institute for Agronomic Research, and is part of the Ministry of Agriculture and Fisheries in Mozambique. Part of their mission is cashew research.

strong support from commercial companies (marketing and processors), donors, and NGOs.

A valuable resources in these areas is regional and international cooperation. Research experiences from other countries may, for instance, well shorten the cycle of developing new and improved planting material. Tested material may only require adaptation as opposed to attempting domestically developing genuine solutions. Furthermore, adaptation research and development of completely new material are not mutually exclusive. Some of these efforts are currently taking place, but need to be part of a continuous program of a useful long-term strategy.

8.4 Moving Forward: Areas of Future Research

While there seems to be well advanced steps towards accumulating knowledge about biological constraints to cashew production in Mozambique, understanding smallholder cashew producer's behavior is an area in which many primary steps have yet to be taken. This research, to our knowledge, is pioneer in trying to generate and use the existing data to built a framework that gather knowledge of smallholders management strategies and constraints facing different types of smallholders in cashew producing areas in Mozambique. Consistent empirical evidence and analytical insights to inform smallholder adoption of new technologies and improved management practices to increase cashew production and quality under the current smallholder sector setting is scanty and it is hard to generalize over possible smallholder cashew production areas. This study also suffers from the same pitfalls. Research findings are in no circumstances to be generalized to all areas where cashew is produced in Mozambique. However, it must be noted that given the importance of the study area in cashew production, these results provide significant insights on the importance of studying smallholder cashew producer behavior.

The suggested approach to the household characterization and the household model developed for analysis will need to be expanded in a number of ways. First, more detailed observation and records of household behavior over a longer period will help to correct events which may have been recorded, but do not constitute a regularity in a given household. In depth data collection, and more systematic records of farmer's resource allocation would provide a better understanding of household allocation processes. This empirical examination of household economies is needed to clarify potential dependencies and possible opportunities of more resource-poor households.

Second, there are technical aspects which the model did not handle particularly well. For instance, the model assumed, based on best available knowledge, that activities for a given technology take place at a particular period in the year. Most of the times these activities were in conflict with food cropping activities on the farm. One possibility to alleviate farmers from these constraints is shifting some of the activities away from high labor demand periods. In order to impose these possibilities on the model, more technical information is necessary from agronomic research as well as better knowledge of the farming systems. This call for a much close collaborative efforts between social, agro-forestry and biology scientists.

Third, efforts were made to adjust secondary data to reflect smallholder conditions in Mozambique a great part of the modeling process. This has to be done so because some of the technologies were not, and some still are not available on-farm. As more research is done both on-station and on-farm (as it appears to be the case in the study area), findings from these experiments can now be integrated in the model to reflect real conditions of current farming systems and practices in cashew producing areas.

Fourth, as labor becomes a constraint for many households a concerted scientific effort may help technology developers to design packages that are both technically and economically feasible, and take into account a range of factors specific to the cashew farming systems. For instance, designing specific research programs to help farmers identify better and with less risk which existing trees should what treatment could have a high pay-off to farmers. From a technological stand point this may be difficult, but it would help reduce risk that farmers are investing in the wrong trees, or the wrong technology package. The bottom line is developing technologies which raise cashew output while saving cost to farmers.

Finally, policy makers, researchers and extensionists need to join forces to understand better the needs of the farmers and thereby develop technological solutions which fit into the smallholder setting. A commitment of policy making institutions involved in providing sufficiently credible signals to smallholders is also necessary and critical to foster smallholders willingness to invest more of their resources in cashew production.

APPENDIX A

YIELD AND INPUT REQUIREMENTS FOR CURRENT SMALLHOLDER CROPPING ACTIVITIES

Table A-1.1 Yield and Input Requirements for Current Smallholder Cropping Activities, Nampula, 1998/9

Yield and Input Information	Current Smallholder Cropping Activities and Household Labor per Adult Equivalent Farm Categories											
	Sole Peanuts			Sole Manioc			Manioc and Beans			Manioc and Peanuts		
	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)
Yield	---------- kgs per Ha ----------											
Beans							228.3	185.4	132.9			
Manioc				650.0	764.1	774.1	458.2	453.7	722.2	458.2	453.7	722.2
Peanuts	190.3	612.3	870.9							503.1	286.6	432.6
Cashew												
Input Requirements	---------- kgs per Ha ----------											
Agricultural Tools	4	5	6	5	4	6	6	5	4	6	5	4
Labor (Man Days)												
January	4.8	33.2	9.2	1.9	4.7	9.8	8.4	29.9	71.3	9.3	16.1	74.4
February	4.8	33.2	9.2	1.3	4.4	8.5	5.5	15.3	61.6	7.4	8.4	58.6
March	13.8	11.1	14.1	-	-	-	5.2	14.9	60.9	1.9	7.6	11.0
April	13.8	11.1	14.1	1.8	1.8	1.8	3.9	12.9	7.8	2.5	7.8	11.2
May	17.3	13.8	17.7	1.8	1.8	1.8	4.9	16.1	9.7	2.9	9.7	14.0
June	3.4	2.7	3.5	1.8	1.8	1.8	4.9	16.1	9.7	0.9	2.1	2.9
July	3.4	2.7	3.5	-	-	-	0.9	3.2	1.9	0.5	1.9	2.8
August	3.4	2.7	3.5	23.6	18.3	11.6	6.9	22.5	13.6	3.4	13.4	19.3
September	3.5	2.8	3.6	30.2	23.6	16.3	8.3	27.4	16.5	4.4	16.3	23.5
October	6.7	38.9	12.4	33.2	29.4	15.7	13.0	58.6	35.5	24.1	29.5	52.9
November	6.7	38.9	12.4	8.9	10.4	3.4	7.1	39.3	23.8	20.9	17.9	36.2
December	2.6	5.9	3.7	4.9	10.5	10.3	11.9	51.1	84.1	29.5	31.2	106.5

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9.

Table A-1.2 Yield and Input Requirements for Current Smallholder Cropping Activities, Nampula, 1998/9

Yield and Input Information	Current Smallholder Cropping Activities and Land per Adult Equivalent Farm Categories (LAE)											
	Manioc, Beans and Peanuts			Sole Cashew			Cashew and Manioc			Cashew, Manioc and Beans		
	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)
Yield	kgs per Ha											
Beans	228.3	185.4	132.9							228.3	185.4	132.9
Manioc	458.2	453.7	722.2				458.2	453.7	722.2	458.2	453.7	722.2
Peanuts	513.1	286.6	432.6									
Cashew				53.3	40.9	75.4	53.3	131.4	22.1	53.3	131.4	22.1
Input Requirements	per Ha											
Agricultural Tools	4	5	6	6	5	4	5	4	6	5	6	4
Labor (Man Days)												
January	5.7	33.5	32.9	0.2	0.2	0.6	12.2	18.3	55.7	29.2	29.2	30.9
February	23.5	23.5	23.8	-	-	-	11.1	10.2	38.4	20.9	20.9	20.5
March	24.2	24.2	25.9	0.3	0.4	1.3	1.9	1.9	1.9	19.7	19.7	19.3
April	8.1	8.1	6.9	0.7	0.7	1.1	2.0	1.9	1.9	4.7	4.7	13.5
May	9.0	9.0	8.3	0.7	0.7	1.1	2.0	1.9	1.9	5.9	5.9	16.7
June	6.3	6.3	5.2	-	-	-	1.9	1.9	1.9	5.9	5.9	16.7
July	0.9	0.9	1.4	1.1	1.5	4.4	2.0	1.9	1.9	1.2	1.2	3.3
August	6.4	6.4	9.7	1.2	1.2	3.5	16.7	4.8	19.1	9.9	9.9	43.4
September	8.8	8.9	12.1	0.9	0.8	2.2	19.1	1.0	21.8	11.6	11.6	38.3
October	35.9	37.4	41.4	1.1	1.0	2.7	25.2	10.8	40.0	25.7	25.7	64.2
November	30.4	30.4	32.9	1.1	1.0	2.7	11.0	7.9	21.5	18.7	18.7	30.8
December	56.5	56.5	57.3	1.1	1.0	2.7	19.5	19.1	56.4	39.7	39.7	44.8

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9.

Table A-1.3 Yield and Input Requirements for Current Smallholder Cropping Activities, Nampula, 1998/9

Yield and Input Information	Current Smallholder Cropping Activities and Land per Adult Equivalent Farm Categories (LAE)					
	Cashew, Manioc, and Peanuts			Cashew, Manioc, Beans and Peanuts		
	Low (LAE)	Medium (LAE)	High (LAE)	Low (LAE)	Medium (LAE)	High (LAE)
Yield	---------- kgs per Ha ----------					
Beans				228.3	185.4	132.9
Manioc	458.2	453.7	722.2	458.2	453.7	722.2
Peanuts	503.1	286.6	432.6	503.1	286.6	432.6
Cashew	53.3	131.4	22.1	53.3	131.4	22.1
Input Requirements	---------- per Ha ----------					
Agricultural Tools	4	5	6	5	6	4
Labor (Man Days)						
January	40.6	44.1	25.9	24.8	20.8	43.8
February	31.9	38.1	18.2	19.5	17.4	37.3
March	6.5	3.1	7.3	21.2	9.6	42.8
April	2.4	3.7	7.9	5.3	6.9	11.6
May	2.9	4.5	9.7	6.6	8.2	14.5
June	0.9	1.4	2.4	4.1	5.6	9.1
July	2.0	0.8	1.8	1.3	1.3	2.9
August	13.0	6.6	29.5	9.9	9.6	34.2
September	15.1	7.3	31.7	11.7	11.6	29.8
October	26.2	28.4	47.4	14.0	19.1	52.6
November	17.8	23.7	36.5	6.8	10.7	35.2
December	55.6	66.5	55.7	28.9	28.2	70.2

APPENDIX B

YIELD AND INPUT REQUIREMENTS FOR IMPROVED SMALLHOLDER CROPPING ACTIVITIES

Table B-1.1 Yield and Input Requirements for Improved Smallholder Cropping Activities, Nampula, 1998/9

Yield and Input Information	Improved Smallholder Cropping Activities and Cashew Field Densities								
	Improved Sole Cashew			Improved Cashew and Manioc			Improved Cashew, Manioc and Beans		
	density 44	density 48	density 52	density 32	density 39	density 43	density 32	density 39	density 43
Yield	kgs per Ha								
Beans							132.9	185.4	228.3
Manioc				722.2	453.7	458.2	722.2	453.7	458.5
Peanuts									
Cashew	81.8	106.6	159.8	59.3	262.9	106.6	44.2	262.9	106.6
Input Requirements	per Ha								
Agricultural Tools	5	6	4	4	6	5	4	6	5
Grafts(unit)									
Scion Material (unit)									
Tractors Services (hours)	5.6	6.2	7.2	4.5	5.4	5.9	4.5	5.4	5.9
Petrol (liters)	7.3	8.0	8.7	5.3	6.5	7.2	5.3	6.5	7.2
Oil (liters)	0.3	0.3	0.4	0.2	0.3	0.3	0.2	0.3	0.3
Blower Services(unit)	146.7	160.0	173.3	106.7	130.0	143.3	106.7	130.0	143.3
Fungicides(liters)	1.5	1.6	1.7	1.1	1.3	1.4	1.1	1.3	1.4
Labor (man days)									
January	5.7	6.2	7.1	16.3	60.6	23 1	34.9	34.0	34.5
February	4.4	4.8	5.2	14.3	42.3	14.0	23.7	24.8	25.2
March	9.2	9.9	11.7	11.5	13.6	13.3	25.7	27.5	28.3
April	5.1	5.5	6.3	5.2	5.8	5.7	16.7	8.6	9.0
May	5.6	6.1	6.9	8.8	10.2	9.9	23.5	14.2	14.9
June	0.5	0.6	0.6	2.3	2.4	2.4	17.1	6.3	6.4
July	2.0	1.7	5.0	8.8	10.2	9.9	10.1	9.4	10.3
August	6.1	6.6	9.3	20.3	23.5	9.6	46.9	14.2	14.7
September	5.2	5.7	7.4	22.3	25.7	8.3	41.5	15.5	15.9
October	6.5	7.1	9.3	29.2	44.8	16.2	68.2	30.6	31.1
November	6.5	7.1	9.3	15.0	26.4	12.7	12.7	23.6	24.1
December	6.5	7.1	9.3	23.5	61.3	23.8	23.8	44.6	45.1

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9.

Table B-1.2 Yield and Input Requirements for Improved Smallholder Cropping Activities, Nampula, 1998/9

Yield and Input Information	Improved Smallholder Cropping Activities and Cashew Field Densities					
	Improved Cashew, Manioc, and Peanuts			Improved Cashew, Manioc, Beans and Peanuts		
	density 32	density 39	density 43	density 32	density 39	density 43
Yield	kgs per Ha					
Beans				132.9	185.4	228.3
Manioc	722.2	453.7	458.2	722.2	453.7	458.2
Peanuts	432.6	286.6	503.1	432.6	286.6	503.1
Cashew	44.2	262.9	106.6	44.2	262.9	106.6
Input Requirements	per Ha					
Agricultural Tools	4	6	5	4	6	5
Grafts(unit)						
Scion Material (unit)						
Tractors Services	4.5	5.4	5.9	4.5	5.4	5.9
(hours)	5.3	6.5	7.2	5.3	6.5	7.2
Petrol (liters)	0.2	0.3	0.3	0.2	0.3	0.3
Oil (liters)	106.7	130.0	143.3	106.7	130.0	143.3
Blower Services(unit)	1.1	1.3	1.4	1.1	1.3	1.4
Fungicides(liters)						
Labor (man days)	44.6	30.8	49.4	47.8	25.7	30.2
January	35.1	22.1	42.4	40.5	21.2	23.8
February	12.9	15.1	11.7	49.2	27.4	29.8
March	5.6	11.8	7.9	14.8	10.8	9.6
April	9.6	18.0	13.5	18.0	12.6	11.3
May	1.2	2.9	1.9	9.4	6.1	4.6
June	8.8	10.1	9.9	9.7	9.6	10.4
July	16.6	33.9	11.4	37.7	14.0	14.7
August	18.3	35.6	11.5	32.9	15.5	15.9
September	30.2	52.3	33.7	56.6	23.9	19.4
October	21.8	41.4	29.1	39.2	15.6	12.1
November	59.6	60.5	71.8	74.2	33.1	34.3
December						

Source: Smallholder Cashew Production Survey, Nampula, Mozambique, 1998/9.

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