This is to certify that the

dissertation entitled

The Economic Impact of Improved Maize Varieties in Zambia

presented by

Julie Ann Howard

has been accepted towards fulfillment of the requirements for

Ph.D. degree in Agricultural Economics

Major professor

Date 17 November 1994

THE ECO

THE ECONOMIC IMPACT OF IMPROVED MAIZE VARIETIES IN ZAMBIA
VOLUME I

By

Julie Ann Howard

A DISSERTATION

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

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1994

THE ECONO[illegible]

This study exami[illegible]

government and interna[illegible]

improved maize varietie[illegible]

First, results from an ad[illegible]

maize-growing districts [illegible]

average rate of return ([illegible]

research complementar[illegible]

Second, numerical sim[illegible]

indicators if key marke[illegible]

examined the historical [illegible]

initial choice of maize [illegible]

Adoption of im[illegible]

following their introdu[illegible]

maize area was plante[illegible]

including research, ext[illegible]

negative ARR for 197[illegible]

the ARR exceeded 10[illegible]

ABSTRACT

THE ECONOMIC IMPACT OF IMPROVED MAIZE VARIETIES IN ZAMBIA

By

Julie Ann Howard

This study examines the impact of research investments by the Zambian government and international agencies that led to the development and adoption of ten improved maize varieties. Maize research impact was assessed from three levels. First, results from an adoption survey of 462 small- and medium-scale farmers in major maize-growing districts of the three agroecological zones were used to calculate an average rate of return (ARR). Because farmer adoption was heavily influenced by non-research complementary investments, their costs were included in the ARR calculation. Second, numerical simulation was used to estimate the effect on the ARR and other indicators if key marketing and price policies had not been in place. Third, the study examined the historical interplay of institutional and organizational factors that led to the initial choice of maize policies and affected their sustainability.

Adoption of improved maize varieties by farmers was rapid and extensive following their introduction in 1984-85. By 1992, 60 percent of small/medium farmer maize area was planted to improved varieties. Despite these high adoption rates, including research, extension, seed and marketing costs in the analysis resulted in a negative ARR for 1978-91. Marketing costs were pivotal; when these were excluded, the ARR exceeded 100 percent.

The numeri

extension and seed

higher, from 126-1

adoption would hav

from large to smal

regions. Economi

technology and co

beneficiaries of th

compared to total

The institu

solidify support fo

segment of the pop

development. The

the remote smallho

transportation cost

Independence maiz

transformation tra

these costs for soc

The numerical simulation suggests that the ARR to investments in research, extension and seed in the absence of marketing policies would have been substantially higher, from 126-139 percent. However, the distribution of benefits from technology adoption would have differed significantly. Marketing policies shifted maize production from large to small farmers, and from areas adjacent to the line-of-rail to more remote regions. Economic surplus for small, remote farmers increased with improved technology and complementary investments, but urban consumers were the primary beneficiaries of the maize policies: estimated consumer surplus was ZK 839 million, compared to total producer surplus of negative ZK 61 million.

The institutional analysis showed how maize investments were intended to solidify support for Kaunda's UNIP party and extend development opportunities to a segment of the population that benefitted little from colonial mining-centered development. They represented an attempt to shift comparative advantage in favor of the remote smallholder, as construction of the railway line and subsequent reduction of transportation costs did for adjacent farmers in the early 1900s. However, the post-Independence maize programs were unsustainable because they merely shifted high transformation/transaction costs from one societal group to another instead of lowering these costs for society as a whole.

To my parents, Paul E. and Mary F. Hercamp Howard, with gratitude

ACKNOWLEDGMENTS

I hope to repay the debts of professional and personal encouragement I have incurred throughout my graduate program by offering others, in the future, the same kind of unselfish support I have benefitted from so richly. I thank my student colleagues, the secretaries, administrative staff and faculty of the Department of Agricultural Economics for together creating a unique learning environment based on mutual support and productive collaboration.

In particular, I am deeply grateful to my major professor and thesis adviser, Prof. Eric Crawford, for his wise guidance, sense of fairness and for the security of knowing that he would always be there to help whenever I asked, and, still amazing to me, would always know the right thing to do. I also value the steadfast encouragement given by Prof. Carl Eicher and the many long afternoon conversations that left me alive with new ideas and convinced that my work could make a difference. I thank Prof. Al Schmid for sparking my interest in institutional economics and for teaching me to think critically about the assumptions I make. Prof. Jim Oehmke gave generously of his ideas and assistance to help me understand the role policies play in technology adoption and how to test hypotheses about policy impacts in my research. Prof. Carl Liedholm made insightful observations on several occasions that improved the quality of the dissertation.

I thank Janet M
for charting a course t
sending me mail once
how much their kind
up throughout the gra
Wordperfect-induced

I am grateful
(USAID). Africa Bur
research through the
A-00-4092-00) and th
2047-00). In Zambia
Fisheries (MAFF), th
(RDSB UNZA) and
quickly and ensuring
Mr. M. R. Mulele, I
the Department of A
Dr. William Whelan

This study be
and Mr. Sylvester K
1991-92. Their insig
well as their intellect
was grounded in the
improve our work.

I thank Janet Munn, Nancy Fair, and Vicky Branstetter of the Business Office for charting a course through the administrative minutiae of field work abroad and sending me mail once a week. Sherry Rich and Patricia Eisele probably do not realize how much their kind encouragement and unstinting willingness to help kept my spirits up throughout the graduate program. Elizabeth Bartilson helped me through every Wordperfect-induced panic.

I am grateful to the United States Agency for International Development (USAID), Africa Bureau and Research and Development Bureau, for funding this research through the Food Security in Africa Cooperative Agreement (No. DAN-1190-A-00-4092-00) and the Food Security II Cooperative Agreement (No. AEP-5459-A-00-2041-00). In Zambia, solid support from the Ministry of Agriculture, Food and Fisheries (MAFF), the Rural Development Studies Bureau of the University of Zambia (RDSB/UNZA) and USAID/Zambia was invaluable in getting the field research going quickly and ensuring continuing cooperation from key organizations. I especially thank Mr. M. R. Mulele, Director, and Dr. K. Munyinda, Assistant Director (Research) of the Department of Agriculture, MAFF; Dr. John Milimo, Director, RDSB/UNZA, and Dr. William Whelan, Agricultural Economist, USAID/Zambia.

This study benefitted enormously from the contributions of Mr. George Chitalu and Mr. Sylvester Kalonge, Senior Research Associates during the field research phase, 1991-92. Their insights and strong identification with farmer needs and concerns, as well as their intellectual curiosity, provided an important check ensuring that the study was grounded in the Zambian reality, and continually generated new ideas about how to improve our work. A dedicated team of enumerators, Mr. Keegan Chikonka, Mr.

Gilbert Nkamba, Mr.

and tireless project dr

fun. The late Mr. M

Environmental Statisti

and weekends helping

detailed maps of samp

and Mr. Stuart Kean.

the role of maize in Z

Catherine Mungoma,

Dr. Paul Gibson reca

and variety developm

Mr. Winter C

both maize variety de

Chance Kabaghe and

find data on Zamseed

Farmers Union (ZNF

us to key members of

welcomed us into the

Dickie, ZAREP, and

Federation (ZCF) wh

related to maize deve

The project te

Officers and their staf

Gilbert Nkamba, Mr. Clement Nsandula and Mr. Champion Tembo, and an excellent and tireless project driver, Mr. Mekamu Siwale, made the field work rewarding and fun. The late Mr. M. Davidson Simusonkwe and his staff at the Agricultural and Environmental Statistics Division, Central Statistical Office (CSO) spent late evenings and weekends helping us select the sample, calculating weighting factors and providing detailed maps of sample areas. Adaptive Research Planning Team (ARPT) members and Mr. Stuart Kean, former ARPT National Coordinator, helped the team understand the role of maize in Zambia's different farming systems. Dr. Dusan Ristanovic, Dr. Catherine Mungoma, Dr. Watson Mwale, Mr. Brian Chivunda, Dr. Ken McPhillips and Dr. Paul Gibson recalled and interpreted the key events in the history of maize hybrid and variety development in Zambia.

Mr. Winter Chibasa, General Manager of Zamseed, shared essential insights to both maize variety development and the birth of the seed industry in Zambia. Mr. Chance Kabaghe and Mr. Philip Kabwe of Zamseed dug through company archives to find data on Zamseed sales between 1979-92. The directors of the Zambia National Farmers Union (ZNFU) and the Zambia Seed Producers Association (ZSPA) introduced us to key members of the farming community who gave continuing guidance and welcomed us into their homes. I thank the staff of CIMMYT/Harare, Ms. Anthea Dickie, ZAREP, and the staffs of SIDA, FAO, NORAD and the Zambian Cooperative Federation (ZCF) who provided detailed information on projects and expenditures related to maize development and dissemination.

The project team received generous assistance from the Provincial Agricultural Officers and their staffs in Northern, Eastern, Southern and Central Provinces. We are

especially indebted
interviewed, who o
Prof. Karl
Department of Agr
1993-April 1994.

Margaret,
several extended tr
friends here and a
Bonnie, Brett and
that I could do this

especially indebted to the village headmen, and the men and women farmers interviewed, who offered the team their unfailing hospitality and sincere cooperation.

Prof. Karl Weckmann and colleagues provided a very warm welcome to the Department of Agricultural Economics of the University of Helsinki during December 1993-April 1994.

Margaret, Don and Greg Beaver generously sheltered body and soul during several extended trips to East Lansing in 1993 and 1994. A special thanks to many friends here and abroad, and particularly to my family: my parents, Steve, Mark, Bonnie, Brett and Kevin, for never ceasing to believe, and constantly reminding me, that I could do this.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ARPT	Adaptive Research Planning Team
ARR	Average rate of return
CIMMYT	International Center for Maize and Wheat Improvement
CSO	Central Statistical Office
CSRT	Commodity and Specialist Research Team
DRC	Domestic resource cost
FAO	Food and Agriculture Organization of the United Nations
GMB	Grain Marketing Board
GRZ	Government of the Republic of Zambia
IRR	Internal rate of return
MAFF	Ministry of Agriculture, Food and Fisheries
MRR	Marginal rate of return
MSU	Michigan State University
NAMBOARD	National Agricultural Marketing Board
NCZ	Nitrogen Chemicals of Zambia
RDSB	Rural Development Studies Bureau, University of Zambia
ROR	Rate of return
SCCI	Seed Control and Certification Institute
SER	Shadow exchange rate
SIDA	Swedish International Development Authority
UNDP	United National Development Program
UNZA	University of Zambia
USAID	United States Agency for International Development
USD	United States dollar
ZAMARE	Zambia Agricultural Development, Research and Extension
ZAMSEED	Zambia Seed Company
ZCF/FS	Zambia Cooperative Federation/Financial Services
ZK	Zambian kwacha
ZNFU	Zambia National Farmers' Union
ZSPA	Zambia Seed Producers' Association

CHAPTER ONE

INTRODUCTION

1.1. Problem statement and objectives

Maize is Zambia's most important crop. Seventy percent of crop area is planted to maize. It represents more than two-thirds of the value of all marketed food production, and 60 percent of the value of all crop production. The need to provide Zambia's politically important urban population[1] with a dependable source of cheap food, and a desire to improve small farmer incomes, motivated considerable investment in maize varietal research by the Government of Zambia (GRZ) and other organizations beginning in the late 1970s. These investments led to the release of ten improved hybrids and open-pollinated varieties from 1984-88.

This study examines the impact of these research investments, hypothesizing that the spread of the new technology was integrally linked to concurrent investments in extension, the seed industry, marketing and price policies that critically influenced farmer adoption decisions. A combination of quantitative and qualitative methods is used to evaluate the effectiveness of maize research investments in the context of policies and organizations that facilitated technology adoption.

---

[1] Zambia is one of sub-Saharan Africa's most highly urbanized countries; over 50 percent of the total population of nine million lives in cities (World Bank 1993). Urbanization is linked to the historical predominance of copper mining, rather than agriculture, in Zambia's economy.

The issue o

adoption has curre

beginning in the 19

marketing services

maize production.

The specific

1) calcu
dono

2) deter
differ

3) exam
organ

1.2. Justification

1.2.1. Agricultural

Agricultural r

plays a critical role i

contributions that the

providing food; (2) s

sector; (3) providing

exchange from expor

and (5) providing a m

and Schuh, 1977; Me

The developm

it can convert agricult

The issue of how complementary investments influence the pattern of technology adoption has current as well as historical relevance. Liberalization of maize marketing beginning in the 1992-93 season caused sweeping changes in the availability of marketing services that have already begun to affect the geographical distribution of maize production.

The specific objectives of the study are to:

1) calculate the rate of return to previous investments by the GRZ and donors in maize technology development and dissemination in Zambia;

2) determine the distribution of benefits from these investments between different producer groups, and between consumers and producers; and to

3) examine the impact of key policy and other institutional and organizational factors on maize research and technology transfer.

1.2. Justification

1.2.1. Agricultural research in economic development

Agricultural research leads to discovery and diffusion of new technology, which plays a critical role in facilitating general economic development. Among the contributions that the agriculture sector can make to overall development are: (1) providing food; (2) supplying capital, especially for the development of the nonfarm sector; (3) providing labor for the expansion of nonfarm activities; (4) supplying foreign exchange from export earnings to facilitate the purchase of critical inputs from abroad; and (5) providing a market for the products of the nonfarm sector (Ramalho de Castro and Schuh, 1977; Mellor, 1976).

The development of cost-saving technology is a key to this process, first because it can convert agriculture from a subsistence to a surplus-producing sector, and second because the nature

path general develo

agriculture in its ov

promote a network

and non-agricultura

1.2.2. Maize resea

Investments

various international

Development (USAI

Food and Agricultur

International Center

new hybrids and two

and varieties were pr

Zamseed, in collabor

Adoption of t

by an array of govern

panseasonal producer

product marketing ser

monopoly buyer of ma

system, from independ

mealie meal, were als

The availabilit

range of agroecological

because the nature of the technology and its pattern of adoption can predetermine the path general development will take. The point of technical change is not just to develop agriculture in its own right, but that technical change and agricultural growth can promote a network of consumption, production and fiscal linkages between agriculture and non-agricultural sectors that will lead to general development of the economy.

1.2.2. Maize research and dissemination in Zambia

Investments in maize improvement research by the government (GRZ) and various international agencies, including the United States Agency for International Development (USAID), the Swedish International Development Authority (SIDA), the Food and Agriculture Organization of the United Nations (FAO), and CIMMYT (International Center for Maize and Wheat Improvement) resulted in the release of eight new hybrids and two new open-pollinated varieties in the mid 1980s. These hybrids and varieties were produced and widely distributed by the new Zambian seed company, Zamseed, in collaboration with the GRZ-supported network of cooperative depots.

Adoption of the new maize varieties and expansion of maize area was affected by an array of government policies, including subsidized fertilizer and panterritorial, panseasonal producer prices for maize, together with direct provision of input and product marketing services. The government of Zambia served as the *de facto* monopoly buyer of maize, first through a marketing board and later the cooperative system, from independence until 1992. Consumer prices for the primary maize product, mealie meal, were also heavily subsidized.

The availability of new hybrids and open-pollinated varieties suited to a wider range of agroecological zones, and the producer policies and marketing arrangements, together encourage

medium-scale farm

and frequently in a

consumed. Small f

marketed maize in

(Wood 1990, 34; G

1.3. Overview of t

The remaind

agroecological and s

Zambia's farmers a

Three sketches the p

in the late 1970s-earl

Chapters Fou

the rate of return to

presents findings fro

improved maize varie

facilities. Conclusion

area, yield improveme

calculate an average

Chapter Five.

Chapters Six a

complementary invest

distribution of maize p

together encouraged the expansion of commercial maize production among small and medium-scale farmers in areas that had traditionally produced crops other than maize, and frequently in areas far from the line of rail or cities where the maize was to be consumed. Small farmer share of maize production increased, from 43 percent of total marketed maize in 1969 to 74 percent by 1980, and to 80 percent by the late 1980s (Wood 1990, 34; GRZ 1990, 30).

1.3. Overview of the study

The remainder of Chapter One, and Chapters Two and Three, describe the agroecological and socioeconomic environment of maize production and maize research. Zambia's farmers and farming systems are characterized in Chapter Two. Chapter Three sketches the process through which ten improved maize varieties were developed in the late 1970s-early 1980s.

Chapters Four and Five examine the evidence on maize technology adoption and the rate of return to maize research and complementary investments. Chapter Four presents findings from a survey of small and medium-scale farmers on their use of improved maize varieties and complementary services such as extension and marketing facilities. Conclusions drawn from the survey and secondary reports on improved maize area, yield improvement, and costs of research and related services, are used to calculate an average rate of return (ARR) to the package of maize investments in Chapter Five.

Chapters Six and Seven discuss the political economy of maize research and complementary investments in Zambia. The effect of policies on the geographical distribution of maize production, and on distribution of producer and consumer surplus, is examined throu

Chapter Seven ou

analyzes the orga

contribute to the e

Chapter Ei

the Zambian priva

organizations. Fi

study.

1.4. Background

Maize has

introduced by Port

Province by the en

Province by Angol

traditionally grew

millet, pumpkins an

arrival of European

Unlike elsew

unimportant in Zamb

Product (GDP) in 19

---

² This compares t
Agriculture's share in
1? percent in 1970. T
Zambians. Two-third
percent of the populat
Bank 1992, 1993).

is examined through numerical simulation of a without-policy scenario in Chapter Six. Chapter Seven outlines the political motivation behind key maize sector policies and analyzes the organizational characteristics that bonded with these political factors to contribute to the economic unsustainability of the parastatal maize system.

Chapter Eight draws on study findings to formulate policy implications for GRZ, the Zambian private sector, and foreign agencies regarding maize research and related organizations. Finally, Chapter Nine presents a summary and major conclusions of the study.

1.4. Background: maize production in Zambia

Maize has been grown in southern Africa since the 16th century, when it was introduced by Portuguese traders. It was reportedly a staple in Zambia's Luapula Province by the end of the 1700s, and was introduced about the same time to Western Province by Angolan traders (Figure 1; van der Bijl 1987, 10-11). Small farmers traditionally grew maize as one of a mixture of crops that also included sorghum, millet, pumpkins and groundnuts; it did not become dominant in most systems until the arrival of European colonizers in the 1900s (Blackie, undated).

Unlike elsewhere in sub-Saharan Africa, agriculture has been relatively unimportant in Zambia's economy, contributing only 14 percent of Gross Domestic Product (GDP) in 1988 and 16 percent in 1991 (Table 1, World Bank 1993).[2]

---

[2] This compares to an average of 31 percent for all sub-Saharan countries. Agriculture's share in Zambian GDP is increasing: it was just 8.3 percent in 1964 and 11 percent in 1970. The sector is an important employer and source of income for most Zambians. Two-thirds of the labor force is employed in agriculture and about 60 percent of the population depends on agriculture for subsistence (Jansen 1982; World Bank 1992, 1993).

Figure 1: Map of Zambia

Former Presi

our mouths" (

copper since l

annually until

declined by 40

then. Zambian

declining reser

1970 and 1985,

while service a

later other indus

Table 1: Zamb

Agriculture, forestry and fishi
Mining, quarrying
Manufacturing
Construction, other industry
Services, other
GDP

Source: World Bank

Former President Kaunda often said, "We Zambians were born with a copper spoon in our mouths" (Pagni 1990, 38). Zambia has been one of the world's major exporters of copper since before independence in 1964. Its economy grew at a rate of 12 percent annually until it was dealt a double blow in the mid-1970s, when world copper prices declined by 40 percent while imported fuel costs skyrocketed (Jansen 1988, 5). Since then, Zambian copper production has declined by 30 percent due to low price levels, declining reserves and falling ore quality. A major structural shift took place between 1970 and 1985, when the mining sector portion of GDP dropped from 36 to 16 percent while service and manufacturing sector shares rose (Table 1). Significantly, copper and later other industries attracted many to urban areas in the Copperbelt region of north-

Table 1: Zambia: Percentage of Gross Domestic Product by sector, 1965-88

	1965	1970	1975	1980	1985	1988
			(current prices)			
Agriculture, forestry and fishing	14	11	13	16	13	14
Mining, quarrying	41	36	14	14	16	15
Manufacturing	7	10	16	18	23	25
Construction, other industry	6	8	12	5	4	3
Services, other	32	35	45	47	44	43
GDP	100	100	100	100	100	100

Source: World Bank, 1992

central Zam

maize produ

because of t

Interventions

investments

marketing p

consumption

The i

area, produc

grew from le

1988-89. Pr

tons.

Durin

Zambian mai

farmers to the

1980s, the sm

production (G

Higher

logistics and c

payment for p

These factors

worsened by t

central Zambia and the capital, Lusaka. Heavy government involvement in all phases of maize production and marketing from the colonial period until 1993 was justified in part because of the need to secure an inexpensive source of food for the urban areas. Interventions included the promotion of maize production through a series of investments in research, extension and the seed industry, and the implementation of marketing policies that dramatically affected the pattern of maize production and consumption.

The investments and policies began to bear fruit in the mid 1970s, when maize area, production and marketing rose markedly (Table 2; Figures 2, 3). Maize area grew from less than 250,000 hectares in the mid-1970s to nearly 800,000 hectares in 1988-89. Production more than tripled in the same period, from 600,000 to 1,997,000 tons.

During the 1970s and 1980s, two important and related changes occurred in Zambian maize production. First, production shifted gradually from large commercial farmers to the small and medium-scale sectors. Between the early 1970s and the late 1980s, the small and medium-scale share rose from 60 to 80 percent of total maize production (GRZ 1990, 34).

Higher fertilizer prices, combined with GRZ's increasing inability to manage the logistics and cost of timely credit provision, physical input delivery, and collection and payment for produce, contributed to farmers' disenchantment with maize production. These factors led to a significant decline in maize area and production in the late 1980s, worsened by the disastrous region-wide drought of 1991-92 (Figure 2, Table 2).

Figure 2: Maize a

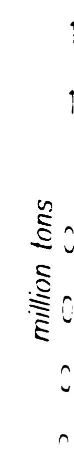


Figure 3: Marketed

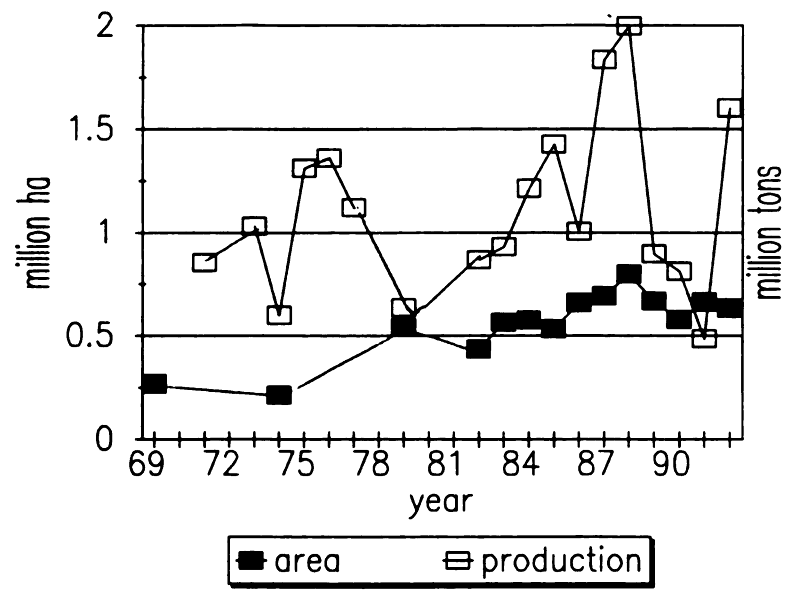


Figure 2: Maize area and production, 1969-92

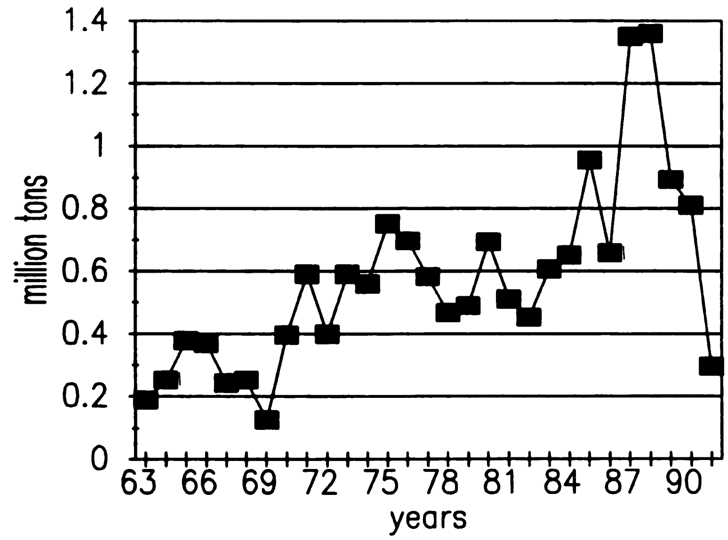


Figure 3: Marketed maize production, 1963-91

Table 2: Maize

Year
1963-64
1964-65
1965-66
1966-67
1967-68
1968-69
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93

Sources: Wood 1990
Central Stat
N.B. FAO data (199
786 mln tons for 199
which may be the mo
strengthened beginnin

Table 2: Maize area, production and sales, 1963-93

Year	Area (ml.ha)	Production (ml. tons)	Off. Purch. (ml. tons)	Yield (tons/ha)
1963-64	...	...	.189	...
1964-65	...	...	.252	...
1965-66	...	...	.378	...
1966-67	...	...	.369	...
1967-68	...	...	.243	...
1968-69	...	...	.252	...
1969-70	.267	.268	.126	1.01
1970-71	...	...	.396	...
1971-72	...	.852	.589	...
1972-73	...	...	.4	...
1973-74	...	1.03	.589	...
1974-75	.212	.60	.56	2.83
1975-76	....	1.31	.751	...
1976-77	...	1.36	.697	...
1977-78	...	1.12	.582	...
1978-79	...	...	.467	...
1979-80	.540	.636	.49	1.18
1980-81	...	...	.693	...
1981-82	...	...	.511	...
1982-83	.434	.867	.452	1.99
1983-84	.564	.93	.607	1.65
1984-85	.576	1.214	.65	2.11
1985-86	.532	1.427	.955	2.68
1986-87	.659	1.003	.657	1.52
1987-88	.692	1.834	1.349	2.65
1988-89	.797	1.997	1.36	2.5
1989-90	.668	1.464	.893	2.19
1990-91	.579	1.448	.81	2.5
1991-92	.662	.486	.261	.73
1992-93	.633	1.6	.927	2.53

Sources: Wood 1990 (1964-69, 1971-74, 1976-1979, 1981-82); World Bank 1992 (1970, 1975, 1980); Central Statistical Office 1973-92 .

N.B. FAO data (1993) show higher area and production levels for the early 1970s, .992 mln hectares and .786 mln tons for 1969-71. These data seem inconsistent with official maize purchases for this period, which may be the most reliable indicator of production levels before CSO monitoring capabilities were strengthened beginning in the late 1970s.

Second, the geograph

the 1980s. The natio

shares of Copperbelt.

Northwestern and Eas

sales had increased by

average increase from

grew from two percent

by the late 1980s. In E

(Table 3; Behnke and K

The data show a

agroecological Region II

areas, to the more remot

farmers (Table 3, Figure

varieties and disseminate

extending the range of hi

best-suited agroecologica

Second, the geographical and agroecological pattern of maize production changed during the 1980s. The national market share of Central Province decreased, while market shares of Copperbelt, and the more remote provinces of Northern, Luapula, Northwestern and Eastern all increased (Table 3). By 1988 Northern Province maize sales had increased by 2,600 percent over average sales during the late 1960s, while the average increase from other provinces was about 400 percent. Its national market share grew from two percent in the post-independence to late 1970s period, to 15-16 percent by the late 1980s. In Eastern Province, maize production doubled between 1979-85 (Table 3; Behnke and Kerven 1989, 5; Jha et al. 1991, 173).

The data show a partial migration of maize production from the areas of agroecological Region II that are centers of large-scale production, close to major urban areas, to the more remote areas of Regions II and III, which are dominated by small farmers (Table 3, Figure 4). The shift is significant because efforts to improve maize varieties and disseminate improved technology beginning in the late 1970s focused on extending the range of high-yielding maize production beyond the boundaries of the best-suited agroecological region and larger farms.

Table 3:

Year
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93

Sources

Table 3: Provincial shares of the national maize market, 1970-93

Year	Central	CBelt	Eastern	Luapula	Lusaka	Northern	NWest	Southern	Western
					(percent)				
1969-70	60.6	0.4	1.0	1.3	...	3.8	1.0	31.0	0.8
1970-71	58.6	0.7	3.4	0.6	...	1.4	0.7	33.8	0.6
1971-72	59.9	0.4	4.7	0.4	...	1.0	0.6	32.8	0.3
1972-73	54.5	2.9	10.9	0.6	...	1.3	0.5	29.0	0.3
1973-74	59.0	0.4	9.2	0.2	...	0.9	0.5	29.3	0.5
1974-75	45.8	0.5	12.4	0.3	...	1.8	0.5	37.6	1.2
1975-76	47.0	0.9	11.1	0.3	...	2.2	0.5	37.0	1.0
1976-77	42.9	0.8	13.3	0.4	...	2.7	0.4	38.3	1.1
1977-78	37.5	0.8	11.9	0.5	...	3.1	0.5	45.0	0.6
1978-79	31.5	1.1	13.6	0.5	...	3.1	0.8	48.6	0.9
1979-80	33.4	0.8	15.9	0.4	4.2	3.3	0.3	41.4	0.3
1980-81	34.6	0.5	15.4	0.7	3.8	4.3	0.6	39.7	0.6
1981-82	32.9	1.2	22.4	0.9	3.8	11.4	0.9	28.9	0.7
1982-83	38.0	1.5	27.1	0.7	3.7	10.9	0.9	16.3	0.9
1983-84	33.4	2.1	29.1	1.1	3.0	11.8	1.1	16.9	1.4
1984-85	31.6	3.4	25.2	0.8	3.8	10.4	1.1	22.4	1.3
1985-86	30.7	3.7	22.4	1.0	5.3	6.4	0.8	28.4	1.5
1986-87	29.0	7.1	27.6	2.1	5.1	12.7	1.6	13.6	1.3
1987-88	27.9	4.0	24.6	1.6	5.1	10.6	1.6	22.9	2.1
1988-89	26.3	3.7	27.3	3.0	3.9	10.2	2.1	21.1	2.4
1989-90	25.6	5.9	19.2	3.3	4.8	15.2	1.4	22.1	2.6
1990-91	30.4	7.8	18.5	4.0	4.7	16.1	1.1	12.6	4.8
1991-92	30.7	11.7	7.1	5.5	1.3	36.2	2.9	2.1	2.5
1992-93	17.8	4.8	20.3	2.4	4.5	8.0	2.8	32.1	7.3

Sources: GRZ 1970-83 annual reports of the extension branch, cited in Mumeka 1991, 78-9; GRZ 1990; Central Statistical Office 1990a-93a.

CHAPTER TWO

ZAMBIA'S FARMERS AND FARMING SYSTEMS

2.1. Types of farmers

In much of southern Africa, including Zambia, colonization introduced modern commercial large-scale farming systems that evolved alongside the traditional small-scale systems. Today, there are three major categories of farmers in Zambia. Small-scale or traditional farmers cultivate less than five hectares and consume most of their produce, using mainly hand hoes and few external inputs. Seventy-five percent of Zambia's 600,000 farm households are small-scale, working more than 60 percent of the total cropped area. In provinces where there has been a heavy out-migration of male labor to the copper mines, including Luapula, Northern and Western Provinces, more than one-third of the farm households are headed by women. Medium- (5-20 hectares) and large-scale farmers (over 20 hectares) use improved seeds and fertilizers, make use of animal draft power and tractors, and sell most of their production (World Bank 1992, 8; GRZ 1991a, 19; Kean and Singogo 1989, xxxiii).

2.2. Land tenure

Zambia's total land area of 752,614 square kilometers is divided into three categories: State Land, Reserves, and Trust Land. About 6 percent of all land is designated as State Land, called British Crown Land during the colonial period, lands taken from the indigenous population and reserved for European settlement. Most State

Land is cor
the Copperb
These areas
are free of
Zambia too

The
and authori
statutory la
granted for
sites and c
and Coppe

Mo
which mak
lands belon
chiefs and
allocated in
held comm
generations
many farme
centers. Fu
current gov
1983, 5).

Land is concentrated 30 kilometers on either side of the line-of-rail from Livingstone to the Copperbelt, with other sites near Chipata, Mbala and Mkushi (Figure 1, Chapter 1). These areas are close to the major urban markets, contain the country's best soils, and are free of tsetse fly. They remain the locus of large-scale commercial farming in Zambia today (Mwila 1986, 119; Milimo 1991, 129; World Bank 1983, 5).

The Land Act of 1975 did away with freehold title and private land ownership, and authorized the President to administer all lands on behalf of the Zambian people. A statutory land rights system for State Land was established under which leases could be granted for periods up to a maximum of 100 years. These leases are usually for urban sites and commercial farming areas around Lusaka and in Central, Southern, Eastern and Copperbelt Provinces (Mwila 1986, 119; Milimo 1991, 129; World Bank 1983, 5).

Most small- and medium-scale farms are located on traditional or Trust Lands, which make up over half of total land area and are governed by customary law. The lands belong to the resident community and are administered by the traditional rulers, chiefs and headmen. Individuals have a basic right to use land, and households are allocated individual plots for dwellings and cultivation of crops, while grazing land is held communally. Once land is allocated, it usually remains in the same family for generations. Under the traditional system, no title deeds are given, but in recent years many farmers have applied for registered title deeds, especially in areas near market centers. Fundamental revisions of the land tenure system are being considered by the current government (Milimo 1991, 130; Noragric and IUCN 1989, 71; World Bank 1983, 5).

Re

Zambia's

forests (W

2.3. Agro

Za

major agro

in the sout

mm in par

mm., good

favorable

Th

Zambia, sl

sea level,

covered wi

(Veldkamp

In c

land remain

of arable la

2.3.1. Reg

2.3.1.1. Le

Sem

specifically.

Reserve Land is land set aside for public use, and makes up about one-third of Zambia's total area. It includes national parks, game management areas and protected forests (World Bank 1983, 5).

2.3. Agroecological regions

Zambia is located in the savanna ecological zone, and subdivided into three major agroecological regions (Figure 4). Rainfall varies from under 700 mm annually in the southern Zambezi valley near the Zimbabwean border in Region I, to over 1400 mm in parts of Northern Province in Region III. Region II's annual rainfall (800-1000 mm), good soils and proximity to Lusaka and the Copperbelt markets make it the most favorable region for maize production.

The rainy season usually begins in late October and lasts until March in southern Zambia, slightly longer in the north. Elevations range from 300 to 1,300 meters above sea level, with most of the country between 900-1,300 meters. Much of the country is covered with miombo woodland, but there are also large areas of grassland and swamp (Veldkamp et al. 1990, 63).

In contrast to other countries in sub-Saharan Africa, most of Zambia's arable land remains uncultivated. Only about two million of an estimated nine million hectares of arable land are cropped or fallowed.

2.3.1. Region I

2.3.1.1. Location and climate

Semi-arid Region I includes areas of southern, eastern and western Zambia: specifically, the Gwembe and Lunsemfwa Valleys, and central and southern Luangwa

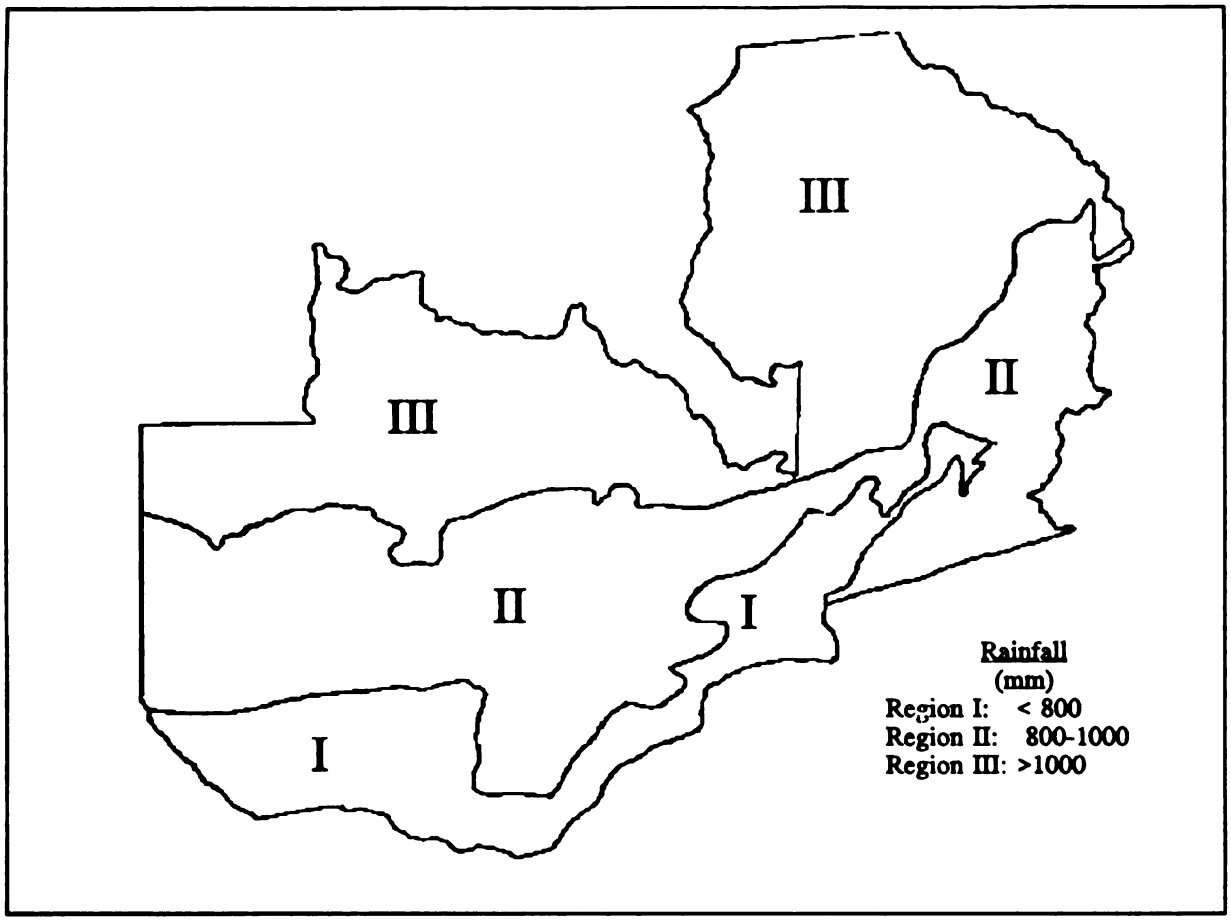


Figure 4: Agroecological regions

Valleys, and central and southern Luangwa Valley. These dry valleys are the lowest-lying areas in the country, with elevations of 300-900 meters above sea level. Mean annual rainfall in Region I ranges from 600 to 800 mm (GRZ 1991a, 32).

The Gwembe, Lunsemfwa and Luangwa Valleys are part of the Luangwa-Zambezi Rift Valley Zone, formed by the rift system along the Luangwa River and the Zambezi Valley below Livingstone. There is little agriculture along the escarpment, but there are areas of better quality valley soils along the Luangwa River and in the Gwembe Valley. The climate is hot and humid most of the year (World Bank 1983, 4).

Th

Most of w

plain of th

generally

southern s

characteri

and is larg

permanen

river delta

Ra

clayey soi

texture and

including c

cracking c

valley dam

Poo

days), punk

region for a

[1] These

[2] A dan
round. Bec
during the c
nursery cro

[3] The gr
half of the p

The southern parts of Western and Southern Provinces are semi-arid plains. Most of western Zambia is covered by a sandy plain which is cut by the wide flood plain of the Zambezi River drainage system. The central and western plains are generally grass-covered and waterlogged during the rainy season[1], while the eastern and southern sandy plains are covered by woodlands. Most of western Zambia is characterized by infertile sands suited primarily for cattle and other livestock grazing, and is largely free of tsetse, fortunately. Pockets of more fertile sand exist where semi-permanent agriculture is possible, especially at the edges of plains and valleys, and in river delta areas (World Bank 1983, 3).

Region I contains a variety of soil types, ranging from slightly acidic loamy and clayey soils with loam topsoil, to acidic sandy soils, to Rift Valley soils of variable texture and acidity. Some characteristics of these soils present problems for cultivation, including erosion, limited soil depth in hill and escarpment areas, difficult-to-work cracking clay soils, crusting, low water-holding capacities in sandy soils, and wetness in valley dambos[2] and swamp areas (GRZ 1991a, 90-91, 33).

Poor soil fertility, and the relatively short and perilous growing season[3] (80-120 days), punctuated by frequent dry spells if not drought, make this the least hospitable region for agriculture in the country. The prevalence of tsetse fly and other livestock

---

[1] These areas are classified as Region II.

[2] A dambo is a low-lying area, usually with clayey soil and a high water table year-round. Because of their more favorable moisture conditions, dambos offer good grazing during the dry season and are sometimes used to produce vegetable, tobacco and other nursery crops.

[3] The growing season is defined as the number of days in which rainfall exceeds half of the potential evapotranspiration.

diseases a

in some a

2.3.1.2.

R

because c

grown th

In

mainly o

food crop

food reli

millet an

Most fing

1984).

C

crops. C

The main

sales of f

1984).

A

by maize

sandier so

field. Far

cropped fo

diseases also limits cattle, sheep and goat husbandry and the use of animals for traction in some areas.

2.3.1.2. Farming systems

Region I farmers are predominantly small-scale hoe cultivators. Despite the risk because of its relatively long growing season, open-pollinated and hybrid maize are grown throughout the region.

In the **Luangwa Valley** system, farmers cultivate with hand hoes and rely mainly on household labor. Sorghum, finger millet and maize are the major starchy food crops, along with some rice. Groundnuts, cowpeas and pumpkins are the principal food relish crops. Maize porridge (nshima) is now the preferred staple, with finger millet and sorghum the first and second substitutes after maize supplies are exhausted. Most finger millet and sorghum is used for beer-making (GRZ 1991a, 33-34; ARPT 1984).

Cotton, sunflower, and maize, to a lesser extent, are the most important cash crops. Goats and chickens are commonly kept, and some farmers have a few cattle. The main source of income is the sale of mats and other items made from reeds, and sales of fish, game meat, chicken and finger millet beer (GRZ 1991a, 33-34; ARPT 1984).

After land has been freshly cleared, farmers usually plant finger millet, followed by maize and then other crops. Groundnuts are normally grown on separate plots with sandier soils, and may be rotated with maize. Sorghum is usually grown in a separate field. Farmers use fertilizer on hybrid and sometimes local maize. Fields are generally cropped for 3-4 years, then fallowed 5-6 years. Farmers interviewed by ARPT said that sorghum

vulnerab

were bec

A

in this sy

planting

exhauste

by April

T

Valley is

Gwembe

crops inc

pumpkin

keep catt

In

ranging f

drought,

major sta

cassava.

conditions

household

[4] The
Project (E
Kalichero.

sorghum, finger millet and cotton were declining in importance, sorghum because of its vulnerability to birds and the lack of markets. Maize, groundnuts, rice and sunflower were becoming more prevalent (ARPT 1984).

A nutrition study carried out in the early 1980s[4] concluded that many households in this system suffered from a seasonal food shortage during the time of heavy pre-planting farm labor requirements. Among sorghum producers, 44 percent had exhausted their stocks by December, increasing to 75 percent by March and 88 percent by April. A similar trend was observed for maize producers (ARPT 1984, 3).

The Gwembe and Luangwa Valley systems are similar, although **Gwembe Valley** is lower in altitude, drier and soils are less fertile than Luangwa Valley. In Gwembe, sorghum, maize and bulrush millet are the main starchy food crops, and relish crops include groundnuts, cowpeas and beans. Vegetables such as cucumbers, pumpkin, rape, tomatoes, onions and melons are also grown. Households commonly keep cattle, goats and chickens (GRZ 1991a, 34; World Bank 1983, 4).

In **Senanga West and Sesheke** (Western Province), wide temperature extremes, ranging from excessive heat to the danger of frost in the cool season, the threat of drought, and the poor, sandy soils are the main constraints to crop production. The major starchy food crops in Senanga West and Sesheke are bulrush millet, sorghum, cassava, and, to a lesser extent, maize. In spite of the apparently unfavorable growing conditions for maize, socioeconomic surveys of Western Province show that almost all households grow it. One survey of Senanga West noted: "... quite a significant number

---

[4] The study was carried out by the Eastern Province Agricultural Development Project (EPAD) and surveyed 250 households in Jumbe, within Region I, and Kalichero, on the plateau (Region II).

of househ

uncommo

1986. 28.

considere

Pumpkins

very impo

chickens.

income (C

Ar

planted or

maize fiel

from lopp

this syster

but is left

legumes a

19).

2.3.2. Reg

2.3.2.1. I

Re

and Easter

populated r

mm. and th

than in Reg

of households grow maize although sorghum and millet are recommended. It is not uncommon for households to harvest nothing from their maize fields" (Kanyangwa et al. 1986, 28, cited in van der Bijl 1987, 16). One-third of households in Senanga District considered maize their main crop (Maro 1986, cited in van der Bijl 1987, 17). Pumpkins, beans, groundnuts and cassava leaves are the principal relishes. Cattle are very important, providing draft power, milk and meat, and families also keep goats and chickens. Sales of baskets, fish, milk, cattle, goats and maize are the major sources of income (GRZ 1991a, 34).

Among the cattle-owning tribes of this area, e.g., the Lozi, maize is sometimes planted on fields which have been enriched through use as a cattle kraal. In other areas maize fields are part of a semi-permanent shifting cultivation system that uses the ashes from lopped and burned tree branches as nutrients. Cassava is also an important crop in this system. In its first season, it may be intercropped with millet, maize or groundnuts but is left as a sole stand afterwards until its harvest 2-3 years later. Vegetables and legumes are also intercropped with local maize, sorghum and millet (van der Bijl 1987, 19).

2.3.2. Region II

2.3.2.1. Location and climate

Region II includes most of central Zambia. The plateaus of Central, Southern and Eastern Provinces hold the country's richest soils and are the most densely populated rural areas of the country. Annual rainfall in Region II averages 800-1000 mm, and the growing season is 100-140 days. Distribution of rainfall is less erratic than in Region I, but dry spells are common and reduce crop yields, especially on sandie

month

1991a.

are mo

product

prone to

retention

1991a. 3

2.3.2.2.

Z

Region II

and are h

coffee, an

and oxen-

below. A

of low cos

unavailabil

characteris

For livestoc

of breeding

38-40).

sandier soils. Average mean daily temperatures range from 23-26°C in the hottest month, October, to 16-20°C in the coldest months of June and July. Frost is rare (GRZ 1991a, 37).

The most common soils in Region II are red to brown clayey to loamy types that are moderately to strongly leached. Physical characteristics of the soils that affect production include low water holding capacity, shallow rooting depth, and topsoils prone to rapid deterioration and erosion. These soils have low nutrient reserves and retention capacity, little organic matter, are acidic and phosphorus-deficient (GRZ 1991a, 38).

2.3.2.2. Farming systems

Zambia's medium- and large-scale commercial farmers are concentrated in Region II. Their rainfed and irrigated farming systems are based on oxen or tractors, and are highly diverse, including maize, soybeans, wheat, cotton, tobacco, livestock, coffee, and vegetables. Besides the large-scale systems, there are four main hand hoe and oxen-based farming systems used by small- and medium-scale farmers, described below. ARPT identified the major constraints to increased crop production as the lack of low cost controls for pests and diseases, soil degradation and depletion of fertility, unavailability of open-pollinated varieties, unreliable rainfall distribution, poor storage characteristics of improved cash crop varieties, and shortage of labor and draft oxen. For livestock, the main problems are poor nutrition during the dry season, disease, lack of breeding stock, poor husbandry practices and inadequate water supplies (GRZ 1991a, 38-40).

In gene
transition from
system based o
burn, entails cu
about 5 meters
before the rain
December or J
year other crop
seasons. After
to regenerate b
1987, 10).

Besides
located close to
groundnuts, and
chitemene syste
extensions of th
1988).

While sn
large-scale farm
commercial farn
crops such as so
their livestock o

In general, small- and medium-scale farming systems in Region II are in transition from the traditional shifting bush-fallow (chitemene) to a semi-permanent system based on hand hoe and plow. Small circle chitemene, a variant of slash-and-burn, entails cutting trees at breast height and piling the branches in many circles of about 5 meters in radius. The wood is left to dry and burned beginning in September, before the rains start. Finger millet, sorghum, or other crops are planted in the ashes in December or January, sometimes intercropped with cowpeas and maize. After the first year other crops, including cassava, beans, and groundnuts may be planted for 3-4 seasons. After it is abandoned, the small circle chitemene area can take up to 30 years to regenerate because of the extensive destruction of the trees (Bolt and Holdsworth 1987, 10).

Besides chitemene fields, farmers also have ibala: open, semi-permanent gardens located close to the house where sweet potatoes, beans, sorghum, local maize, groundnuts, and pumpkins are grown. Increasingly, farmers are moving from the chitemene system to cleared, plowed and fertilized fields, which are sometimes extensions of the ibala gardens, particularly for cash crops such as hybrid maize (ARPT 1988).

While small and medium farmers have intensified commercial maize production, large-scale farmers have diversified away from it. Beginning in the late 70s and 80s commercial farmers complained that maize prices were too low and began to grow other crops such as soybeans and tobacco, sometimes in rotation with maize, or intensified their livestock operations (GRZ 1990).

Provin

and oth

sunflow

sunflow

provide

they so

planting

waterm

tradition

potatoes

complet

I

decades

Province

the smal

others m

C

Eastern

identical

rented tra

although

meat, mil

Maize is the main staple of the **hand hoe system in Central and Eastern Provinces**. Beans, groundnuts, pumpkins, and cassava leaves are the principal relishes, and other crops include cotton, sorghum, soybeans, finger millet, cassava and sunflower. Cattle, chickens, goats, pigs and sheep are common. Sales of hybrid maize, sunflower, cotton, groundnuts, beer from finger millet or sorghum, chickens and goats provide the main sources of income. Farmers rely primarily on family labor, although they sometimes hire outside workers during the busiest period, December-January, for planting and weeding. Local and hybrid maize, sorghum and intercropped pumpkins, watermelons and beans are all planted in November and December. Women traditionally plant groundnuts during the same period. Sole stands of beans, sweet potatoes, rape and tomatoes are planted in March after the first weeding of the cereals is completed (ARPT 1988; GRZ 1991a, 38).

Maize is newly dominant in some areas, but has been well-established for decades in others. The 1978-79 CIMMYT recommendation domain study for Central Province identified six small-scale farming systems. In three of these, representing half the small-farmer population, maize was already the main starch staple, while in the others millet and sorghum were still most important (cited in Drinkwater 1990, 7).

Crops and livestock in the **maize-cattle mixed farming system of Central, Eastern and Southern provinces, and Kaoma District, Western Province**, are almost identical to the hand hoe system above, with the addition of tobacco. Here, oxen and rented tractors are the main sources of draft power for land preparation and planting, although most of the maize weeding is done by hand. Cattle are also important for meat, milk and manure. Hybrid maize dominates this system, and has been popular for many year

Rural, mai

proximity

traction. S

of goats ar

1988, 28;

La

February a

seedbed, v

results in l

potatoes, a

Th

sorghum,

potato leav

this system

and trade.

home cons

In t

sorghum, r

major relis

milk, poult

important p

fish, cattle,

many years in some places. For example, in the Muswishi-Bombwe area of Kabwe Rural, maize has been the principal crop for 40 years, due in part to the area's proximity to the urban market of Kabwe and to the continuous availability of oxen for traction. Sunflower, cotton, soybeans and tobacco are also major cash crops, and sales of goats and chickens are additional sources of income (Drinkwater 1991, 2; ARPT 1988, 28; GRZ 1991a, 39).

Land clearing, including full removal of tree stumps, usually takes place in February and March. Most farmers plant "behind the plow" as they prepare the seedbed, which may contribute to poor maize stands. The shortage of draft power often results in late planting of maize. Other crops such as sunflowers, beans and sweet potatoes, are planted after the critical October-January period is past (ARPT 1988, 29).

The major crops in the **hand hoe system of Western Province** are cassava, sorghum, bulrush millet and maize. Cassava leaves, cowpeas, pumpkin leaves, sweet potato leaves, beans, bambara nuts and groundnuts are common relishes. Farmers in this system commonly keep cattle, chickens, ducks and goats for meat, milk, manure and trade. Maize, sorghum, millet, cassava and sweet potatoes are grown primarily for home consumption, but are often sold informally (GRZ 1991a, 39).

In the **central Zambezi floodplain farming system** (Western Province), sorghum, maize, bulrush millet and cassava are the principal starchy food crops. The major relishes are cassava leaves, local beans and vegetables, supplemented by beef, milk, poultry and fish. Oxen are the main source of draft power, and cattle are an important part of the overall farming system. Household income comes from the sale of fish, cattle, milk, rice, bulrush millet and cassava (GRZ 1991a, 39).

2.3.3

2.3.3

North

is the

precip

month

July. T

annual

cover r

during t

streak vi

grassy sv

S

Conseque

exchangea

Periodic li

expense an

low capacit

large circle

the predomin

the soil (GRZ

2.3.3. Region III

2.3.3.1. Location and climate

Region III, the high-rainfall area, lies across northern Zambia, including Northern, Luapula, Copperbelt, Northwestern and some parts of Central Province, and is the least densely populated part of Zambia. This region receives 1000-1500 mm of precipitation each year, and the growing season ranges from 120-150 days. The mean monthly temperatures during the growing season are 19-27°C, and 16°C in June and July. There is usually no frost (GRZ 1991a, 42). The long rainy season is favorable for annual crops with extended growing seasons, but rain, low sunshine hours and cloud cover reduce temperatures and limit cotton and tobacco production. High humidity during the rainy season facilitates the spread of rust and fungal diseases as well as maize streak virus. Most of the plateau area is covered by relatively dense woodland, with grassy swamps along the drainage lines (World Bank 1983, 2).

Soils in Region III are highly weathered and leached, and extremely acidic. Consequently, the soils have few nutrients available for plant growth, and are high in exchangeable aluminum and manganese, both of which are toxic to most crops. Periodic liming is strongly recommended by the extension service, but because of its expense and limited availability, only the large-scale farmers do so. Most soils have a low capacity for water retention and some are easily eroded. However, the traditional large circle chitemene system (described below), which leaves tree stumps intact, and the predominance of hand hoe rather than mechanized cultivation, both aid in preserving the soil (GRZ 1991a, 43; Noragric 1989, 30).

2.3.3.2

state ar

fundikil

method

of Regi

the nort

surroun

to 100 r

(Bolt an

I

manurin

grass is

into circ

season.

broadcas

mounds

Fundikila

settled ar

10. Nora

B

near the

pumpkins

2.3.3.2. Farming systems

Small-scale farming predominates in Region III, although there are a few large state and private farms where coffee and other crops are grown. Chitemene and fundikila are two traditional, widely used, very low input shifting and semi-permanent methods of cultivation. Small circle chitemene, which is practiced in the southern parts of Region III, was described in section 2.3.2.2. The large circle chitemene common in the north is similar, but involves cutting only the higher branches of trees from a surrounding area as large as 10 hectares, then making large piles with a diameter of up to 100 meters. The ash from the burned trees improves soil fertility and raises its pH (Bolt and Holdsworth 1987, 10; Noragric 1989).

In areas with a longer tradition of settled agriculture, a semi-permanent green manuring/fallow system, fundikila, is commonly used on already cleared fields. Here, grass is cut from fields and piled in heaps. The heaps are covered with soil and made into circular mounds or long mounded ridges, then left to decompose during the rainy season. The composted material is either spread out during the next season and broadcast with finger millet, or maize, cassava and beans may be directly planted in the mounds themselves. Maize is becoming increasingly important in this system. Fundikila developed because of the shortage of trees for chitemene in the more densely settled areas of the region, and it is increasingly popular (Bolt and Holdsworth 1987, 10; Noragric 1989, 34).

Besides chitemene and fundikila fields, households may also plant ibala gardens near the house for sweet potatoes, beans, sorghum, local maize, groundnuts and pumpkins. Where commercial agriculture is important, these systems are giving way to hand-hoe

Holdswo

A

fertility.

pests an

by the s

1991a. 4

T

of North

potatoes

markedl

vegetabl

Bangweu

swampy

in some

fish, bea

8).

S

and Cop

minor cro

sweet pot

rivers. C

in Solwezi

hand-hoe or oxen-based systems using purchased inorganic fertilizers (Bolt and Holdsworth 1987, 10.

ARPT identifies the main constraints to production as high soil acidity and low fertility, lack of animal power, poor storage characteristics of improved maize hybrids, pests and diseases in food crops, and shortage of labor. Livestock production is limited by the scarcity of breeding stock, disease, thin markets and poor husbandry (GRZ 1991a, 46).

There are four main farming systems. Principal crops in the **hand hoe system of Northern, Luapula and Northwestern Provinces** are cassava, maize, sweet potatoes, pumpkin, finger millet and beans. Commercial maize production increased markedly in this system during the 1980s. Cowpeas, groundnuts, onions and leafy vegetables such as rape are grown as relishes, and fish is also important near Lakes Bangweulu, Mweru and Tanganyika. Rice is an increasingly important cash crop in swampy areas. Most farmers have chickens and a few goats, but the presence of tsetse in some areas constrains cattle production. Households earn income through the sale of fish, beans, maize, cassava, beer and chicken (GRZ 1991a, 43; Bolt and Silavwe 1988, 8).

Sorghum is the most important cereal in the **hand hoe system of Northwestern and Copperbelt Provinces**, followed by finger millet. Sweet potatoes and maize are minor crops. Cassava is the most important starch, and relishes include cassava and sweet potato leaves, beans and game meat. Fish are also important in areas close to rivers. Chicken and goats are common in many households, and a few cattle are found in Solwezi and parts of the Copperbelt, although not in tsetse-infested Kasempa.

Househ

potatoes

and hon

C

of Isoka

permane

crops. (

use hand

beans ar

In

Province

groundnu

primarily

groundnu

R

productio

2,600 per

representa

non-farm

millet and

In

soils has

that may

Households earn income through the sale of sorghum, finger millet, beans, sweet potatoes, the brewing and sale of sorghum/millet beer, and sales of game meat, chicken and honey (GRZ 1991a, 44).

Cassava, finger millet and maize are the staples of the **fundikila farming system of Isoka and Mbala Districts**, in Northern Province. This area has a long history of permanent agriculture and maize production. Beans and groundnuts are important relish crops. Cattle, chickens and goats are also kept by farm households. Farmers mainly use hand hoes for cultivation, but oxen are sometimes used for draft power. Maize and beans are the most important cash crops and sources of income (GRZ 1991a, 44).

In the **chitemene farming system of Northern, Luapula and northern Central Province**, finger millet, cassava and maize are the main crops, with beans and groundnuts the most important relishes. Goats, chickens and some cattle are kept, all primarily for meat. The main source of household income is the sale of beans, maize, groundnuts and beer (GRZ 1991a, 45).

Region III experienced the most dramatic increase in commercial maize production in all of Zambia during the 1980s. By 1988 maize sales had increased by 2,600 percent over average sales during the late 1960s, and in the late 80s maize sales represented almost half of small-scale farmers' total household cash income, including non-farm income. Maize has also become the preferred food staple, replacing finger millet and cassava (Behnke and Kerven 1989, 2-7).

Increased land clearing and intensification of cultivation on the region's poor soils has prompted concern over the possibility of long-term environmental degradation that may result from expanding production of commercial maize. A 1989 study conclu

ecologi

attribut

as long

is conti

howeve

concluded that, up to then, intensified hybrid maize production had caused no serious ecological damage in Northern Province (Noragric and IUCN, 8). This is partly attributable to the traditional practice of shifting to a new plot every 3-5 years, feasible as long as population density is low. Soil productivity will decline eventually if maize is continuously monocropped on poor, acid soils without fertilization and liming, however (Noragric 1989, 8-9).

3.1.

first:

used.

this la

well k

intern

led to

anywh

maize

these i

sustain

on leng
were p
separat
it was f
their cu

CHAPTER THREE

MAIZE IMPROVEMENT IN ZAMBIA: A BIOGRAPHICAL SKETCH[1]

3.1. Introduction

The story of Zambia's maize improvement program appears straightforward at first: a recitation of dates when breeders began work, a description of the techniques used, varieties released, amount of funding, and later, adoption of the technology. At this level, the considerable accomplishments of the maize program, while perhaps not well known even in Southern Africa, are documented in journal articles and international proceedings.

At another level, that of process, the individual and organizational dynamics that led to initial success but eventual fragmentation of the maize program is not documented anywhere. It is gathered here through a series of interviews with past and present maize researchers and policymakers. The frankness and intensity that characterized these interviews perhaps reflected a common sentiment about the important lessons for sustainability offered in this part of Zambia's maize story.

---

[1] This chapter draws on Howard, Kalonge, and Chitalu (1994), and is based in part on lengthy interviews with past and current maize scientists and policymakers. These were personal interpretations of events, but what is recorded was in most cases separately confirmed by two or more persons. Personal references were omitted where it was felt that attribution of comments to individuals might cause them difficulties in their current positions.

3.2

Sou

as e

that

Sout

vers

in Sc

1949

devel

was w

germp

taking

Havaz

primar

The in

report

---

[2] S

[3] T
maize
propor
The "d
Local
Flinty
for ins

3.2. Maize research in the colonial era

Before independence, Northern Rhodesia relied on its Federation partner Southern Rhodesia for maize seed. Southern Rhodesia had a maize breeding program as early as 1933. The hybrid program was based largely on open-pollinated varieties that were white versions of varieties originating in the Southern U.S., coming to Southern Rhodesia via South Africa. Southern Cross, Salisbury White and a white version of American Hickory King were grown and mass selected[2] by individual farmers in Southern Rhodesia for more than 25 years. The first hybrid, SR11, was released in 1949, and the spectacularly successful SR52 followed in 1960. One of its parents was developed from a selection in Southern Cross, the other from Salisbury White. SR52 was widely adopted throughout Southern Africa and remains a major influence on maize germplasm in the region. It is a tall white dent[3] with large ears, and has a long season, taking 160-165 days to reach maturity (Hoyle 1965; Eicher 1994; Tattersfield and Havazvidi 1991; Olver 1987).

In Northern Rhodesia, large-scale European commercial farmers were the primary users of SR52, SR11 and Hickory King imported from Southern Rhodesia. The introduction of SR52 greatly affected commercial farmer maize yields. Makings reports that the average maize yield for commercial farmers, which was under 1.3

---

[2] Selection for characteristics based on visual appearance.

[3] The texture of the maize grain ranges from hard (flint) to soft (dent). "Dent" maize has a characteristic depression in the top of the kernel which comes from the proportion of hard or vitreous endosperm in the kernel to the soft or floury endosperm. The "dent" is formed because the soft endosperm collapses inwardly as the kernel dries. Local or unimproved maize in Zambia tends to be flinty, and improved hybrids denty. Flinty maize appears to store better than dent types, as the harder grain is more difficult for insects and microorganisms to penetrate (Blackie:5-6).

tons l

1966.

manag

long-s

and op

denty

as mai

from n

King. l

and go

with lo

generat

persona

1993; D

3.3. Za

Z

Abingtor

produce

farmers i

Southern

[4] Sma
varieties i

tons/ha between 1949-53, more than doubled, to 2.7 tons/ha, by 1959-63 (Makings 1966, 240).

Small-scale farmers, who could not afford inputs or meet the higher management requirements, usually planted "local" maize. "Locals" are open-pollinated, long-season varieties, requiring lower levels of management than the imported hybrids and open-pollinateds. They are flinty and have small grains as opposed to the large, denty hybrids. Over time, the distinction between "importeds" and "locals" has blurred as maize in small-scale farmers' fields became cross-pollinated with improved maize from neighboring commercial farms, especially Hickory King.[4] A derivative of Hickory King, known as milishi, is still a popular "local" variety today, because of its flintiness and good storability. Small farmers also began to try SR52, often mixing the hybrid with local seed. In subsequent seasons, farmers commonly replanted advanced generations of the hybrids instead of purchasing new seed each year (McPhillips, personal communication, July 9, 1991; Gibson, personal communication, March 12, 1993; Drinkwater 1990, 9).

3.3. Zambian breeding program

Zambia's maize breeding program was initiated in 1965 with the arrival of J.B. Abington, partially supported by British ODA. Abington's principal objective was to produce varieties that would be higher yielding and better suited to the needs of small farmers in different agroecological zones than SR52 and the other popular hybrids from Southern Rhodesia, SR13 and SR11 (Ristanovic et al. 1985).

---

[4] Smale et al. (1991) report similar cross-pollination of "locals" by imported varieties in Malawi.

ge

tw

inb

ori

inb

hyb

Zar

ZH

offe

prov

yiel

Bank

Brad

in co

impr

dwar

Mwa

[5] I

[6] A

[7] C

Abington inaugurated the country's maize germplasm collection,[5] assembling germplasm from Ecuador, Mexico, Kenya and Zimbabwe. In 1969-70, he developed two maize varieties, Zambian Composite A (ZCA), from Hickory King plus seventeen inbred lines from the Zambian program, and ZUCA (Zambia Ukiringuru composite A), originally developed in Tanzania as UCA and crossed to Zambian germplasm. An inbred line, 63J, was also selected and crossed with SR52 to produce the first Zambian hybrid, ZH1, in 1970. Two other composites were released during Abington's tenure, Zambia Yellow Composite (ZYC) and Zambia Short Composite (ZSC). The seed of ZH1, a three-way cross hybrid, was cheaper to produce than the single cross SR52 and offered at a lower cost to farmers (Norrby 1986, 32). None of these varieties ever proved very popular, partly because their growing seasons were still quite long while yields were inferior to SR52 (Chibasa, personal communication, Oct. 30, 1992; World Bank 1983, 27).

When Abington left Zambia in 1973, an ODA-supported agronomist/breeder, Bradwell, took over Zambia's fledgling maize breeding program until 1976. Working in collaboration with CIMMYT, the breeding orientation shifted from quantitative (yield improvement) to qualitative factors such as protein quality, cytoplasmic male sterility,[6] dwarf brachytic genes[7] and testing foreign hybrids and varieties for agronomic suitability (Mwale 1987). However, before the 1980s and the establishment of its Harare office,

---

[5] For a layperson's summary of steps involved in maize breeding, see Appendix 1.

[6] A condition in which pollen is absent or non-functional in flowering plants.

[7] Genes that cause short stature in plants.

CIMM

altitude

3.4. C

by then

Zambia

reported

which th

near the

maize b

research

commun

C

arrived i

breeding

Zambia

Zambia

developn

A

breeder a

germplas

collection

different

CIMMYT had little suitable material with the maturity range required for tropical altitudes of 1000-1500 meters (World Bank 1983, 27).

3.4. Cooperation with Yugoslavia's Maize Research Institute

Yugoslav involvement in maize research stemmed from a visit in 1974 or 1975 by then President Kaunda to Yugoslavia. Dissatisfied with the lack of progress in the Zambian program, and visibly impressed by the maize crop around Belgrade, Kaunda reportedly asked his friend Marshal Tito for assistance. An agreement was reached in which the Yugoslav Maize Research Institute (MRI) would be allowed to use a farm near the town of Mazabuka as a winter nursery site. In return, MRI would send a maize breeder to work with the Zambian program, and Zambian maize and sunflower researchers would also be trained on-site and in Yugoslavia (McPhillips, personal communication, Oct. 28, 1992; Chibasa, personal communication, Oct. 30, 1992).

C. Jovanovic, the first maize breeder sent by MRI to help the Zambian program, arrived in 1977. The following year, the first Zambian professionals joined the maize breeding program, both with Bachelor of Science degrees from the University of Zambia School of Agriculture. Jovanovic brought many CIMMYT populations to Zambia for testing and improvement, and was keenly interested, like Bradwell, in the development of high-lysine maize.

At the same time, another Yugoslav, D. Ristanovic, began work as senior maize breeder at the MRI winter nursery farm near Mazabuka. Ristanovic also brought germplasm to Zambia, primarily South American and African in origin, from the collections of the Yugoslav Gene Bank. After a first screening of some 3.5 million different samples, some material was handed over to the Zambian maize germplasm collection. a

1992).

After

required his

in the Zamb

later. he rem

11. 1992).

3.5. Purific

Soon

height and un

SR52.[8] althou

characteristics

maintenance o

and 23 percen

result was a yi

original Rhode

Fortuna

the same farm.

contamination w

within the lines

the parents (Rist

[8] After indep
the parent lines i

collection, and Jovanovic started selfings (Ristanovic, personal communication, Oct. 11, 1992).

After three years of work, Jovanovic was involved in a serious car accident that required his early return to Yugoslavia. Ristanovic was asked to substitute temporarily in the Zambian program; eventually the transfer was made permanent. Thirteen years later, he remains with the Research Branch (Ristanovic, personal communication, Oct. 11, 1992).

3.5. Purification of SR52

Soon after he arrived in Zambia, Ristanovic began to notice the lack of uniform height and unusual morphological variation in the most widely planted hybrid, Zambian SR52,[8] although hybrids are expected to be consistent in height and other characteristics. Contamination of both parents of SR52 occurred because of improper maintenance of the breeder's seed, so that only 5 percent of the cobs of the male parent and 23 percent of the cobs of the female parent corresponded to the correct type. The result was a yield loss of about 15 percent in the Zambian SR52 compared to the original Rhodesian/Zimbabwean version (Ristanovic et al. 1985).

Fortunately, basic seed of the female and male parents was never produced on the same farm, and was kept well-isolated from other maize varieties. The contamination within the inbreds apparently came from residual variation and mutation within the lines rather than from out-crossing with other lines, facilitating purification of the parents (Ristanovic et al. 1985). Efforts to obtain the original parents from

[8] After independence, breeders began producing a Zambian version of SR52 from the parent lines instead of importing SR52 from Southern Rhodesia.

Zimbabwe fai

completing th

conducted dur

20 percent ov

version. the fi

released in 19

number indica

the connectio

3.6. Improv

It was

maize product

carried out by

into commerc

adapted to sm

Perhap

planting comm

required early

several reason

fields before t

early in the se

plant commerc

have been plan

streak virus, es

Zimbabwe failed, so Ristanovic started cleaning both parents in the 1977-78 season, completing the work in 1978-79. Additional testing of the newly purified SR52 was conducted during 1980-82 at five locations countrywide and showed a yield increase of 20 percent over the old SR52, although this was not statistically significant. The new version, the first of the Zambian improved varieties examined in this study, was released in 1983 under the name Mount Makulu 752 (MM752). The seven is an FAO number indicating the (relatively long) time to maturity, while 52 was retained to show the connection with SR52 (Ristanovic et al. 1985).

3.6. Improved maize for small farmers: open-pollinated or hybrids?

It was clear to Zambian policymakers by the 1970s that the key to increased maize production lay with the small farmer, and the price and marketing policies being carried out by GRZ already reflected the greater emphasis on drawing small farmers into commercial maize production. Developing new maize technologies that were better adapted to small farmer needs was a logical next step.

Perhaps the most serious problem confronting small farmers interested in planting commercial maize varieties like SR52 was the long growing period that required early planting. Zambian small farmers tend to plant commercial maize late for several reasons. If they are using hand hoes, it is extremely difficult to prepare the fields before the first rains have softened the very hard surface. Also, if farmers hoe early in the season, fields must be weeded a second time later. Farmers usually wait to plant commercial maize until after local maize and the other family subsistence crops have been planted, but this has a high cost. Late planted maize is vulnerable to maize streak virus, especially in wetter areas such as Region III. More important, researchers e

p

co

th

3.6

pop

vari

prim

farm

the b

CIM

as op

inbrec

1991)

the ear

CMM

Jovanov

breeder

before b

estimate that farmers lose 1-2 percent of maize yield for each day of delay (Gibson, personal communication, March 12, 1993).

Small farmers required maize seed that was shorter-season and better adapted to conditions in the different agroecological regions. In the late 1970s, a key question was the suitability of open-pollinated vs. hybrid varieties for small farmers.

3.6.1. Open-pollinated varieties and CIMMYT's contribution to the maize program

Until the mid-1980s, CIMMYT's maize improvement strategy focused on population improvement and the development of open-pollinated rather than hybrid varieties, and on qualitative instead of quantitative traits. Small maize farmers were the primary target group, and CIMMYT felt that hybrids were inappropriate because small farmers were generally unable to obtain or purchase new seed every year, or to afford the higher level of inputs required to achieve the yield potential of hybrids. In 1987 CIMMYT shifted its strategy and began working in the development of hybrids as well as open-pollinated varieties, although hybrids themselves were not distributed, only the inbred lines that form the parents of hybrids (Gelaw, personal communication, July 1991).

CIMMYT has been a sustaining presence in the Zambian maize program since the early 1970s, when Bradwell formulated his research program in collaboration with CIMMYT/Mexico (Mwale, 1987). The first Yugoslav maize breeder from MRI, Jovanovic, came to Zambia after spending a year and a half at CIMMYT. American breeders from the USAID ZAMARE project also traveled to CIMMYT for briefings before beginning their work in Zambia.

beca

cons

visit

prepa

term

CIM

regio

for Za

by the

provic

Gibso

Resea

Adapti

technic

Total n

1991 a

3.6.2.

Zimbab

[9] See

After the establishment of a regional center in Harare, Zimbabwe, CIMMYT became even more active in the Zambian maize program, playing an ongoing consultative and training role. Beginning in 1980, CIMMYT Maize Program staff visited Zambia five to six times a year to assist in germplasm development, program preparations and provide in-country training. Zambian scientists also received short-term training at CIMMYT headquarters in Mexico and in Harare, and attended periodic CIMMYT-sponsored workshops on maize improvement with other scientists in the region (Gelaw, personal communication, July 1991; Gelaw 1985:220).

CIMMYT's Maize Program has been the most important source of germplasm for Zambia's population improvement efforts. Two open-pollinated varieties released by the Zambian program in 1984, MMV400 and MMV600, were based on populations provided by CIMMYT (Gelaw, personal communication, July 1991; Gelaw 1985:220; Gibson and Ristanovic 1985).

Finally, CIMMYT Economics Program staff was instrumental in helping the Research Branch carry out initial preparatory studies, and design and set up the Adaptive Research Planning Teams (ARPT). CIMMYT staff continued to provide technical assistance and some funding for ARPT activities through the early 1990s. Total maize research-related expenditures by CIMMYT from the late 1970s through 1991 are estimated at USD 860,000 (Table 38, Appendix 2).

3.6.2. The case for hybrids

Unlike many other countries in sub-Saharan Africa, in Zambia (and similarly, Zimbabwe[9]) a special set of conditions combined to create an environment that

---

[9] See Eicher 1994 for a description of Zimbabwe's smallholder maize revolution.

faci

imp

wer

scha

focu

prog

hybr

estin

Cros

it ea

instit

depo

little

farme

consu

hybrid

and N

10

pricing
adoptio
the tas
(Smale
locals.
store d

facilitated the adoption of SR52 by small farmers, then made further development of improved hybrids possible. First, improved open-pollinated varieties like Hickory King were already being promoted through extension programs such as the peasant farming scheme in the 1950s. Adoption of SR52 in combination with fertilizer use was the focus of the extension service's Lima program during the 1980s. Through these early programs small farmers learned about the yield advantage they could obtain by using hybrids with fertilizer instead of local open-pollinated varieties. SR52's yield was estimated to be 46 percent greater than the improved open-pollinated variety Southern Cross in Zimbabwe (Eicher 1994, 11).

Second, the expansion of parastatal marketing outlets and credit programs made it easier for small farmers to obtain purchased inputs and market surplus maize. The institution of pan-seasonal pricing policies also motivated farmers to market it at local depots immediately after harvest. There was no seasonal price adjustment, and thus little incentive for farmers to store commercial maize on the farm. While most small farmers adopting improved maize continued to grow flintier local varieties for personal consumption, they did not have to worry about the increased vulnerability of denty hybrids to insect attack in storage; these worries were transferred to the cooperatives and Namboard.[10]

---

[10] Zambia's extensive marketing outlet network, combined with the pan-seasonal pricing policy, may be an important factor explaining the much higher hybrid maize adoption rate in Zambia compared to Malawi. Malawians have a distinct preference for the taste and storage characteristics of flinty local varieties over the denty hybrids (Smale et al. 1991). Zambians also say they prefer the taste of porridge made from locals. They continue to produce local maize for their own use, but do not have to store denty commercial varieties because of the marketing structure.

exp

on i

imp

and

Zan

Pro

Swe

from

repr

reve

Zam

hybr

varie

---

indus
mult
comp
July
exist

maize
from
pollin
allow
time i
desira
origin

Third, Ristanovic, through his graduate education in the U.S. and work experience as a senior breeder in the Yugoslav Maize Research Institute, was focused on improvement of hybrid maize, convinced that the real opportunities for yield improvement lay in hybrids, not open-pollinated varieties, even for small farmers.

Fourth, at the beginning of the 1980s SIDA was starting to fund maize research, and simultaneously helping to establish a seed industry.[11] A semi-commercial company, Zambia Seed Company (Zamseed), was organized in 1981 with GRZ, Zambia Seed Producers' Association (ZSPA), Zambia Cooperative Federation (ZCF), Svalöf (a Swedish seed company) and Swede Fund as the major shareholders. It was obvious from the start that maize seed would be the most important product. Maize seed represented 70-90 percent of the total volume of Zamseed's sales, and 60 percent of revenue in the late 1980s (SIDA 1988, 63). To ensure the new company's viability, Zamseed and its technical advisers at Svalöf in Sweden pushed for the development of hybrids, for which new seed would be purchased each year, rather than open-pollinated varieties whose seed could be saved and replanted.[12]

---

[11] The coincidence of improved hybrid development with the establishment of a seed industry also distinguishes Zambia from Malawi. In Malawi, elementary seed multiplication was carried out by the extension service until recently when private seed companies such as Cargill entered the market (Waddington, personal communication, July 1991). Before this, the capacity to produce hybrids on a commercial basis did not exist.

[12] Berlan and Lewontin (1983), among others, argue that the yield advantage of maize hybrids today stems not from any innate superiority over open-pollinateds, but from the U.S. Department of Agriculture's massive redirection of resources from open-pollinated to hybrid research beginning in the 1920s. Hybrids were chosen because they allowed seed producers to capture greater benefits from their products: "...it is the first time in agricultural history that a seedsman is enabled to gain the full benefit from a desirable origination of his own or something that he has purchased. The man who originates devices to open our boxes of shoe polish or autograph our camera negatives,

SIDA was receiving mixed signals about the suitability of hybrids vs. open-pollinated varieties for small farmers, and in turn its program guidance to the maize breeding team was confusing. While Zamseed and Svalöf advisers pushed for hybrid development, another recipient of SIDA funds, the Adaptive Research Planning Teams (ARPT), argued that hybrids were unsuitable for small-scale farmers. Small farmers were used to replanting seed, and, with single-cross hybrids such as SR52 replanting second-generation seed will result in a large yield reduction. Moreover, ARPT argued, even if farmers had the power to purchase hybrid seed yearly, it is not available in all areas. SIDA used the ARPT arguments against hybrids to press the maize breeding team, initially, for development of open-pollinated varieties (McPhillips, personal communication, October 28, 1992).

Nevertheless, Ristanovic persisted with his work on hybrid development. He later recounted that the SIDA Agricultural Sector Support Program (ASSP) evaluation mission of 1982, disappointed to find Ristanovic working on inbred line development, had advised him to stop hybridization, collaborate with the international centers and concentrate on population improvement. The next year, Ristanovic deceived a follow-up mission into thinking that a test plot for hybrid maize development was part of the population improvement program (Ristanovic, personal communication, 1992). The debate over hybrid or open-pollinated ended in mid-1982, when funding from the new USAID Zambia Agricultural Development, Research and Extension Project (ZAMARE)

---

is able to patent his products and gain the full reward for his inventiveness...the utilization of first generation hybrids enables the originator to keep the parental types and give out only the crossed seeds, which are less valuable for continued propagation (East and Jones 1919, 224, cited in Berlan and Lewontin 1983, text notes 4,7)."

brought another expatriate maize breeder to the program, P. Gibson, enabling the initiation of a hybrid **and** open-pollinated approach.

3.7. Swedish aid to maize research and the seed industry

3.7.1. Development of shorter-season maize hybrids

SIDA began funding maize breeding activities in 1980 as part of its ASSP Program for Zambia. ASSP had four objectives: (1) improvement of agricultural research being carried out by the Ministry of Agriculture, Food and Fisheries (MAFF); (2) formation of a commercial seed company organized as a joint venture between the government and private entities; (3) establishment of the Seed Control and Certification Institute (SCCI); and (4) provision of training for research, extension, and the seed industry (Erikson et al. 1989: ii).

The commodity research program initially focused on the development of improved maize varieties, later expanding to pasture species, vegetables, sorghum, millets, and root and tuber crops. Assistance to the maize research program included taking over the payment of Ristanovic's salary and operational support. Beyond the purification of Zambian SR52, Ristanovic and his counterparts sought to develop new hybrids that were earlier maturing, drought tolerant and more disease resistant than SR52 (Erikson et al. 1989: iv).

As a result, seven shorter-season hybrids were developed and released between 1984-88 (Table 4). Breeders have continued to make advances; an extremely short-season hybrid, MM414, was released in late 1992. The characteristics of the new hybrids addressed several issues of the open-pollinated vs. hybrid debate. First, the new varieties had shorter seasons than SR52 or MM752 by as much as 35 days. Small

Tabl

T re
M 19
M 19
M 19
M 19
MM 19
MM 19
MM 19
MM 19
MM 19

Sourc

Table 4: Characteristics of Zambian maize hybrids and varieties

Type and year released	Days to maturity	Yield in tons/ha[a]	Target area	Characteristics
MM501 1984	130-135	6.0	Regions I,II	Single cross, white semi-dent; drought tolerant; mod. resistant maize streak virus (MSV), rust, blight, cob rot
MM502 1984	140-145	7.5	Regions II, III	Single cross, white semi-dent; multiple cobs; high resistance MSV; mod. res. blight, cob rot
MM504 1984	135-140	6.5	Region I	Three-way cross, white dent; drought tolerance; good resistance lodging; mod.res. MSV, rust, blight, cob rot
MM601 1984	140-145	7.5	Regions, II, III	Single cross, white semi-dent; mod.drought tolerance; resistance blight, rust, MSV, cob rot
MM603/604 1984	145-150	7.0	Regions II, III	Three-way cross, white dent; multiple cobs; high resistance MSV, resistance blight, rust, cob rot
MM752 1984	160-165	8.0	Regions II, III	Single cross, white dent; susceptible lodging, MSV; mod.resistant rust, blight
MM612 1988	155-160	7.0	Regions II, III	Double cross, white dent; resistant MSV
MMV600 1984	150-160	4.0-5.0	Regions I, II, III	Open-pollinated,white flint; resistant lodging, rust, blight, MSV
MMV400 1984	120-125	2.5-3.5	Region I	Open-pollinated, white flint; resistant blight

Sources: Zamseed Maize Production Guide; Ministry of Agriculture, Food and Fisheries Guide to Commercial Crop Production; D. Ristanovic, personal communication, 1992

[a] Research station yields under medium levels of management.

far
and
mai
eve
Thi
thre
seco
whe
MM

thre
high
that
mar
smal

By 1
were
had

3.7.2

fundi
of th

farmers could plant them later, after the start of the rains, or after sowing other crops, and still get good yields. Second, in all but the most adverse environments, hybrid maize outyielded open-pollinated locals and (later) improved open-pollinated varieties even when no fertilizer was used (Gibson, personal communication, October 1993). Third, unlike the single crosses SR52 and MM752, several new hybrids were double or three-way crosses, which meant that their yields were more stable if farmers planted second generations (although this was never recommended). The average yield loss when SR52 was replanted was about 33-43 percent, but for advanced generations of MM603/604 it was only 15-20 percent (Norrby 1986; Gibson and Ristanovic 1985, 2).

Finally, on the question of affordability of hybrid seed, the seed yield from three-way crosses was as much as three times higher than from single crosses. The higher the seed yield, the lower the cost of producing maize seed. These were savings that could be passed along to the farmer as cheaper seed. Zamseed also began to market seed in 10 kg packets instead of just 50 kg bags, making seed more accessible to small farmers (SIDA 1990, 50).

SIDA also funded graduate training for professional staff of the maize program. By 1990, two maize breeders had completed Ph.Ds, two breeders and two agronomists were studying abroad for master's degrees, and one pathologist and one entomologist had begun Ph.D. studies (SIDA 1990, 50).

3.7.2. Assistance to the seed industry

Concurrent with its support for maize breeding, SIDA provided extensive funding and technical assistance to the Zambian seed industry. The general objectives of the seed company were to organize the multiplication of seed varieties developed by

the
far
sor
pro
Co

in
cha
'er
ma
fol
MS
wi
sin
pro
No

197
rese
indi
and
2).

the Research Branch and to carry out their processing, storage and distribution to farmers. Zamseed produces and distributes a variety of seeds, including potatoes, sorghum, vegetables, pasture, wheat, soybeans, sunflower, and maize. SIDA also provided major funding, technical assistance and training to strengthen MAFF's Seed Control and Certification Institute (SCCI) (Erikson et al. 1989).

Ristanovic developed a close working relationship with Zamseed professionals, in part because funding for the hybrid maize program's operating expenses was channeled through the seed company. Ristanovic later described himself as an "entrepreneur" in his dealings with Zamseed, selling and shaping a product for a market. One result was the rapid availability of the new hybrids through Zamseed following their release from the breeding program. Another was a heavy emphasis on MM603/604, a triple cross hybrid for which seed could be produced cheaply, and widely adaptable across Zambia's agroecological regions. Several other releases were single or double crosses of one or more of the parents of the MM603/604, making seed production simpler and more economical (Ristanovic, personal communication, November 9, 1992).

Total SIDA expenditures on agricultural research and the seed industry between 1979-91 are estimated at USD 30.1 million. Of this, expenditures related to maize research are estimated at USD 6.9 million, and maize-related expenditures for the seed industry at USD 9.8 million. Details of maize research and seed expenditures by SIDA, and maize research expenditures by GRZ, are presented in Tables 34 and 36 (Appendix 2).

3.

(Z

US

ma

ass

bre

a r

AR

of

pro

Risi

bree

saw

and

app

Mar

U.S

Ban

Gur

41.

3.8. USAID support for maize research

The Zambia Agricultural Development, Research and Extension Project (ZAMARE), funded by USAID, was carried out between 1982-88 at a total cost to USAID of USD 12.5 million, of which an estimated USD 3.1 million was spent on maize-related research (Table 35, Appendix 2). ZAMARE provided long-term technical assistance to three Commodity and Specialist Research Teams (CSRT): a maize breeder, a sunflower agronomist and a soybean breeder. An agronomist, economist and a research-extension liaison officer were also provided to help establish Zambia's first ARPT, in Central Province. In addition, the project funded degree training for a total of 49 Zambian students, 28 from Research Branch, and 21 from Extension, and provided short-term training for 85 students (University of Illinois undated, 12).

SIDA-funded researchers and the ZAMARE maize team informally agreed that Ristanovic would continue to concentrate on hybrid breeding, while the principal maize breeder assigned to ZAMARE, Dr. Gibson, focused on open-pollinated maize. Gibson saw a place for both hybrids and open-pollinated varieties in Zambian farming systems, and acted as an intermediary between "camps" of those who felt hybrids were not appropriate for small farmers and Ristanovic's team (Gibson, personal communication, March 12, 1993).

The populations in the maize improvement program came originally from the U.S., Latin America and Southern Africa via CIMMYT, IITA and the Yugoslav Gene Bank. Gibson and his Zambian colleagues, C. Mwambula, C. Mungoma and M. Gumbo, released two open-pollinated varieties in 1984, MMV400 and MMV600 (Table 4). MMV400 was derived by merging selections of several CIMMYT varieties, incl

drou

more

EV

regi

impr

reco

deliv

hybr

perce

resul

seed

comr

throu

late b

motiv

fertili

delive

took r

coope

with i

including Pirsabak 7930 and Poza Rica 7930, and was developed as a fast-maturing, drought-tolerant variety suitable for low-rainfall areas. MMV400's flinty kernel made it more resistant to weevil infestation in storage. MMV600, a reselection of Tanzanian EV 8076, is a medium long maturing, streak virus-resistant variety suited for all regions, particularly Regions II and III (Gibson 1986).

Since the yields of the new post-MM752 hybrids were better than locals or the improved open-pollinated varieties under most conditions, even with no fertilization, in recommending hybrids to small farmers a critical question was the reliability of the seed delivery system. If seed delivery is late, forcing farmers to plant late, or plant retained hybrid seed, they may be better off with open-pollinateds rather than hybrids. The 1-2 percent yield loss each day that planting is delayed beyond the establishment of the rains results in a 30-50 percent loss after one month. There were many complaints about late seed delivery in the mid-1980s (Gibson and Ristanovic 1985, 2; Gibson, personal communication, March 12, 1993). These lessened when Zamseed began to market seed through retail shops as well as cooperatives, but many farmers were still forced to plant late because of delays in delivery of credit or fertilizer (Kerven et al. 1988).

Although a possible niche existed in the commercial market, it was difficult to motivate farmers to use open-pollinated varieties after they had tried hybrids with fertilizer and realized impressive yield gains. As long as the expectation of input delivery was there, because of the presence of the local cooperative depots, farmers took the chance, either consciously or because their credit packages tied them to cooperative-delivered input packages. The real, and unanticipated, success associated with improved open-pollinateds to date has been MMV400's growing popularity as an early f

(Miti.

pollina

on-stat

breeder

the pro

pollina

were te

missior

variety

(Gibsor

had inte

1986, fa

Howeve

Party fo

eventual

focused

Gradual

evaporat

Z

breeders

early food source (green maize) during the hungry period between January and April (Miti, personal communication, February 21, 1992).

Gibson himself estimates that he spent only 20 percent of his time in open-pollinated maize breeding. Perhaps more important was his role as facilitator between on-station maize breeders working on hybrid and open-pollinated varieties, and between breeders, ARPTs and large-scale commercial farmers. He established close links with the provincial ARPTs and oversaw ARPT testing of the new hybrids as well as open-pollinated varieties, and in promotion of the hybrids among commercial farmers. They were tested at over 60 sites countrywide between 1984-86, including commercial and mission farms. Gibson and his counterparts also developed a commercial farm maize variety demonstration plot and reactivated national variety trials throughout Zambia (Gibson, personal communication, March 12, 1993).

Dr. Oval Meyers replaced Gibson as ZAMARE maize breeder in 1986. Meyers had interacted frequently with Gibson during his tenure and overlapped with him in 1986, facilitating a smooth transition and continuation of the work Gibson had initiated. However, only a few months after assuming the post, Meyers was appointed Chief of Party for the ZAMARE project. Another American scientist, W. Harada, was eventually named to fill the vacant position, but he had less interest in breeding and focused more on upgrading the microcomputer facilities and skills of fellow scientists. Gradually, much of the hybrid-open-pollinated and breeder-ARPT cooperation evaporated.

ZAMARE provided masters-level training for three of the principal Zambian breeders, besides short courses and in-country training for other staff conducted with

C

th

de

be

US

(U

Za

fun

ZA

ma

coo

3.9.

with

was

assis

who

biolo

virus

also

Coop

CIMMYT, and on-site training by Gibson and his successors. Meyers and Harada, with their counterparts, worked extensively in population improvement, toward the development of additional open-pollinated releases, but no further releases were made before the project ended. Although the project received a positive evaluation from USAID, an anticipated Phase II of the project was unexpectedly cancelled in 1988 (USAID 1988).

Some linkages continued between the ZAMARE technical assistance staff and Zambian staff from 1988-90 under the program Zamlink, which provided limited funding for in-country workshops and exchange visits (USAID 1988,1991). After ZAMARE ended, the open-pollinated maize breeding work was assumed by a FAO-managed project, but discontinuities in breeders and methodologies, combined with coordination problems with the hybrid group, hampered its progress.

3.9. Food and Agriculture Organization (FAO)

FAO began providing technical assistance to the maize research program in 1978 with funding from the Norwegian Trust Fund and UNDP. The initial focus of the work was plant protection. In Phase I, "Control of Maize Diseases," FAO provided technical assistance, including several agronomists and a long-term plant pathologist, K.N. Rao, who also assisted the sorghum pathology program. They studied the epidemiology and biology of causal agents for two important maize problems, cob rots and maize streak virus, and developed screening methods to identify resistant germplasm. The project also provided long and short-term training for Zambian counterparts (FAO/Government Cooperative Program 1990).

a

th

F

fu

wl

ma

the

SID

rele

com

fund

prote

Vidak

justifi

pollina

separa

funded

develop

populat

Phase II, "Development of Pest and Disease Resistant Maize," began in 1983 and continued through 1988, after which maize research activities were continued through the FAO-administered UNDP Maize and Bean Research Project until 1992. Funding for the maize program ended in 1992. Total expenditures by these FAO-funded agricultural research projects from 1978-92 are estimated at USD 2.6 million, of which USD 2.1 million were maize-related (Table 37, Appendix 2).

After 1983, the FAO-funded researchers began to get more directly involved in maize breeding. They initially screened germplasm for disease resistance to feed into the hybrid and open-pollinated breeding program being supported cooperatively by SIDA and USAID, and three of the hybrids and one of the two open-pollinated cultivars released in 1984-88 had high resistance to maize streak virus (Table 4).

However, the FAO project eventually evolved into a separate and somewhat competitive open-pollinated and hybrid breeding program, especially after the USAID-funded project ended in 1988 and the FAO program, which had focused on plant protection, expanded its direct breeding activities. A FAO-funded breeder, Dr. Vidakovich, was added to the team in 1988 and continued until 1991. The initial justification for FAO involvement in the breeding program was to continue open-pollinated development following ZAMARE. The later expansion into hybrid work, separate from that conducted by SIDA-funded breeders, came about because FAO-funded breeders felt it was too limiting for them to concentrate on open-pollinated development when they had been trained in the full cycle of maize improvement, from population selection through hybrid development.

FA

FA

enc

dist

in t

him

Per

(Res

desi

Mun

posi

team

agenc

flexib

Zamb

to a n

divisio

Maize scientists and policymakers attribute the friction that developed between FAO-funded scientists and other maize scientists partly to personality conflicts between FAO and the other breeders, but also to the structure of agency incentives that encouraged field scientists to create separate programs whose contributions could be distinguished from those of other organizations. Similar coordination problems erupted in the sunflower program between ZAMARE and FAO scientists.

In the maize program, the FAO team leader battled to oust Ristanovic and have himself named maize coordinator. The resulting acrimony eventually reached the Permanent Secretary, who requested that the Assistant Director of Agriculture (Research) step in instead as maize coordinator. In effect, this meant that there was no designated Team Leader for maize from the mid-80s until 1991, when Dr. C. Mungoma, recently returned from Ph.D. studies in the U.S., was named to fill the position. Neither the Research Director nor the CARO intervened directly in maize team management.

There were complaints, too, about the high salary supplements paid by external agencies to local maize scientists. One administrator noted how this practice limited the flexibility of the Research Branch to reassign its staff members, recalling how one Zambian scientist working in the FAO program refused to be transferred out of the team to a new position where the administration felt the scientist would be more useful.

SIDA evaluation missions in the late 1980s grew increasingly worried about the divisions in the maize program:

> The Mission noted with concern that the involvement of UNDP/FAO in the maize breeding program had not been coordinated with ASSP support. The Mission asked MAWD to make up a work plan for the national maize breeding

16. an

about 7

pre-rele

I

pollinate

the hybr

example

came in

another a

redoing s

The chan

set the op

communi

Vidakovic

of Zambia

> program, which should clearly indicate areas of responsibilities of the two donors (SIDA 1987, 75).
>
> The Mission noted with concern that the coordination with the FAO/UNDP maize breeding programme is very limited and needs to be considerably improved in order to avoid costly duplication (SIDA 1988, 63).
>
> The extent of professional jealousy between the proponents of the two approaches (hybrid vs. open-pollinated varieties) is now considerable. Firm policy guidance is needed from the Research Branch to ensure that the programmes complement each other and that scarce technical expertise and resources are used to joint effect rather than adopting conflicting approaches (Erikson et al. 1989, 35).

No new open-pollinated varieties have been released since 1984, although Pool 16, an extremely short-season, streak-resistant variety that can produce green maize in about 70 days, has been promising and extremely popular with Region I farmers in its pre-release stage (Miti, personal communication, February 21, 1992).

Lack of continuity in breeders working on population improvement and open-pollinated varieties is one reason behind the slow progress, and contrasts sharply with the hybrid program, which has had the same senior maize breeder since 1981. For example, Gibson and Meyers used a half-sib breeding technique. When Vidakovich came in 1988, after an extended break in the open-pollinated program, he began using another approach, full sib, as respectable as the former but involving backtracking and redoing some selection work in populations already advanced by Gibson and Meyers. The change of breeders with no overlap, and subsequent switch in technique, may have set the open-pollinated program back by one to two years (Gibson, personal communication, March 12, 1993; Mwale, personal communication, October 30, 1992). Vidakovich's departure in 1991 left the open-pollinated program completely in the hands of Zambian scientists, some with master's training but none with doctorates.

fric

prog

hyb

imp

the

thr

coo

abo

The discontinuities caused by ZAMARE's premature end and the ensuing frictions between the hybrid and open-pollinated programs probably also retarded the progress of hybrid development. Under normal circumstances open-pollinated and hybrid programs share the initial stages of germplasm collection and population improvement (Appendix 1). Identification of open-pollinated varieties comes through the process of population improvement. Promising inbred lines are also identified through population improvement for further development and eventual crossing. When coordination between the two programs is hampered, the resource base of information about germplasm and population characteristics available to both shrinks.

MA

4.1.

4.1.1.

relatec

of the

a surv

farmer

region

4.1.2.

Agricu

Bureau

include

of Agri

for sma

about fa

provinc

CHAPTER FOUR

MAIZE TECHNOLOGY ADOPTION: DETERMINANTS, SPEED, AND SCOPE

4.1. MSU/MAFF/RDSB maize adoption survey sample and questionnaire

4.1.1. Introduction

The rate and extent of adoption are critical impact indicators for technology-related investments, and pivotal to the rate of return analysis. To find the adoption rate of the improved maize varieties, and key factors influencing farmer adoption decisions, a survey of 462 small- (less than five hectares) and medium-scale (5-20 hectares) farmers located in the principal maize-growing areas of Zambia's three agroecological regions was carried out between April and July 1992.

4.1.2. Sample selection

The sample of farmers interviewed in the Michigan State University/Ministry of Agriculture, Food and Fisheries/University of Zambia Rural Development Studies Bureau (MSU/MAFF/RDSB) Maize Adoption Survey was a subset of households included in the Central Statistical Office (CSO) sampling frame for the 1991-92 Census of Agriculture. The CSO sampling frame is the only national sampling frame available for small- and medium-scale agricultural households. It is used to collect information about farm characteristics and production for seven major crops at the national, provincial and district levels.

4.

po

(C

lar

En

10

CS

pro

inf

use

of

pro

The

sam

4.1.

rese

the f

Prov

Cent

South

4.1.2.1. Census of Agriculture sampling frame

The Census of Agriculture sampling frame was derived from the national population census of 1990. For the population census, the country is divided into CSAs (Census Supervisory Areas) whose major boundaries are defined by geographical landmarks such as rivers and power lines. CSAs are subdivided into Standard Enumeration Areas (SEAs), also delineated by geographical boundaries, composed of 100-120 households, estimated to be a manageable workload for one enumerator. Each CSA has approximately five SEAs. CSAs can be aggregated to both district and provincial levels.

During the 1990 Population Census, an extra questionnaire was attached to get information from each household on its agricultural activities. This information was used to stratify SEAs into seven crop zones. Sample SEAs (or clusters) for the Census of Agriculture were selected using a stratified two-stage process with probability proportional to size. Each year a listing of households is conducted in all sample SEAs. The last sampling stage is the selection of households by farm size stratum within each sample SEA.

4.1.2.2. MSU/MAFF/RDSB Maize Adoption Survey sample

Because of resource constraints that made a full-country sample unfeasible, the research team limited sample selection to the three top maize-producing districts within the four major maize-producing provinces of Zambia, according to CSO data. Provinces and districts selected were:

Central Province: Kabwe Rural, Mkushi and Mumbwa Districts

Southern Province: Choma, Kalomo, Mazabuka Districts

Eastern F

Northern

T

between a

different

neither of

Agricultu

superimpo

provinces

aggregatio

staff also

and towns

Sa

"close" SE

chosen sys

SEA, seve

were few r

selected, a

using this r

four SEAs

dropped fro

in Table 5;

Eastern Province: Chipata, Lundazi, Petauke Districts

Northern Province: Isoka, Mbala, Mpika Districts

The objectives of the Maize Adoption Survey included cross-comparisons between agroecological regions, areas considered remote/close to service centers, and different size categories of farmers. Information on farm size was readily available, but neither of the other characteristics was used to construct the original Census of Agriculture sample. Working with CSO staff, agroecological boundaries were superimposed on a national map of all CSAs and SEAs, and SEAs in the chosen provinces/districts were stratified accordingly. CSO staff derived weights to permit aggregation of survey results by agroecological region. The research team and CSO staff also stratified SEAs as "remote" or "close" according to distance from major roads and towns and the CSO staff's general knowledge of the areas from field visits.

Sample selection was two-stage. In the first stage, one "remote" and one "close" SEA from each agroecological region represented within a selected district was chosen systematically. At the second stage, 14 households were chosen from each SEA, seven small-scale (0-4.99 ha) and seven medium-scale (5-19.99 ha). Since there were few medium-scale households in a given SEA, all medium-scale households were selected, and small-scale households were selected systematically. The sample drawn using this method underrepresented Regions I and III. As a correction, an additional four SEAs in Regions I and III were systematically selected, and two SEAs were dropped from Region II. The distribution of sample households between strata is shown in Table 5; sample sites are shown in Figure 5.

CSO provided detailed site maps to help the team locate sample SEAs. In the field, district agricultural officers and extension agents frequently accompanied the team

Table 5: Distribution of sample households, MSU/MAFF/RDSB survey

	Small/ close	Medium/ close	Small/ remote	Medium/ remote	Total
	number of households[a]				
Region I	45	9	55	0	109
Region II	102	38	62	18	220
Region III	42	11	46	5	104
Total	189	58	163	23	433

[a] valid responses

to make introductions to the village headmen and aid in finding sample households.

Enumerators visiting SEAs made every effort to locate and interview the individuals designated in the sample selection process. This was not always possible, as each SEA was visited only once for one-two days and the selected individuals were not always available. A neighbor of the absent person was usually substituted.[1] During the field work, some persons listed as "medium-scale" farmers by CSO actually reported landholdings that put them in the "small-scale" category, resulting in fewer actual medium-scale respondents than anticipated.

[1] Between 20-30 percent of the original sample was substituted. Substituting neighbors who were present in the village for absentees could have biased the sample, i.e., towards families with more available labor or other resources (so that more time could be spent away from the field) or less dedicated farmers. However, at the time the survey was carried out the 1991-92 drought was already taking a toll on crops and field work was curtailed in Regions I and II. In Region III, the maize harvest was largely complete before the survey was carried out.

Fi

4.

cor

car

rely

in th

proj

comp

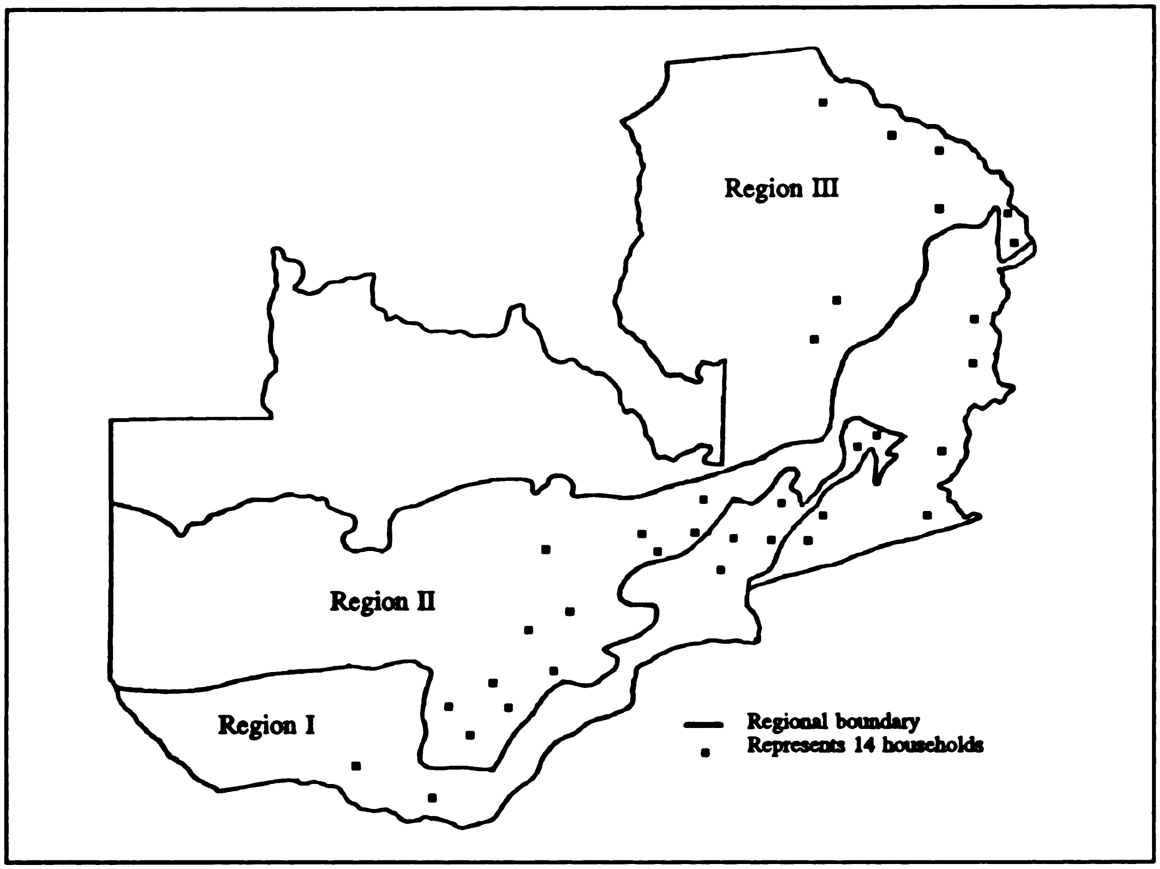


Figure 5: Sample sites, MSU/MAFF/RDSB Maize Adoption Survey

4.1.3. Questionnaire design and interviewing

The questionnaire used in the survey appears as Appendix 3. Because of the complexity of the questionnaire, a small group of enumerators was intensively trained to carry out all interviews with close supervision from the senior researchers, instead of relying on CSO enumerators resident in each province. Four enumerators, each fluent in three or more local languages and most with prior survey experience, joined the project in March 1992. After one month of training, field work began in April and was completed in early July 1992.

in w

rec

ma

imp

for

not

mea

fam

eac

add

of e

twel

fiel

bloc

bea

prop

estin

4.1.4

as fa

ques

Farmers were asked if they had ever used improved maize varieties, and, if so, in what season they began planting them. Improved maize users were then asked to recall their cropping patterns, beginning the season before they began using improved maize. For some farmers, the recall period was extremely long, up to eight years. To improve the quality of data, enumerators developed a list of significant historical events for each province and district to use as memory aids during the interviews.

Accurate information about farm size and allocation of area to different crops is notoriously difficult to extract from oral interviews, but resources did not allow measurement of individual farm fields. Enumerators probed carefully to find the most familiar unit of measurement for each farmer. Farmers estimated the current size of each field in that unit, and reviewed the history of each field, noting in what years additional areas were cleared or lost. This information allowed calculation of the size of each field for each year. Each enumerator carried a wooden model divided into twelve blocks. Farmers were asked to imagine that the model represented, for example, field A in 1991, and asked to allocate the field to different crops using the blocks. Four blocks might have been planted to MM603, four blocks to local maize, two blocks to bean/pumpkin/local maize intercrop and two blocks not cleared. Later, these proportions were combined with the information on field size in a given season to estimate the area planted to specific crops.

4.1.4. Large farm mail survey

No existing sample frame was available for large-scale maize growers, defined as farmers usually growing 15 or more hectares of maize each season. Instead, a questionnaire was mailed to all of the large maize farmers who could be identified through

(Append

ZNFU a

were rec

4.2. Re

4.2.1. S

T

July 199

farmers

small-sca

men, one

4.2.1.1.

A

almost ha

had plant

smallhold

farmers h

[2] As w
survey (20
i.e. perso
with more
are overre

[3] "Zam
3): MM50
MMV600 a

through the membership roster of the Zambia National Farmers' Union (ZNFU) (Appendix 4). In addition, blank questionnaires were sent to the chairperson of every ZNFU affiliate to be forwarded to large maize growers in that area. Sixty responses were received.[2]

4.2. Results

4.2.1. Socioeconomic characteristics

The MSU/MAFF/RDSB survey team interviewed 462 farmers between April-July 1992. After data cleaning, 433 responses were considered valid. Of these, 109 farmers were from Region I, 220 from Region II, and 104 from Region III; 352 were small-scale, and 81 were medium-scale farmers. Two-thirds of survey respondents were men, one-third women.

4.2.1.1. Improved maize use

All of the respondents had grown local or improved maize at some time, and almost half the small farmers, and 90 percent of the medium-scale farmers, said they had planted a Zambian improved maize variety[3] in at least one season. For smallholders, there were significant differences by region: less than a third of Region I farmers had tried an improved variety, while over half in Regions II and III had. Most

---

[2] As with most mail surveys, there was a low response rate to the large farmer survey (20 percent). The most important consequence is a possible non-response bias, i.e. persons who are most interested in a topic or who hold particular views, or those with more leisure time, are most motivated to return the questionnaire; thus their views are overrepresented in the sample (Alreck and Settle 1985, 45).

[3] "Zambian improved varieties" refers to the varieties described in Table 4 (Chapter 3): MM501, MM502, MM504, MM601, MM603, MM604, MM752, MM612, MMV600 and MMV400.

farmers who tried improved maize continued to use it in successive seasons; improved maize users had planted it for four seasons on average (Table 6).

Small farmers living close to service areas and main roads were more likely to adopt improved maize than those in more remote areas, but there was no significant difference for medium farmers, possibly because they have better access to or even their own means of transportation (Table 6).

4.2.1.2. Farm area

Mean and median small farm sizes were 1.75 and 1.5 hectares. Small farm areas differed by region, with larger farms in Region II, and improved maize users had larger farms than non-adopters. Small farmers had 1.7 fields on average; holdings were more fragmented in Regions III and II than Region I. Improved maize adopters tended to have more fields than non-adopters. For medium-scale farmers, mean and median farm areas were 9.6 and 9.5 hectares, and improved maize adopters again had larger farms than non-adopters (Table 6).

Mean small farm size reported in this study, 1.75 ha, is very close to the official MAFF estimate of 1.8 ha,[4] but MSU/MAFF/RDSB medium farm area estimates are larger, 9.6 ha compared to 5.3 ha (Table 6; GRZ 1991a). Medium farms had an average of 2.3 fields each; this did not vary much across regions, or between adopters and non-adopters.

---

[4] The MAFF "traditional" farmer category corresponds to "small-scale" in the MSU/MAFF/RDSB study; MAFF's "smallholder emergent" category is the same as "medium-scale" in this study.

Table 6: Characteristics of small- and medium-scale farmers

	Reg. I	Reg. II	Reg. III	Total	Adopter	Non-adopter	Close	Remote
SMALL								
Number of respondents	100	164	88	352	160	186	188	163
Have grown improved maize at least one season (percent)[a]	27.3***	54.3***	54.5***	46.7			52.1*	40.5*
Mean farm size (ha)	1.66*	1.94*	1.48*	1.75	2.13***	1.42***		
Median farm size (ha)	1.23	1.62	1.22	1.5				
Avg. no. of fields	1.78**	1.57**	1.97**	1.73	1.88**	1.59**	1.68	1.79
Mean no. of persons in household[a,b]	6.41**	7.49**	6.03**	6.82	7.61**	6.16**		
Mean no. under age 15[a,b]	3.00	3.40	3.30	3.26	3.61*	2.98*		
Mean grade in school completed (respondent)	4.21**	4.66**	5.83**	4.82	5.91***	3.90***		
MEDIUM								
Number of respondents	9	56	16	81	73	8	58	23
Have grown improved maize at least one season (percent)	88.9	94.6	75.0	100			93.1	82.6
Mean farm size (ha)	8.60	10.21	8.49	9.69	10.0*	6.70*		
Median farm size (ha)	6.48	10.0	9.45	9.50				
Avg. no. of fields	2.67	2.02	2.88	2.26	2.29	2.0	2.17	2.48
Mean no. of persons in household[a]	8.89**	11.07**	7.5**	10.12	10.64**	5.38**		
Mean no. under age 15[a]	4.88	5.50	4.64	5.28	5.45*	2.8*		
Mean grade in school completed (farmer)	5.22	5.8	5.5	5.68	5.96*	3.13*		

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992
[a] Differences between small and medium farmers were significant at $p < .001$
[b] Defined as eating from the same pot daily
* $p < .05$; ** $p < .01$; *** $p < .001$

4.2.1.3. Household size

The mean number of persons living in small farm households was 6.8. There were three persons under age 15 on average, leaving 3-4 adults available for farm labor, and fewer in Region III (2.7). Medium-scale households were larger, 10.1 persons, with half under age 15. Households were larger in Region II than other areas. These household sizes were slightly larger than reported in some studies, but smaller than others. Rural surveys carried out in the mid-1980s by IRDP in Northern Province estimated average household size as 5.2 persons, but Mwila's study of Northern and Central Provinces found eight persons per household (Table 6; Mwila 1987; Noragric 1989, 47).

Mean small farm size reported in this study, 1.75 ha, is very close to the official For both small and medium-scale categories, household size was significantly higher for improved maize users. This finding supports earlier studies by Marter (1978) and Mwila (1987) linking surplus-producing farms in Western, Northern and Central Provinces to larger than average household size, important because most farms depend almost exclusively on family labor (Table 6).

4.2.1.4. Education

Small farmers had completed almost five years of school on average, medium farmers 5.7 years. Education was the only variable in Table 6 for which there was no significant difference between small and medium categories. Region III farmers had more formal schooling than farmers elsewhere, and small and medium improved maize users had 2-3 more years of education than non-adopters (Table 6).

4.2.1.

farme

third

quarte

small

prepar

betwee

almost

use of

Region

farmer

adopter

three-q

finding

virtually

28-73 p

(1991).

A

oxen, tra

oxen, in

hoes for

4.2.1.5. Cultivation method

Means of land preparation differed dramatically between small and medium-scale farmers. More than 60 percent of small farmers said they used only hand hoes, and a third used oxen only or a combination of oxen and hand hoes. In contrast, less than a quarter of medium-scale farmers used only hand hoes. In terms of land area, half of small farmer land is prepared by hand, while over 80 percent of medium area is prepared with oxen or a combination of oxen and hand hoes (Table 7).

Among small farmers, land preparation techniques differed by region and between users and non-users of new maize varieties. Region III small farmers relied almost exclusively on hand hoes, while small farmers in the other regions made more use of oxen and tractor services. Sixty-two percent and 45 percent of farmers in Regions I and II said they used only hand hoes, compared to 90 percent of Region III farmers. There were significant differences between improved maize users and non-adopters: less than half of the adopters said they used only hand hoes, compared to three-quarters of non-adopters (Table 8). These data are consistent with Mwila's finding that while almost one-third of Central Province (Region II) farmers used oxen, virtually no one in Northern Province (Region III) did (1987). Jha et al. estimated that 28-73 percent of farmers in different areas of Eastern Province (Region II) used oxen (1991).

Almost all Region II medium-scale farmers used only oxen or a combination of oxen, tractors and hand hoes. Eighty percent of Region I medium farmers used only oxen, in contrast to Region III medium farmers, 90 percent of whom used only hand hoes for land preparation (Table 40, Appendix 5).

4.2.2.

season

proport

thirds o

farm ar

varied f

maize, c

about ha

F

season (p

Appendi

may have

non-maiz

farmers a

By 1988,

to less tha

4.2.3. Cl

Co

in 1991-92

farmers. (

[5] "Uni
used by Za

4.2.2. Maize area

Improved maize users were asked to recall their cropping patterns beginning the season before they adopted improved maize through 1992. Smaller farmers devoted proportionally more farm area to maize (improved plus unimproved varieties[5]): two-thirds of the small farms were planted to maize, compared to 56 percent of medium farm area, in 1991. This proportion was consistent across regions for small farms, but varied for medium farms. Medium farms in Region II had the greatest concentration of maize, over 60 percent of farm area, compared to less than 30 percent in Region III and about half in Region I (Table 9).

For 1984 adopters, the proportion of farm area planted to maize in the 1983 season (pre-adoption) was compared with maize area in successive seasons (Table 41, Appendix 5). There were no significant differences. This suggests that while adopters may have substituted improved for unimproved maize varieties, they did not replace non-maize crops with maize, although they may have done so before 1984. Medium farmers adopted improved Zambian maize much earlier than small farmers (Figure 6). By 1988, almost 70 percent of medium farmers had planted improved maize, compared to less than a third of small farmers (Table 42, Appendix 5).

4.2.3. Changes in area and cropping pattern following improved maize adoption

Comparing total cropped area the season before adoption of improved maize and in 1991-92, small farmers expanded their area proportionally more than medium farmers. On average, small farmer cropped area was 15 percent greater in 1991-92

---

[5] "Unimproved varieties" refers to local varieties, SR52, and Zimbabwean hybrids used by Zambian farmers: CG4141, PNR473, R201, R215, ZS 206, and ZS225.

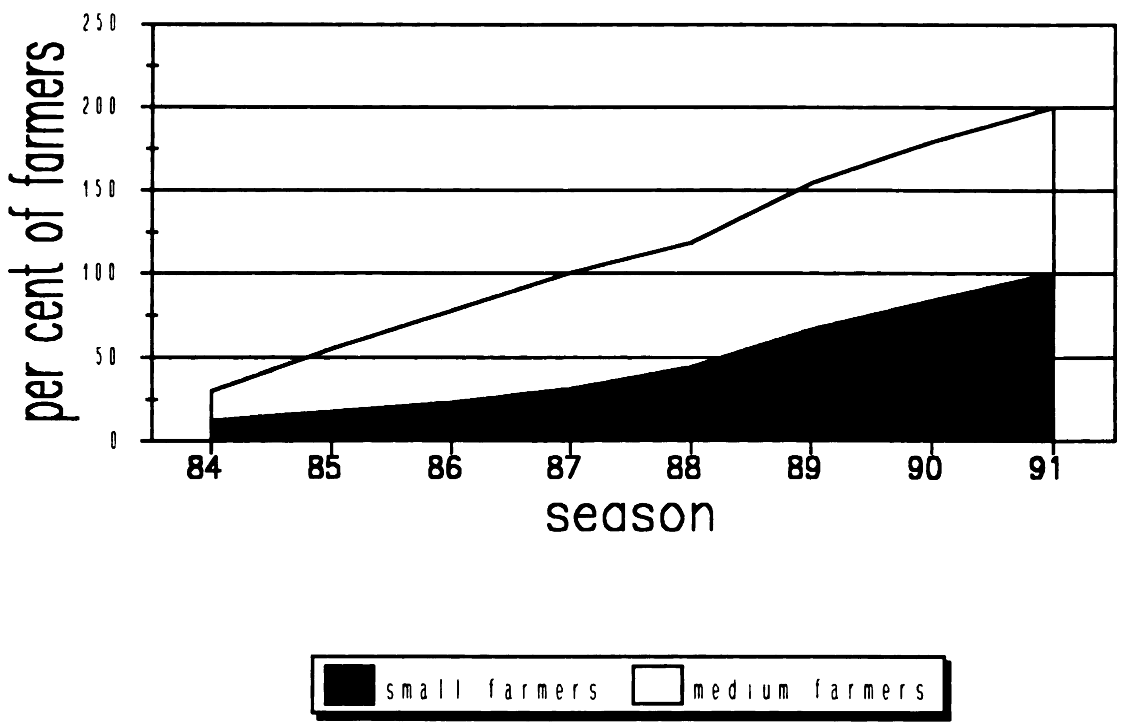


Figure 6: Year of improved maize adoption, cumulative distribution

than the year before adoption, while medium farmer area expanded by only 4 percent (Table 43, Appendix 5).

Comparison of farm cropping patterns before and after improved maize adoption is complicated because sample farmers adopted in different years. Here, information from farmers about their cropping patterns the season before improved maize adoption, regardless of the actual year of adoption, was pooled. This is obviously problematic, since pre-adoption cropping patterns are influenced by factors such as weather that vary between seasons. Testing the statistical significance of changes is not possible, but interesting trends emerge nonetheless. Results of the analysis are presented in Tables 44 and 45, Appendix 5.

Table 7: Means of cultivation, small vs. medium farmers

Method of cultivation[a]	Small	Medium	Small	Medium
	(percent of farmers)		(percent of area)	
Hand hoe only	61.1	22.2	51.3	18.3
Oxen only	26.8	70.4	33.9	73.3
Tractor only, or combination of tractor and oxen or hand hoe	1.7	3.7	2.2	4.6
Hand hoe and oxen	10.4	3.7	12.6	3.8
Total	100.0	100.0	100.0	100.0
n	352	81	347	81

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992
[a] Differences between small and medium farmers are significant at $p < .001$.

Table 8: Small farmer cultivation

Method of cultivation[a]	Region I		Region II		Region III		Imp.mz adopter	Non-adopter
	% farmers	% area	% farmers	% area	% farmers	% area	% farmers	% farmers
Hand hoe only	62.0	50.6	45.3	37.6	89.5	86.7	46.3	74.2
Oxen only	26.0	35.2	39.1	44.3	4.7	6.4	37.5	17.2
Tractor only, or combination tractor/oxen/ hand hoe	4.0	3.5	1.2	2.3	0.0	0.0	1.3	2.2
Hand hoe + ox	8.0	10.7	14.3	15.8	5.8	6.9	15.0	6.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.1	100.1
n	100	100	161	161	86	81	160	186

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992
[a] Regional differences are significant at $p < .001$; differences between improved maize adopters and non-adopters are also significant at $p < .001$.

Table 9: Maize area as a proportion of total farm area, 1991

	Region I	Region II	Region III	All
SMALL				
Maize area/total farm area (percent)[a]	65.2	68.1	66.3	67.1
n	26	83	40	149
MEDIUM				
Maize area/total farm area (percent)[b]	48.7	62.0	28.1	55.8
n	7	53	10	70

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992

[a] Small/medium differences are significant at $p < .01$. Small regional differences are not significant.
[b] Medium regional differences are significant at $p < .001$.

4.2.3.1. Region I

Before adoption of improved maize, the dominant crop on small farms in Region I was local maize, planted on 46.2 percent of total area. Total area planted to maize including local, SR52[6] and Zimbabwean hybrids was 48.4 percent. After maize, sole and intercropped[7] groundnuts were the most important crop (16.5 percent). Nearly 8 percent of farm area was fallowed. Sunflower, rice and sorghum were sown on 6.1, 5.7 and 4.6 percent of the land.

---

[6] Small farmers in all regions reported relatively small areas planted to SR52. Some of the area reported as local may actually be mixed local and SR52, or advanced generations of SR52 reported as local varieties by farmers.

[7] Crop area includes both sole stands and intercrop combinations where the named crop is dominant.

Following improved maize adoption, in 1991-92, total area devoted to maize rose to 65.9 percent. Improved Zambian varieties were planted on 41.3 percent of total area, while local maize declined to 24.6 percent. The area share of sorghum rose to 11.2 percent, but groundnuts declined to 10.1 percent.

Over half of Region I medium-scale farm area was planted to maize before adoption of improved Zambian varieties, half in SR52 and half in local maize. The overall proportion of area planted to maize had not changed by 1991-92, but improved Zambian varieties became predominant, planted on 29 percent of total area, with 13.7 and 8.5 percent planted in Zimbabwean hybrids and local varieties. Other important crops pre-adoption were sunflower (13.1 percent), cotton (10.9 percent), sorghum (7.3 percent) and groundnut (6.9 percent). Sunflower and groundnut proportions did not change very much in 1991-92, but sorghum's importance increased (18.6 percent) and cotton area declined to 1.6 percent.

4.2.3.2. Region II

Beyond the replacement of local by improved Zambian maize, there were few striking cropping pattern changes pre- and post-adoption for either small or medium Region II farmers. Maize share of total area remained constant for small farmers, 64.4 percent pre-adoption and 64.5 percent in 1991-92. Before adoption, local maize was planted on 52.8 percent of total area; afterwards, local maize share declined (11.2 percent) while Zambian improved varieties were planted on 51.9 percent of area. Shares of other important crops before adoption, groundnut (8.8 percent), fallow (7.0

percent), cotton (5.6 percent), and sunflower (5.5 percent), changed little after improved variety adoption.

Similarly, total maize area did not change for Region II medium farmers -- 65.1 percent pre-adoption and 63.4 percent afterwards. Before adoption of Zambian varieties, local maize was planted on 43.3 percent of area, and SR52 on 20.7 percent; afterwards, local declined to 4.4 percent and Zambian improved area was 56.5 percent. Among other crops, the groundnut share (10.0 percent) did not change, sunflower area (9.5 percent) declined to 3.9 percent, cotton (5.9 percent) increased to 9.2 percent, and fallowed area also increased, from 3.9 to 7.5 percent.

4.2.3.3. Region III

Maize area increased from 42.4 percent of total area before adoption to 46.6 percent afterwards for Region III small farmers. Before adoption of Zambian varieties, almost all maize area was planted to locals, 41.2 percent of total area. In 1991-92, 35.6 percent of area was planted to Zambian improved maize varieties, and only 11 percent to local maize. Area allocated to other major crops -- cassava (25.8 percent) and millet (15.0 percent) -- declined to 16.0 and 7.8 percent in 1991-92, while bean area increased from 7.3 to 12.5 percent and fallowed area also increased in 1991-92.

Medium farmer maize area declined, from 38.3 percent of total area before adoption to 26.6 percent in 1991-92. Improved Zambian varieties were planted on 16.6 percent of total area, and local maize on 10 percent. Area allocated to millet rose, from 12.4 percent to 26.8 percent, bean area fell from 28.7 percent to 12.2 percent, and area planted to cassava and fallowed increased.

4.2.3.4. Summary

The results of the cropping pattern analysis clearly show the large extent to which Zambian improved maize replaced local maize in all three regions, although both small and medium farmers continued to allocate from four to 25 percent of area to local maize. The most striking change is the apparent move to a more maize-dominated system by Region I small farmers. Total maize share increased from 48.4 percent to 65.9 percent of total area. While sorghum area increased, proportions of other crops declined, indicating a transition to less diverse farming systems. Small farmer maize area also increased in Region III, from 42.4 to 46.6 percent, but other reports suggest that the initial, more dramatic shifts from cassava-millet-bean systems to maize dominance took place outside the period of this study, in the late 70s and early 80s. During 1976-85, marketed maize production increased by 500 percent in Northern Province (IRDP 1986; Bolt and Holdsworth 1987, 11). Maize area proportions have changed recently in Regions I and III, but have been stable for many years in Region II. A 1957 study of participants in the improved farmer scheme (Region II) found that 62 percent of farm area was planted in maize (Makings 1966, 219-220).

MSU/MAFF/RDSB study findings indicate that when small farmers adopt commercial maize varieties, they continue to cultivate local maize and other subsistence crops on 40 percent or more of their land area. Similarly, a study of Northern Zambia concluded that the attitude of small farmers moving into commercial maize production was "subsistence plus" -- the first objective is to ensure household subsistence needs, with any remaining resources going toward cash crop production, rather than a sweeping substitution of cash for food crops (IRDP 1986, 7). Small farmers produce some cash crops besides commercial maize. Medium-scale farmers also continue to produce subsistence crops alongside commercial maize, but total cash crop production is more diversified and important in total area allocation.

4.2.4. Area and rate of improved maize adoption by small/medium farmers

Survey results suggest that adoption of improved maize varieties by small and medium farmers was rapid and extensive following their introduction. Improved varieties were planted on .8 percent of small/medium maize area in 1984-85, the first year that MM752 was available in limited quantities (Table 10, Figure 7). In the following season, almost a quarter of maize area was planted in improved maize. By 1988-89, Zambian improved varieties were planted on almost half the total small/medium maize area, and the proportion had climbed to almost 60 per cent by 1991-92.

Table 10: Small and medium farmer adoption of improved maize

	83-84	84-85[a]	85-86	86-87	87-88	88-89	89-90	90-91	91-92
	(percent of total small/medium maize area)								
Region I n=111	0	n/a	7.0	18.9	12.4	16.4	25.2	22.4	23.6
Region II n=225	0	n/a	29.0	40.6	49.0	58.8	62.7	69.0	71.9
Region III n=97	0	n/a	19.1	26.6	35.2	27.5	44.0	37.6	38.1
Total n=433	0	.8	23.4	34.6	40.7	47.0	53.0	55.1	58.6

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992, except 1984-85, based on Zamseed sales estimates

[a] Survey results showed much higher rates of adoption than were possible given Zamseed sales of improved seeds that season (see Table 55, Appendix 6). Farmers interviewed may have confused SR52 and MM752, both of which were available in 1984-85. Adoption estimates for 1984-85 were based on Zamseed sales.

Adoption rates differ dramatically between regions (Table 10, Figure 7). In 1991-92, improved maize was planted on almost three-quarters of maize area in Region II, but less than a quarter of Region I maize area was improved, and less than 40 percent of Region III area. Also, while adoption rates in Region II have continued to grow, in Regions I and III adoption peaked in 1989-90 and has since declined. Possible explanations include higher fertilizer prices and increased difficulty in obtaining credit and securing inputs on time beginning in the late 80s.

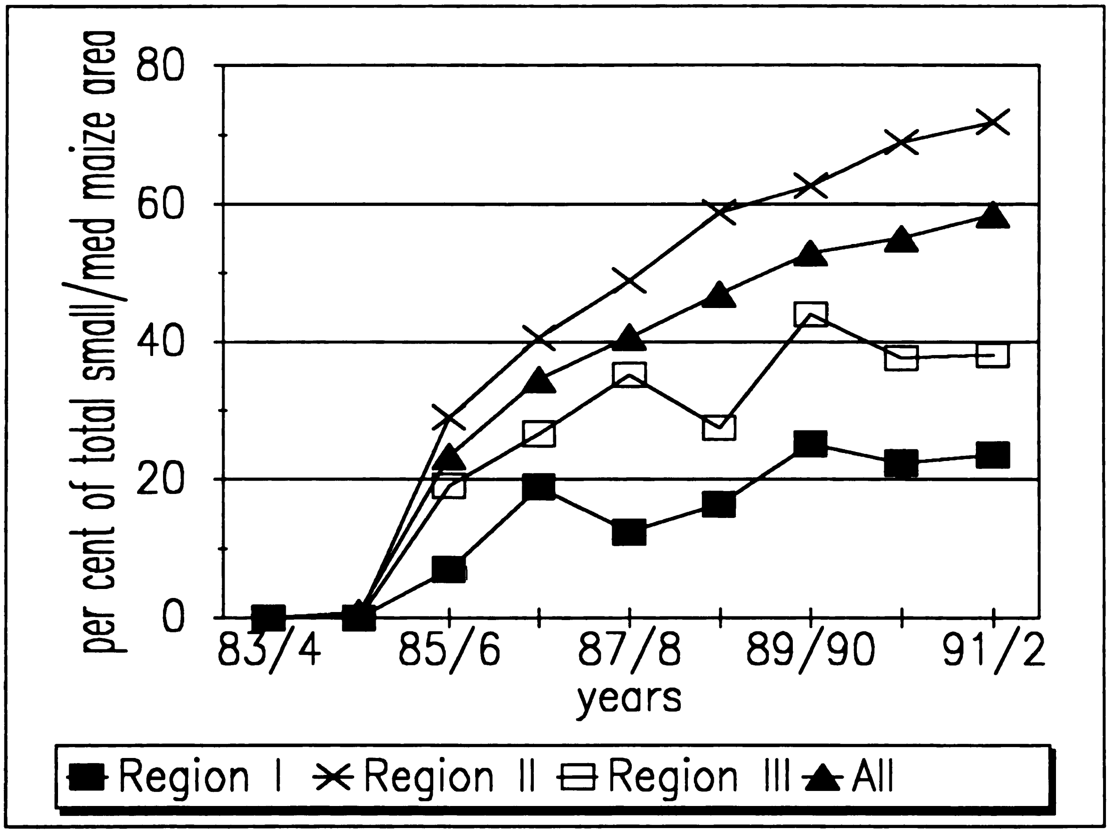


Figure 7: Small and medium farmer adoption of improved maize

MSU/MAFF/RDSB adoption rates differed somewhat from those estimated in a 1985-86 survey of hybrid maize adoption in Eastern Province (Jha et al. 1991). Jha et al. estimated adoption to be 31.1-42.7 percent in Region II sites and 3.2 percent in

Region I sites. MSU/MAFF/RDSB estimates for the 1985-86 season were 29 percent in Region II and 7 percent in Region I. However, the Jha et al. study included adoption of SR52 and Zimbabwean hybrids besides Zambian improved hybrids.

4.2.5. Area and rate of improved maize adoption by all farmers

Adoption data for small/medium farmers from the MSU/MAFF/RDSB Maize Adoption Survey were combined with national-level data and estimates of the division of maize area and production between large and small/medium farmers, to estimate the proportion of total maize area in Zambia planted in improved varieties. Table 11 summarizes the estimates of small/medium and large farmer maize area, production and yields.

Estimated total maize area in Zambia, including local, improved and imported varieties, was 564,000 hectares in 1983. Total maize area climbed to almost 800,000 hectares in the late 1980s, but has declined since then, probably due to the combined disincentives of declining real producer prices, higher fertilizer prices, lack of credit and an increasingly unreliable input delivery and product marketing system.

Table 12 combines adoption data from all farmer groups to estimate total improved maize area from 1983-92, and projected area from 1993-2001. Estimates of large farmer maize area planted in improved varieties are based on responses to the mail-in questionnaire distributed to large maize farmers, and Zamseed sales records (Appendix 6). More than 60 percent of maize area was planted in improved varieties by the 1991-92 season. Total improved maize area more than doubled between 1985-86 and 1988-89, but has declined with overall maize area since 1989.

As a check, adoption estimates from MSU/MAFF/RDSB survey data were compared to estimates based on Zamseed seed sales from 1984-92 (Table 13). Improved maize area was roughly estimated, assuming that each bag of seed maize is sufficient to plant two hectares of land (Gibson, personal communication, March 1993). In general, MSU/MAFF/RDSB survey data were comparable to the estimates based on seed sales, except in the 1984-85 season. Survey data estimates of improved maize area were almost six times greater than the seed-derived estimate, possibly because sample farmers confused MM752 with SR52, both of which were available in 1984-85. For that season only, the seed-derived estimate was substituted for the MSU/MAFF/RDSB survey estimate.

By any standard, the uptake of improved maize hybrids and varieties in Zambia has been fast and extensive. Malawi, by contrast, is agroecologically similar to Zambia but has never had more than 20 percent of aggregate maize area sown to improved hybrids or open-pollinated varieties (Smale 1991). The only other countries in Eastern and Southern Africa (excluding South Africa) which have comparable adoption rates are Zimbabwe, where improved varieties are planted on almost all of the maize area, and Kenya, with improved varieties planted on 65 percent of total maize area. In Tanzania, Uganda and Ethiopia, improved maize is planted on only 17, 35 and 16 percent of the total maize area, respectively (CIMMYT 1990).

4.2.6. Adoption of specific varieties

Zambian farmers were growing many different maize varieties at the time the improved varieties were released from the national maize program. Large farmers used SR52 and several hybrids imported from Zimbabwe, including CG4141, PNR473,

Table 11: Maize area and production by farmer category

Year	Area (ml. ha)	Production (ml. tons)	Yield (tons/ha)
1983-84 total	.564	.93	1.65
large	.06	.330	5.5
small,medium	.504	.600	1.19
1984-85 total	.576	1.214	2.11
large	.06	.362	6.03
small,medium	.516	.852	1.65
1985-86 total	.532	1.427	2.68
large	.06	.384	6.39
small,medium	.472	1.043	2.21
1986-87 total	.659	1.003	1.52
large	.06	.362	6.03
small,medium	.599	.641	1.07
1987-88 total	.692	1.834	2.65
large	.06	.362	6.03
small,medium	.632	1.472	2.33
1988-89 total	.797	1.997	2.5
large	.06	.362	6.03
small,medium	.737	1.635	2.22
1989-90 total	.668	1.464	2.19
large	.051	.307	6.03
small,medium	.617	1.157	1.87
1990-91 total	.579	1.448	2.5
large	.044	.266	6.03
small,medium	.535	1.182	2.21
1991-92 total	.477	.515	1.08
large	.06	.362	6.03
small,medium	.417	.153	.37

Sources: Totals, all years, from Central Statistical Office Crop Forecasting Survey results. 1989-90, 1990-91 data for large, small/medium farmers from Central Statistical Office data. Other years are estimated based on Gibson (1986).

Table 12: Improved maize adoption 1983-92 and projected rates 1993-2001

Season	83-4	84-5	85-6	86-7	87-8	88-9	89-90	90-1	91-2	92-3	93-01
Zambian improved maize area, lg farmers[a,b] ('000 ha)	0	7.9	47.3	55.0	53.0	49.8	33.8	37.4	44.9	46.3	46.3
Zambian improved maize area, sm/med farmers[c] ('000 ha)	0	3.9	110.6	207.0	257.0	346.5	327.2	294.7	244.7	258.0	258.0
Total, Zambian improved maize area ('000 ha)	0	11.8	157.9	262.0	310.0	396.3	361.0	332.0	289.6	304.3	304.3
Total maize area[d] ('000 ha)	564	575.6	532.4	659	691.5	797.3	667.9	578.8	477.3	500	500
Improved maize/ total maize area (percent)	0	2.1	29.7	39.7	44.8	49.7	54.1	57.4	60.7	60.9	60.9

[a] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1986) for other years.
[b] Estimates of large farmer area planted to improved varieties are based on Zamseed sales records (Tables 53-62, App. 6) and MSU/MAFF/RDSB Maize Adoption Survey for 1978-91. 1992-2000 projections are based on 1991 data.
[c] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-91. Projections for 1992-2000 were based on 1991 data.
[d] Central Statistical Office estimates, 1983-92.

Table 13: Comparison, estimates of improved maize area

Year	Total 50 kg bags of Zambian improved seed sold[a]	Estimated area planted in improved varieties[b] ('000 ha)	MSU/MAFF/RDSB estimates of area planted in improved varieties ('000 ha)
1984-85	5,924	11.84	11.84
1985-86	131,925	263.85	157.93
1986-87	174,297	348.59	262.03
1987-88	80,987	161.97	310.00
1988-89	179,669	359.34	396.26
1989-90	196,000	392.00	361.08
1990-91	149,600	299.20	332.03
1991-92	138,635	277.27	289.60

[a] Source: Zamseed records. See Appendix 6.
[b] Assumes that each bag of seed maize is sufficient to plant 2 hectares of land (Gibson,personal communication, March 1993)

R201, R215, ZS206, and ZS225. Small and medium farmers planted local varieties and SR52 and Zimbabwean hybrids, to a limited extent. The most remarkable change between 1983-92 was the replacement of small/medium area planted to locals with improved Zambian varieties. Table 46 (Appendix 5) shows how the proportions of

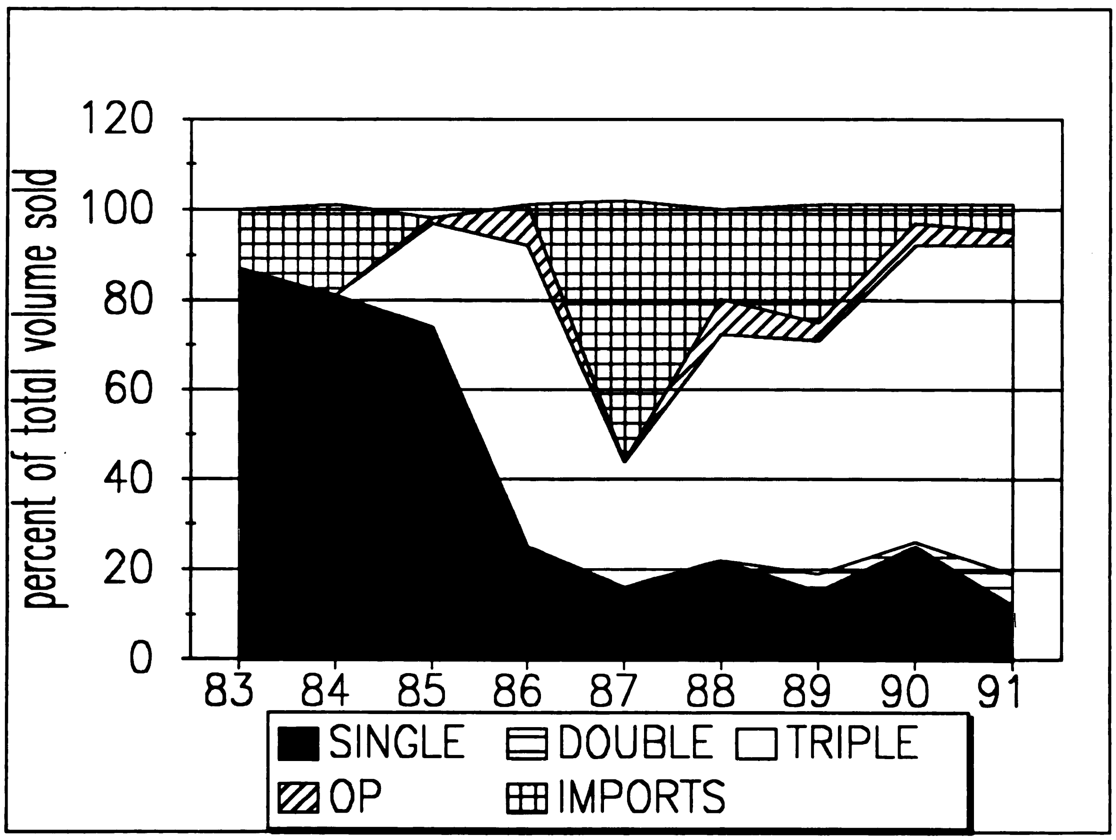


Figure 8: Shares of hybrid and open-pollinated types in Zamseed sales

maize area planted to each variety category changed between 1983-92.

Among the Zambian improved varieties, MM604, MM603 and MM752 have been most widely adopted. These three hybrids together accounted for almost 80 percent of all maize seed sold by Zamseed in 1991 (Table 62, Appendix 6). The success of these hybrids, especially MM603 and MM604, is partly due to their high yields and wide adaptability across agroecological regions. Also, Zamseed has increasingly focused seed production on the triple-cross hybrids, MM504, MM603 and MM604 (Figure 8). Seed for three-way cross hybrids is cheaper to produce than seed for single-cross hybrids, which dominated seed sales in the early to mid-80s, or for open-pollinated varieties (CIMMYT 1987).

The selection of maize seed hybrids and varieties available to Zambian farmers has progressively narrowed since 1986 (Appendix 6). The open-pollinated varieties that were products of the USAID-funded maize research program have not been widely adopted, but were not widely available, either. Sales of MMV400 and MMV600 peaked in 1986, when they represented 9 percent of total maize seed sales, but have declined since. In 1991, combined sales of the two varieties were only 3 percent of total maize seed sales. However, the open-pollinated varieties, especially MMV600, have been popular exports. Over 40,000 bags of primarily open-pollinated maize seed have been sold to Mozambique since 1987 (Zamseed 1991).

4.2.7. Yield improvement

Estimating the yield improvements gained from farmer adoption of improved maize varieties was one of the most difficult tasks of the study. Yields from on-station trials (Table 4, Chapter 3) are obtainable only under medium to high levels of management. While it may be reasonable to assume that large-scale farmers can approach these yields, they are not good estimates of yields for small and medium farmers. Results of ARPT on-farm trials of the new varieties in Northern, Eastern and Central Provinces were extremely variable.

Based on conversations with maize researchers and commercial farmers, the average yield obtained by large farmers using improved varieties was estimated at just

Table 14: Comparison of small/medium maize yield estimates

	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92
					tons/ha					
MSU/ MAFF/ RDSB Survey estimate	n/a	n/a	2.22	2.3	2.36	2.2	2.18	2.24	2.12	n/a
CSO estimate[a]	1.81[b]	1.19	1.65	2.21	1.07	2.33	2.22	1.87	2.21	.37

[a] See Table 11
[b] Estimated from CSO survey of non-commercial farms, 1982-83, 1983-84

over six tons/ha. Estimates of small/medium farmer yields obtained by MSU/MAFF/RDSB survey participants were calculated by summing reported maize retentions and sales and dividing by area planted. Table 14 compares the survey results with estimates of small/medium farmer yields based on CSO production and area estimates. CSO estimates are based on farmer self-reporting of area planted and production and data from official grain marketing agencies.

MSU/MAFF/RDSB survey estimates were slightly higher than the CSO estimates for most seasons; the more conservative CSO estimates were used in the ARR estimation. The data suggest a general increase in yield levels beginning in the 1985-86 season, when most of the new hybrids and varieties became available. Yields rose from 1.6-1.8 tons/ha to 2.0-2.2 tons/ha, an increase of about 20 percent, and have fluctuated around this level since.

Calculation of the ROR required an estimate of the yield differences between the improved varieties and other categories of maize, i.e., local, SR52 and Zimbabwean hybrids. The yield advantage of improved Zambian varieties over SR52 was estimated at 20 percent (Ristanovic 1988). Results of on-farm trials of improved and local maize varieties showed that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson estimated that yields of non-Zambian hybrids are 5-10 percent higher than SR52 on large farms, and 20 percent higher than SR52 on small and medium farms (personal communication, March 1993). Based on these estimates, it was assumed that SR52 yields are 1.37 * local yields[8]; yields of Zambian improved varieties are 1.64 * local yields[9]; yields of Zimbabwean hybrids are 1.075 * SR52[10] on large farms, and 1.64 * local yields on small/medium farms.[11] These estimates of yield gain were less than the 68-324 percent gain reported for participants in the Global 2000 program (Foster 1987), but are in the same range as other estimates of average hybrid yield gain over local varieties in southern Africa. Rohrbach estimated that adoption of hybrids by Zimbabwean farmers increased yields by up to 46 percent (1988, 199).

These yield estimates suggest that an important impact of the development and adoption of improved Zambian hybrids was a narrowing of the maize yield gap between large and small/medium farmers (Table 11). The remaining, smaller yield gap is partly

---

[8] since 1.37 + .20 * (1.37) = 1.64

[9] Reflects results of on-farm trials of improved and local maize varieties that indicate the average ratio of Zambian hybrid to local yields was 1.64 from 1984-91.

[10] Gibson estimated that Zimbabwean varieties yielded 5-10 percent more than SR52 on large farms (personal communication, March 1993). Taking the average, it was assumed that Zimbabwean hybrids would yield 7.5 percent more than SR52.

[11] Based on Gibson's estimate that yields of Zimbabwean hybrids are 20 percent higher than SR52 on small/medium farms, the same yield advantage as Zambian improved hybrids, and results of on-farm trials of improved and local maize varieties indicating that the average ratio of Zambian hybrid to local yields was 1.64 from 1984-91 (Gibson, personal communication, March 1993; Ristanovic 1988).

attributable to small farmers' more limited access to fertilizer, and their different management objectives and strategies. Shortage of labor is a major constraint on small farms[12], and there is a tendency for farmers to plant more land than they can adequately weed. ARPT trials show that failure to weed reduces maize yields by as much as 25 percent (Bolt and Silavwe undated). Small farmers intercrop and weed less than commercial farmers because risk is lessened by growing a variety of crops with overlapping labor requirements. Farmers accept lower yields on all crops (that they are unable to weed optimally) as a tradeoff for insuring subsistence requirements in case one crop fails (Collinson 1978, cited in Klepper 1980). Subsidized and more widely available inputs may have encouraged farmers to substitute fertilizer for weeding labor, by planting more land than can be weeded with available labor and fertilizing it to increase maize yield (GRZ 1990, 54).

4.2.8. Why do small/medium farmers adopt improved maize?

Small/medium farmers consistently cited high yields and early maturity as the most important reasons why they decided to grow improved maize varieties (Table 47, Appendix 5). The importance of improved maize as a source of cash and food, and particularly desirable characteristics, such as drought tolerance, size of seeds, or the size and number of cobs, were also frequently mentioned.

---

[12] Evaluators of the Global 2000 project in Zambia recently noted that they now believe labor to be the most important limiting factor for small scale production, although it was not recognized when the Global 2000 technology package was developed in the mid-1980s (Global 2000 1993, 19).

Although not explicitly mentioned by sample farmers, embedded in their answers is the reasoning behind cultivation of maize in general vs. other crops. The only staple for which there has been a consistent market, increasingly accessible to smallholders during the 1980s, is maize. Sorghum and millet markets are extremely thin, with most transactions taking place informally between neighboring households (GRZ 1991d, xi).

4.2.9. Sources of information about improved maize

Farmers named fellow farmers, extension workers, and primary cooperative society staff as their most important sources of information about improved maize (Table 48, Appendix 5). Differences in sources of information between regions, and between small and medium farmers, were not significant, but differences between close and remote farms were. Extension workers were far more important sources of information for remote farmers. 40 percent of remote farmers listed extension workers as their primary source of information, compared to 21 percent of close farmers. Most farmers living close to service centers instead found out about improved maize from other farmers.

4.2.10. Use of extension, credit, fertilizer and marketing facilities

The high proportion of contacts with extension, credit, fertilizer and marketing agencies reported by sample farmers who adopted improved maize supports the hypothesis that these complementary organizations played a critical role in the adoption decision process (Table 15). Half of all farmers were visited at least once by an extension agent, and almost 75 percent in Region I. A striking proportion of farmers used fertilizer on maize, over 90 percent in Regions II and III, and 63 percent in Region

I. Almost three-quarters had sold maize after at least one season. This proportion was highest in Region II, where almost 80 percent of farmers had sold maize, and lower in Regions I and III, where 58 and 65 percent had marketed maize, respectively. Regional variations in extension visits, fertilizer use and sale of maize were significant.

Medium-scale farmers were more likely than small farmers to have received credit for maize. Two-thirds of the farmers had received credit, compared to 42 percent of small farmers. The proportion of farmers using fertilizer was high in both classes, but significantly higher among medium farmers. Almost all medium farmers (97 percent) had used fertilizer, compared to 88 percent of small farmers. The largest small/medium gap was in the proportion of farmers having sold maize. 90 percent of medium farmers had sold maize after one or more seasons, compared to 64 percent of small farmers.

4.2.10.1. Credit receipts

Table 16 shows the average amount of maize-related credit received by adopters obtaining credit in a given year. Farmers reported credit receipts in seeds, fertilizer, bags and sometimes cash. Inputs were converted to monetary amounts using values from the financial production cost tables for each year (Appendix 7). Although nominal amounts rose, in real terms average credit declined through the 1980s. Medium farmer credit receipts were significantly higher than amounts received by small farmers between 1987-91, in most years double or more. Farmers located close to service centers received more credit than remote farmers, in some years twice as much.

4.2.10.2. Fertilizer use and delivery

In all years, the average small adopter used less than half the fertilizer total for medium farmers, 560-740 kg of product on average compared to 1240-1600 kg for medium farmers. Regional differences were significant in the late 1980s, with farmers in Region II using up to twice as much fertilizer as Region I or III (Table 49, Appendix 5).

Table 17 shows fertilizer used per hectare of maize area in 1991, under different assumptions about application to improved and local varieties. Calculations were made (1) assuming fertilizer was applied only to improved Zambian varieties, and (2) alternatively, assuming fertilizer was also applied to Zimbabwean varieties and half the local maize area, the pattern suggested by ARPT reports (1991). If fertilizer is applied only to improved Zambian varieties, small farmers used 709-957 kg of product per hectare, more than double the recommended amount for small and medium farmers of 200-400 kg/ha. If it is assumed that fertilizer is applied to a larger maize area, rates range from 546-846 kg/ha. Application rates for medium farmers were lower, from 133-828 kg/ha for improved maize area only, and 82-640 kg/ha for the larger area.

MSU/MAFF/RDSB estimates are higher than fertilizer rates estimated by Jha for Eastern Province in 1985, 90 (local)-400 (improved) kgs/maize ha, and also higher than CIMMYT estimates of under 200 kg product[13]/maize ha (Jha 1991, 203; CIMMYT

---

[13] CIMMYT and Jha et al. estimates are in terms of nutrient/ha, MSU/MAFF/RDSB data are in product/ha. Nutrient/ha data are multiplied by 2.5 to convert them to product/ha, based on averages calculated from the **Fertilizer Yearbook** (FAO 1991).

Table 15: Use of extension, credit, fertilizer, marketing facilities

	Visited by an extension agent[a,b] (%)	Received credit[c,d] (%)	Used fertilizer on maize[e,f] (%)	Sold maize[g,h] (%)
	(n in parentheses)			
ALL REGIONS	50.2 (237)	49.6 (232)	91.0 (234)	72.1 (233)
small	47.0 (164)	41.6*** (161)	88.3** (163)	64.4*** (163)
medium	57.5 (73)	67.6*** (71)	97.2** (71)	90.0*** (70)
close	49.3 (152)	50.7 (148)	93.3 (149)	73.0 (148)
remote	51.8 (85)	47.6 (84)	87.1 (85)	70.6 (85)
REGION I	74.3 (35)	41.9 (31)	62.5 (32)	58.1 (31)
small	70.4 (27)	36.0 (25)	53.8 (26)	50.0 (26)
medium	87.5 (8)	66.7 (6)	100.0 (6)	100.0 (5)
close	76.5 (17)	61.5 (13)	78.6 (14)	92.3*** (13)
remote	72.2 (18)	27.8 (18)	50.0 (18)	33.3*** (18)
REGION II	40.8 (142)	53.9 (141)	95.1 (142)	78.2 (142)
small	34.8 (89)	46.6* (88)	94.4 (89)	70.8** (89)
medium	50.9 (53)	66.0* (53)	96.2 (53)	90.6** (53)
close	43.6 (94)	52.1 (94)	94.7 (94)	75.5 (94)
remote	35.4 (48)	57.4 (47)	95.8 (48)	83.3 (48)
REGION III	58.3 (60)	43.3 (60)	96.7 (60)	65.0 (60)
small	56.3 (48)	35.4* (48)	95.8 (48)	60.4 (48)
medium	66.7 (12)	75.0* (12)	100.0 (12)	83.3 (12)
close	51.2 (41)	43.9 (41)	95.1 (41)	61.0 (41)
remote	73.7 (19)	42.1 (19)	100.0 (19)	73.7 (19)

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992

[a] At least one visit from an extension agent.
[b] Regional differences were significant at $p < .001$.
[c] Received credit at least one season.
[d] Regional differences were not significant at $p < .05$.
[e] Used fertilizer at least one season.
[f] Regional differences were significant at $p < .001$.
[g] Sold maize at least once.
[h] Regional differences were significant at $p < .05$.
* $p < .05$
** $p < .01$
*** $p < .001$

1990). However, the CIMMYT and Eastern Province estimates are rates for total maize area, while the MSU/MAFF/RDSB are average rates of application on farms applying fertilizer to maize. The MSU/MAFF/RDSB data indicate that those small farmers who have access to fertilizer may be applying it excessively, suggesting that labor-constrained small farmers use fertilizer as a substitute for weeding labor. Farmers may plant a larger maize area than they can adequately weed given available labor, but the combination of heavy fertilizer application and improved varieties still outyields what farmers would get on a normally tended plot of local maize, despite the stress of weed competition.

CIMMYT data show that the rate of fertilizer application on maize in Zambia is among the highest in Africa. Zambia's 75 kg nutrient/ha compares to 100 kg nutrient/ha in Burundi, 70 kg nutrient/ha in Tanzania, 62 kg nutrient/ha in Zimbabwe, 55 kg/ha in Nigeria, 52 kg/ha in Kenya and 33 kg/ha in Malawi (CIMMYT 1990).

The proportion of improved maize adopters using fertilizer declined between 1984-91 (Figure 9; Appendix 5, Table 50). In 1985, 89 percent of medium-scale improved maize users and 84 percent of small-scale adopters used fertilizer. Use fell

Table 16i Mean credit receipts per household, 1984-91

YEAR	84	85	86	87	88	89	90	91
ALL REGIONS	51.0	223.3	436.3	336.6	462.4	706.6	1806.0	3679.8
	(14)	(17)	(21)	(34)	(49)	(61)	(64)	(46)
real (1985=100)	70.0	223.3	287.0	155.0	136.9	106.5	107.9	114.1
Small	48.4	168.3	338.6	224.9*	330.2*	437.7**	1183.6**	2346.0**
	(8)	(5)	(8)	(16)	(26)	(35)	(37)	(29)
Medium	54.5	246.2	496.5	435.8*	605.6*	1068.3**	2658.8**	5955.0**
	(6)	(12)	(13)	(18)	(24)	(26)	(27)	(17)
Close	50.4	227.1	516.1*	402.6**	507.1	856.6*	2235.8**	3745.9
	(11)	(12)	(15)	(24)	(35)	(38)	(39)	(34)
Remote	53.4	214.0	236.9*	178.1**	358.1	458.7*	1135.5**	3492.5
	(3)	(5)	(6)	(10)	(15)	(23)	(25)	(12)
REGION I	13.9	---	234.1	48.8	68.0	812.5	1005.3	3537.8
	(1)		(2)	(1)	(2)	(4)	(6)	(2)
REGION II	57.23	220.7	480	369.6	523.1	835.1	2112.5	4337.7
	(12)	(15)	(17)	(27)	(39)	(42)	(45)	(33)
REGION III	13.9	242.3	267.5	235.9	287.1	318.3	1114.5	1731.8
	(1)	(2)	(2)	(6)	(9)	(15)	(13)	(11)

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992

* $p < .05$

** $p < .01$

*** $p < .001$

Table 17: Fertilizer use by improved maize adopters, per hectare of maize

kg product/ha; n in parentheses[a]	1991
REGION I	
SMALL	
Imp.maize ha only	709 (5)
Imp.+Zimb.+ half of local maize ha	546 (5)
MEDIUM	
Imp.maize ha only	133 (1)
Imp.+Zimb.+ half of local maize ha	82 (1)
REGION II	
SMALL	
Imp.maize ha only	957 (49)
Imp.+Zimb.+ half of local maize ha	846 (49)
MEDIUM	
Imp.maize ha only	279 (33)
Imp.+Zimb.+ half of local maize ha	261 (33)
REGION III	
SMALL	
Imp.maize ha only	818 (30)
Imp.+Zimb.+ half of local maize ha	690 (30)
MEDIUM	
Imp.maize ha only	828 (5)
Imp.+Zimb.+ half of local maize ha	640 (5)

Source: MSU/MARR/RDSB Maize Adoption Survey, 1992

[a] Calculations were made by dividing mean fertilizer used in each farmer category by (1) estimated area planted to improved Zambian maize, and (2) area planted to improved Zambian maize+Zimbabwean varieties plus .5* local maize area. Average areas were taken from estimates for median farm area in each category (Table 6) and estimated proportions of farm area planted to improved, Zimbabwean and local maize varieties (Table 46, Appendix 5).

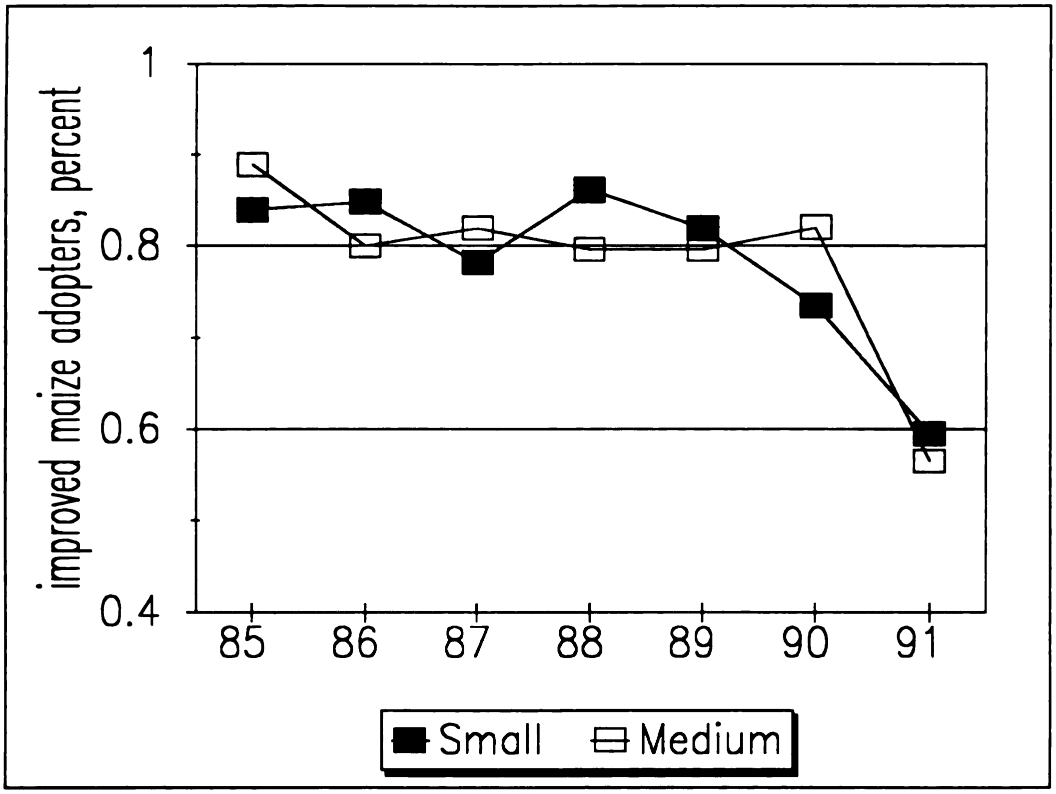


Figure 9: Fertilizer use by improved maize adopters

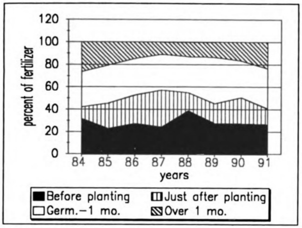
sharply in the late 1980s. In 1990 and 1991, 74 percent and 60 percent of small farmer adopters used fertilizer, compared to 82 percent and 57 percent of medium farmers. The dropoff in medium users began after 1985, perhaps reflecting diversification toward other crops, but for small farmers the abrupt drop in the late 1980s is probably linked to increasing nominal and real fertilizer prices, declining credit availability and problems with fertilizer delivery.

Most fertilizer (82 percent), was obtained by farmers through local primary society depots (total fertilizer purchases, all years). Another 8 percent came from district and provincial-level cooperative stores, and 7 percent came directly from credit agencies such as Lima Bank and CUSA (MSU/MAFF/RDSB Maize Adoption Survey 1992).

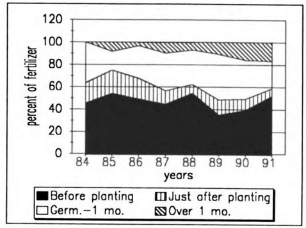
Figure 10 shows the time of basal fertilizer delivery to different groups of improved maize adopters (Table 51, Appendix 5). Although farmers depended on local depots as the primary source of fertilizer, the data clearly show major problems in getting fertilizer to these depots and farmers before planting. Less than 50 percent of fertilizer for medium farmers was delivered before planting in most years, and one-third of the fertilizer was delivered up to one month after planting. The situation was worse for small farmers; generally only about one-quarter of their fertilizer was delivered to nearby depots before planting.

Delivery times varied by region. Region II farmers had the best chance of getting fertilizer on time; still, less than half arrived before planting in most years. Delivery to Region III was worst. Only 20 percent of fertilizer was available before planting in most years, and one-third in Region I. In Regions I and III, between 25 and 50 percent of fertilizer was delivered over one month after planting. Farmers living close to service centers also received a greater proportion of fertilizer on time than remote farmers, but differences were not statistically significant. Kerven et al. (1988) identified late fertilizer delivery as a major problem in Region III, with 20-40 percent of farmers in several districts not receiving basal fertilizer before the latest possible planting date, mid-December. The MSU/MAFF/RDSB data suggest that late fertilizer delivery was a serious problem throughout the country. Since maize plants take up most important nutrients in the very early stages of growth, fertilizer delays

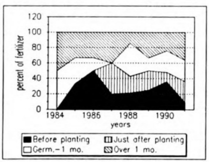
Figure 10: Fertilizer delivery



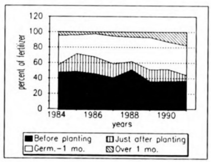
Small farmers



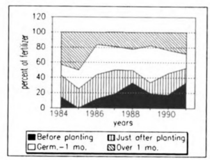
Medium farmers



Region I



Region II



Region III

may be an important factor explaining the yield gap between small/medium and large farmers.

4.2.10.3. Maize retention and sales

Three-quarters of the adopters in the sample sold maize after at least one season (Table 15). Those who sold maize retained on average 30-40 percent and sold 60-70 percent of total maize production (Table 18). Region III farmers sold a greater proportion of production than farmers in other regions, 70-80 percent, perhaps because maize as a staple is supplemented by other foods, e.g., cassava and millet, to a greater extent than other regions. Regional differences were not statistically significant, however, nor were differences between small/medium and close/remote farmers.

Most farmers in Region I (78 percent) and Region II (95 percent) delivered their own maize to a centralized collection point, but in Region III maize (70 percent) was collected by the cooperative from the farmgate. Eighty-six percent of farmers selling maize, over all years, sold their maize at the local cooperative depot. Deliveries/collections were sluggish, especially in Region III. Farmers throughout the country experienced long delays in receiving payment for maize. The maize harvest is complete throughout the country by May-June. Less than half of the farmers in any year reported that their maize was delivered or collected by the end of July, however. Because of the pan-territorial pricing system, farmers were not paid a storage premium and should have had an incentive to sell maize as quickly as possible after harvest. In most years, about 50 percent of Region II maize was collected/delivered by late July. Region I varied from 0-50 percent. In Region III, where farmers waited for farmgate

Table 18: Maize retention and sales

	84	85	86	87	88	89	90
	PERCENT OF TOTAL MAIZE PRODUCTION; N IN PARENTHESES						
ALL	(21)	(38)	(52)	(71)	(94)	(109)	(127)
retained	36	32	31	38	39	39	40
sold	64	68	69	62	61	61	60
REG. I	(2)	(3)	(3)	(6)	(9)	(9)	(12)
retained	86	8	13	63	38	37	38
sold	14	92	88	37	62	63	62
REG. II	(14)	(29)	(36)	(50)	(69)	(75)	(92)
retained	36	37	33	38	41	42	43
sold	64	63	67	62	59	58	57
REG. III	(5)	(6)	(13)	(15)	(16)	(25)	(23)
retained	14	18	30	25	22	30	25
sold	86	82	70	75	78	70	75
SMALL	(10)	(17)	(23)	(33)	(53)	(64)	(71)
retained	33	35	32	38	39	41	41
sold	67	65	68	62	61	59	59
MEDIUM	(11)	(21)	(29)	(38)	(41)	(45)	(56)
retained	38	30	30	37	36	36	37
sold	62	70	70	63	64	64	63
CLOSE	(15)	(27)	(36)	(52)	(63)	(74)	(87)
retained	46	35	32	38	39	41	38
sold	54	65	68	62	61	59	62
REMOTE	(6)	(11)	(16)	(19)	(31)	(35)	(40)
retained	10	25	30	35	34	35	43
sold	90	75	70	65	66	65	57

Source: MSU/MAFF/RDSB Maize Adoption Survey 1992 collection, less than 15 percent of maize was collected by the end of July in any year (Figure 11).

Farmers who delivered maize may have delayed because payment was so slow. Over half of farmers in Regions I and II, and up to 95 percent of Region III farmers, waited until October or later for payment every year; Region III farmers waited longest; 80-95 percent of farmers said they waited until October or afterwards (Figure 12). Regional differences were significant in all years for time of collection, and for time of payment in some years.

Late payment for the previous season's harvest may be one reason why small/medium farmers tend to plant improved maize later than the recommended dates. Kerven et al. report that Northern Province (Region III) farmers often complain that because they have not received payment for the previous year's maize, they do not have the finances to pay for labor to prepare the land and plant in the new season. Sixty percent of the early planters in Northern Province had received payment by October, compared to only 30 percent of the late planters (1988).

4.2.10.4. Seed delivery and choice

Most farmers got their improved maize seed from local cooperative depots, 82.3 percent in 1987, declining to 61.5 percent in 1991, the first year when seed distribution was opened widely to retailers. An additional 6-15 percent purchased seed from district or provincial cooperative stores. Sample farmers were asked when maize seed became available for purchase in different years. Figure 13 suggests a deteriorating ability to get seed to farmers before the start of planting in November. Less than half the farmers reported that maize seed was available in October or before. In 1985, most farmers (80

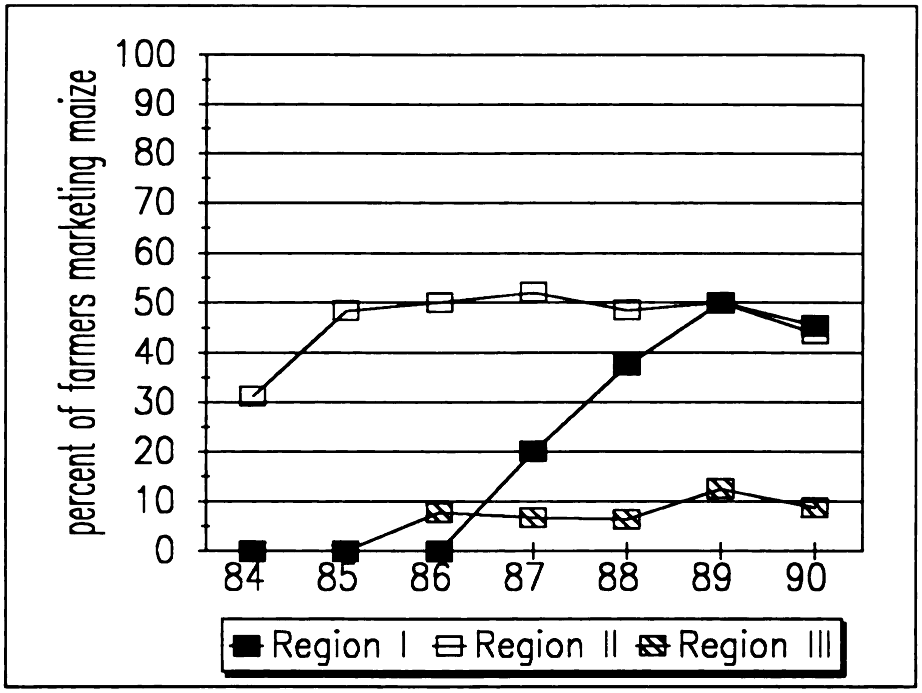


Figure 11: Maize collected/delivered by end July

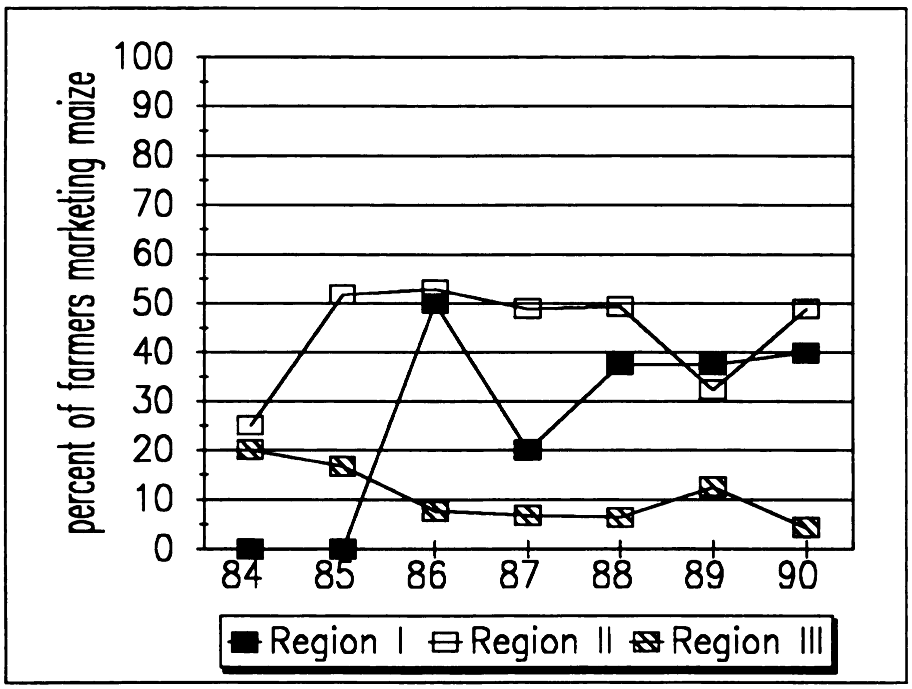


Figure 12: Maize payments received by end September

percent) had seed by at least November, but this proportion fell to 70 percent by 1991. Regional differences were significant for some years; generally seed delivery in Regions I and III lagged behind delivery in Region II.

Late seed delivery obviously affects the ability of farmers to plant within the recommended dates. Kerven et al. found that the earlier farmers received seed in Northern Province, the earlier they planted. Seventy-three percent of farmers who got their seed before November 15 planted by that data; 58 percent of late planters did not receive their seed before December 15 (1988).

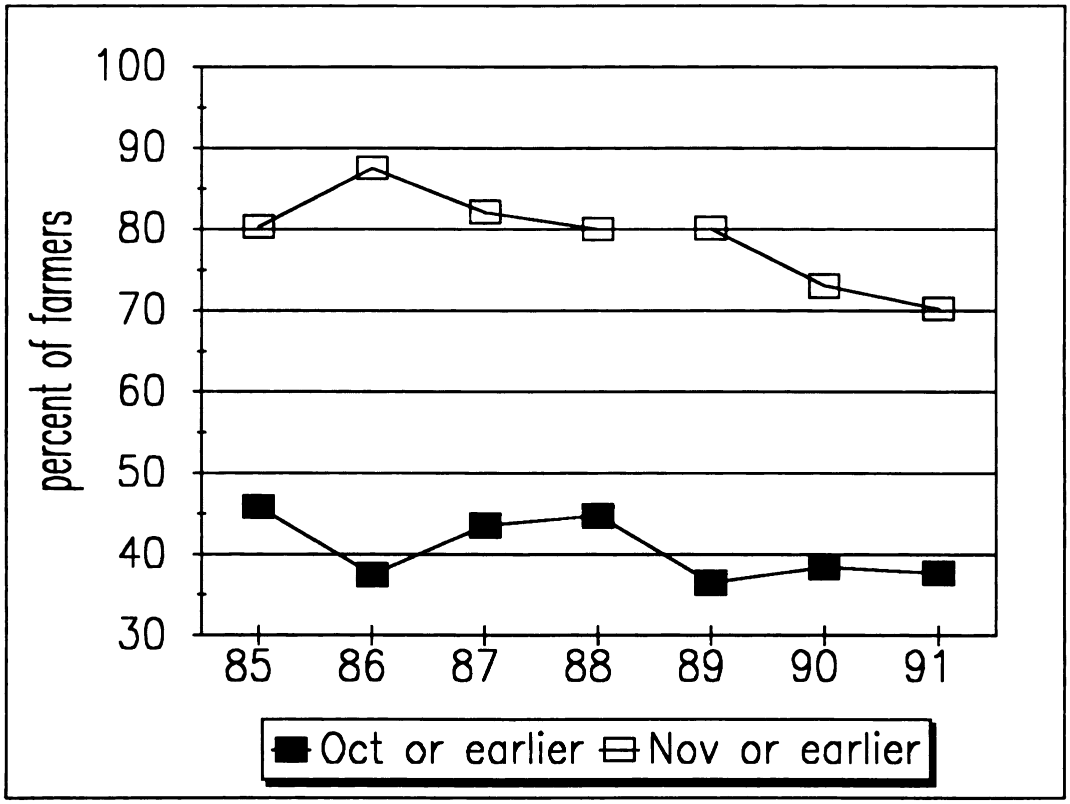


Figure 13: Seed delivery

Sample farmers were asked whether the improved maize seed available was the variety they preferred (Table 52, Appendix 5). Fourteen percent in Region I, 18 percent in Region II, and 34 percent in Region III could not get the variety they wanted. Farmers in Region I complained of the lack of availability of MMV400, but also of MM604, 752, 603, and MMV600, perhaps betraying a lack of knowledge about the comparative risk in planting these longer-season varieties in drier areas. Of the farmers in Region II, who typically used MM752, 604 and (mostly) 603, most of those commenting preferred 604 over 603, but could not get it. This is interesting because 603 and 604 are very close genetic relatives, except the grain of 604 has a yellowish cast that researchers have assumed would make it less attractive to farmers (Siame, personal communication, Feb. 12, 1992). Region III farmers, who generally used 603, 604, and some 752, asked for much more 752 and 612. Several Northern Province researchers, extension officials and administrators commented during interviews about the continued unavailability of 752 despite repeated requests to Zamseed. MM752 is preferred by Region III farmers because of its high yield and large cobs and kernels.

4.3. Conclusions

Adoption of improved maize varieties by Zambian farmers was rapid and extensive following their release beginning in 1984. By 1991-92, 60 percent of maize area in Zambia -- three-quarters of maize area in Region II, 40 percent in Region III, and 25 percent in Region I -- was planted to improved varieties. The overall increase in yields was 20 percent. Development and availability of improved maize hybrids narrowed the yield gap between large and small/medium farmers.

Access to resources in general distinguished adopters from non-adopters. Improved maize adopters had larger farms, more labor (bigger households), a higher level of formal education, were more likely to use animal traction or farm machinery, and tended to live close to service centers and major roads.

Government policies and organizations created a facilitative environment that drew smallholders into commercial maize production by providing incentives and essential services. Pan-territorial and pan-seasonal pricing enforced through an effective parastatal monopoly on maize marketing, substantial fertilizer subsidies, and the countrywide establishment of local depots for sales of inputs and collection of maize were most important. These policies and organizational innovations took shape beginning in the mid-1970s, laying the groundwork for the successful introduction of Zambian improved varieties. By the time these were released in the mid-1980s, many small and medium farmers had already adopted fertilizer or SR52 and had been motivated to increase their maize area for commercial production.

The major change in cropping patterns of improved maize users, before and after adoption, was the replacement of local maize with improved varieties. Before adoption, small farmers planted between 41-53 percent of total farm area in local varieties; afterwards, only 11-25 percent remained under local maize. Medium farmers, who used local maize on 23-43 percent of total area before adoption, decreased local maize share to 4-10 percent after.

For small farmers, total maize area as a proportion of farm area increased markedly only in Region I, from 48 percent to 66 percent of farm area. In Region III there was a smaller increase in total maize area with adoption, from 42 percent to 46 percent, but virtually no change in Region II. Medium farmer total maize area stayed the same pre- and post-adoption in Regions I and II, 50 and 63 percent, and declined in Region III, from 38 to 27 percent.

Expansion of farm area, by clearing or otherwise obtaining claim to new land, was not very important during the mid to late 1980s. Small farmers increased total farm size by an average of 15 percent between the year before adoption and 1991; medium farm size increased by 4 percent.

Maize is the dominant crop in small and medium farming systems, but at least one-third of the farm area is devoted to other crops or fallowed. Small farmers have a "subsistence-plus" attitude to commercial maize, continuing to plant a variety of other crops and local maize for home consumption. Medium farmers also plant subsistence crops as well as other cash crops.

Detection of an increase in total maize area in Region I, but not in the other regions, reflects the timing of the study. Region II has historically been Zambia's most important maize-producing area. Maize area as a proportion of farm area stabilized before independence. The outlying regions, I and III, are relative newcomers to commercial maize production. Other reports (IRDP 1986; Bolt and Holdsworth 1987) indicate that a major expansion in Region III maize area took place in the late 1970s and early 1980s, motivated by pricing policies and fertilizer availability. The expansion of maize area in drier Region I noted during the timeframe of this study probably reflects the new availability of shorter-season hybrids in a region where SR52, the most widely available improved hybrid up to the mid 1980s, never performed very well.

During the 1970s and 1980s, credit, fertilizer and marketing services expanded in outlying Regions I and III, although credit and fertilizer amounts, and timeliness of services, never matched those available in Region II. If the impact of maize policies and organizations were judged by the numbers of farmers using the provided services, they would be seen as very successful. A striking proportion of improved maize adopters had used fertilizer, 88 percent of small and 97 percent of medium farmers, and fertilizer application rates for maize are the second highest in Africa. In addition, 64 percent and 90 percent of small and medium farmers sold maize; 42 percent and 68 percent had received credit for maize, and 47 percent and 58 percent of small and medium farmers had been visited by an extension agent. The dependence of small and medium farmers on local, as opposed to regional, depots is an indication of how widespread and localized service provision became throughout Zambia's maize-growing areas. Eighty-two percent of improved maize users got their fertilizer at local depots, 86 percent sold their maize there, and 80 percent purchased maize seed locally.

The quality of government-supported services declined in the late 1980s, and, with rising fertilizer prices and declining real maize prices, diminished incentives for growing maize in outlying areas. After 1989-90, the proportion of small/medium maize area planted to improved varieties leveled off and declined slightly in Regions I and III, while continuing to grow in Region II. The declining ability of the government to finance and coordinate maize-related services was reflected in the shrinking availability of credit and fertilizer, and persistent and worsening delays in input delivery and payment for maize, especially in Regions I and III.

CHAPTER FIVE

THE RATE OF RETURN TO INVESTMENTS IN MAIZE RESEARCH AND ADOPTION

5.1. Methods

In this chapter, the rate of return method is used to estimate the impact of research and complementary investments in Zambia's maize sector. Results of the MSU/MAFF/RDSB survey, reviewed in Chapter Four, showed that adoption of improved Zambian maize varieties by small- and medium-scale farmers was linked to complementary investments in extension, the seed industry, marketing and price policies. The implication is that the high rate of adoption of new maize varieties among small farmers was contingent on the availability of services provided through non-research investments made primarily by the government. Because of the close tie between technology adoption and non-research services, it is not appropriate to calculate the impact of research in isolation from these other investments in the Zambia case. A rate of return is calculated for the whole package of maize investments, and contrasted with the rate resulting when the costs of some programs are excluded, as in most studies of research impact.[1]

---

[1] Most, but not all, studies have ignored complementary investments. Oehmke et al. (1992) summarizes the literature on the rate of return to agricultural research. A number of authors include extension in their calculations (Pray 1978; Librero and Perez 1987; Lu, Cline and Quance 1979). Studies by other MSU researchers feature a quantitative and/or qualitative assessment of the impact of one or more complementary investments. Studies of Mali, Cameroon and Uganda analyze the impact of research

5.2. Benefit-cost and index number methods (economic surplus)

Benefit-cost and index number methods (BCI) were used to calculate an average rate of return (ARR) to the set of investments in maize research, extension, the seed industry and marketing organizations during 1978-91, and a projected ARR for 1992-2001. BCI is a test for potential Pareto improvements. A potential Pareto improvement (PPI) is a change that makes at least one person better off and no one worse off, assuming that gainers can compensate losers. If an investment generates enough gains so that losers could be compensated, and gains are still left over, the change is a PPI (Randall 1987, 234-5).

BCI compares the values of the "with project" (including project costs) and "without project" environments. If "with" exceeds "without" the project(s) is judged a PPI. The "without" scenario represents a projection of what would have happened without program investments, i.e., continued production in the pre-project environment. In this study, the "without" case assumes the availability of local, SR52 and non-Zambian varieties, but fertilizer is used only by large farmers. The "with" case assumes that the new Zambian improved varieties are available to all farmers, and small/medium farmers also have access to fertilizer.

Figure 14 shows the "with" and "without" concepts graphically. The projected impact of investments in Zambian maize research, extension, seed and marketing is a nonmarginal increase in the supply of maize, represented by the outward shift of the

---

plus extension (Boughton and Henry de Frahan 1994; Sterns and Bernsten 1994; Laker-Ojok 1994). Mazzucato (1991) examines returns to research in the presence of policy distortions and Henry de Frahan (1990) projects the future impact of research investments in Mali given simultaneous investments in extension, infrastructure and policy.

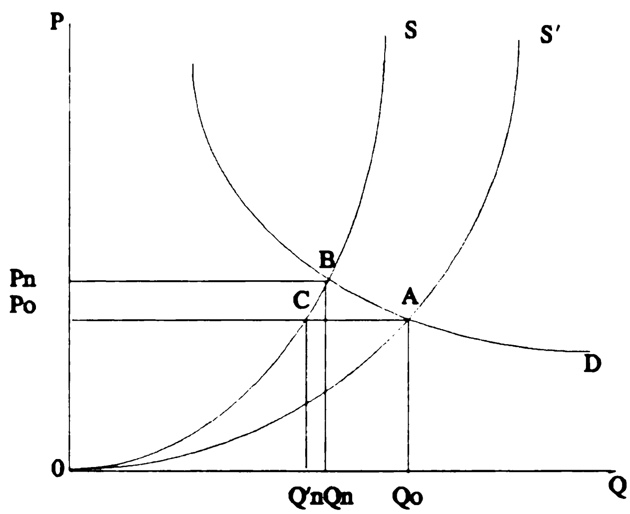


Figure 14: Supply shift from research and related investments

supply curve from S (without) to S′ (with). Consumers benefit from the investments in two ways, through an increase in maize output from Q_n to Q_0, and a decrease in maize price from P_n to P_0. Total consumer gain, or the increase in the Marshallian consumer surplus, is approximated by the area P_nBAP_0. Producers gain by expanding their maize output, but lose with the lower unit price. The area below the supply curve represents the total cost of producing maize; the area above the supply curve but below the price line approximates the producer surplus or economic rent. At quantity Q_n, producer surplus was P_nB0. At the new expanded output Q_0, producer surplus is P_0A0. The price elasticities of demand and supply determine the relative benefits gained by producers and consumers. In Figure 14, the change in consumer surplus = P_nBCP_0, and the change in producer surplus = $A0C - P_nBCP_0$.

The total change in economic surplus resulting from investments in the maize sector is approximated by the algebraic sum of gains and losses to consumers and producers, or $P_nBAP_0 - P_nB0 + P_0A0$. The net change is approximately 0BA (Akino and Hayami 1975). The additional economic surplus created by the outward shift in the supply curve represents gross benefits from investments in maize research and related programs. To estimate the ARR, net benefits for each year (or other relevant time period) are calculated by subtracting additional production costs and program expenditures from the gross benefits for that period. The ARR is the discount rate that just makes the net present value of the net benefit stream equal zero.

5.2.1. Literature review--economic surplus

Schultz (1953) was the first to use the economic surplus approach to estimate the impact of agricultural research investments, calculating the increase in consumer surplus resulting from the savings in inputs through more efficient production techniques, compared to the cost of their development. Griliches (1958) estimated the impact of increased hybrid corn yields on the net social surplus of the U.S. for the polar cases of perfectly elastic and perfectly inelastic supply curves. Other researchers (Peterson 1967; Hertford and Schmitz 1977) subsequently modified the approach to accommodate less stringent assumptions about demand and supply elasticities and the nature of the supply shift.

5.2.1.1. Akino-Hayami index number method

Akino and Hayami (1975) used the surplus approach to estimate benefits from Japanese rice breeding research, including distributional effects of rice import policies. They developed formulas to quantify the area of the change in surplus. Their index number method has moderate data requirements and has been widely applied in subsequent developing country studies, and it is used here. Referring again to Figure 14, assuming market equilibrium and no commodity imports, the change in net surplus due to research equals the area AB0. The change in consumer surplus = ABC + P_nBCP_0. The change in producer surplus = AOC - P_nBCP_0.

To estimate the change in consumer and producer surplus, Akino and Hayami assume constant elasticity demand and supply functions, as follows:

$D = H P^{-n}$,

where D = quantity of maize demanded
p = price of maize
n = price elasticity of demand

$S = a_I P^e$;

where S = quantity of maize supplied
e = price elasticity of maize supply
and S = D.

With the adoption of improved maize technology, the supply curve becomes

$S' = (1+h)a_I P^e$,

where h is the rate of shift in the supply function due to adoption of new maize technology.

The relation between the rate of shift in the marginal cost function (h) and the rate of shift in the production function (k) is approximated by

$h = (1+n)k$

The approximation formulas derived by Akino and Hayami for estimating P_nBCP_0, ABC, A0C are:

$$P_nBCP_0 = P_0Q_0\frac{K(1+e)}{e+n}[1-\frac{\frac{1}{2}K(1+e)n}{e+n}-\frac{1}{2}K(1+e)n]$$

$$ABC = \frac{1}{2}P_0Q_0\frac{[K(1+e)]^2}{e+n}$$

$$A0C = KP_0Q_0$$

$$ACQ/_nQ_0 = (1+e)KP_0Q_0$$

where K = shift in the production function, and [(1 + e)K] approximates the shift in the supply curve.

5.2.1.2. Index number vs. benefit-cost approaches

Both index number and benefit-cost approaches are methods of estimating the change in economic surplus from an investment, but they differ in how the shift in the supply curve is measured and in the treatment of supply and demand elasticities. In the benefit-cost approach, the shift is measured by the difference in total production values, with and without the investment. The index number method, however, relates the change in total production value specifically to the proportion of area under improved technology and the resulting yield improvement. Also, the index number method explicitly incorporates the elasticities in the ARR estimate, while the benefit-cost method does not. This is equivalent to assuming perfectly inelastic supply and perfectly elastic demand in the benefit-cost case. These assumptions are valid in cases where the country is clearly a "price-taker," where the intervention being evaluated is not expected to change the country's status from net importer to net exporter of the commodity. An assumption of highly inelastic supply is valid when fixed inputs such as labor or land resources are almost fully employed, and when the commodity being evaluated is the principal user of these resources.

In Zambia, recent estimates indicate that consumer demand for maize is actually highly inelastic, and supply is somewhat elastic (Harber 1992, Nakaponda 1992).[2] Assumptions about elasticities are critical for calculating the distribution of benefits between consumers and producers (see Chapter 6), but less so for determining the total societal economic surplus, in this chapter. The more inelastic the demand curve, the more producers will lose as a result of technical change. Consumers will also receive a greater share of the benefits when the supply elasticity is absolutely larger than the demand elasticity (Norton and Davis 1981, 690).

In this study, the ARR is calculated using both the Akino-Hayami index number and benefit-cost methods. While the Akino-Hayami advantage is its analytically more sophisticated calculation of surplus, and the explicit incorporation of supply and demand elasticities, the benefit-cost method offers a more transparent view of the data and assumptions used in the analysis.

---

[2] Price elasticity of demand is estimated at .12 and -0.04, and price elasticity of supply is estimated at .8 and .51 by Harber (1992) and Nakaponda (1992), respectively. The inelasticity of demand may result from the highly controlled consumer price structure from 1964-92, which left mealie meal the cheapest staple food, as well as the worsening economic climate, reflected in the declining per capita GDP since the 1970s (Nakaponda 1992:122). Maize supply by farmers is somewhat elastic, probably because in Zambia, unlike other African countries, availability of arable land is not a constraint. Only about 2 million of the estimated 9 million hectares of arable land in Zambia are cultivated.

5.2.1.3. Other issues in economic surplus measurement

Studies using economic surplus methods differ in the specification of supply and demand functions, in the nature of supply function shifts, and in the way that K values are derived. The nature of the supply shift is important in determining how benefits are distributed between producers and consumers. For example, divergent shifts such as Akino and Hayami's yield fewer benefits to producers than parallel (e.g., Griliches) or convergent shifts. Lindner and Jarrett (1978) linked the nature of the supply shift to the type of innovation (e.g., biological, chemical, mechanical, organizational) and its effect on average costs (Norton and Davis 1981, 689).

While the difference in supply shifts is probably most important, supply and demand curve specifications have also varied, e.g., Akino and Hayami assume constant elasticity supply and demand curves, while Griliches and others use linear functions. Measurement of K, the main determinant of net benefits, has also varied. Some studies have measured it as an output effect, implying a horizontal shift in the supply curve (Akino and Hayami), and others as a cost effect, or a vertical supply shift (Lindner and Jarrett) (Norton and Davis 1981,689-690).

5.3. Average vs. marginal rate of return

The benefit-cost/index number methods used in the Zambia study generate an average rate of return (ARR). The ARR is the rate that results in

$$\sum_{t}^{T} \frac{R_t - C_t}{(1+r_i)^t} = 0$$

where R_t is the benefit in year t, C_t is the program cost in year t, and T is the year in which it is assumed that the investment will no longer produce a return. Here, the ARR is calculated for two periods, 1978-91 and 1978-2001.

There are two ways to calculate the rate of return to a set of investments, as an average or a marginal rate. An average rate of return (ARR) takes the whole expenditure as given and calculates a rate of return to the global set of expenditures. The ARR shows whether the **entire** investment package was successful, but not whether the allocation of resources between investment components (e.g., research, extension, seed, marketing) was optimal (Oehmke et al. 1992).

According to economic theory, resources are allocated optimally between program components when the last dollar spent on each component yields the same return. The marginal rate of return (MRR) calculates the return to the last dollar invested in each component, through econometric estimation of the relationship between the supply function and program expenditures. This entails estimation of an aggregate production function that includes research and complementary investments as separate variables. The results of the analysis indicate the effect that individual investment components such as research and extension have on increasing the supply of agricultural products and in theory could guide the policymaker toward optimal resource allocation, by indicating where to invest or subtract resources until the marginal dollars spent on alternative investments are equal (Oehmke et al. 1992).

The benefit-cost/index number, for the ARR, and the production function method, for the MRR, are the two most important approaches used in ex-post evaluation of returns to agricultural research. The index number/benefit-cost approach has been most commonly used to calculate the rate of return from investments in the improvement of single crops or the development of single technologies. Production functions have been used to determine the rate of return from research and complementary investments in multiple crops or for an entire sector (Oehmke et al. 1992).

Estimating an MRR to investments in Zambia's maize sector was not considered appropriate, for several reasons. Estimation requires good quality time series data that is not readily available in Zambia, and, more generally, there are serious methodological difficulties in specifying and obtaining data for some variables, especially those related to organization and management. Most important, if it was the complementarity and coordination between program components that brought about widespread adoption of the new maize varieties, measurement of the contributions of individual programs is not valid. For example, MRR estimation in Zambia may show higher marginal returns to research than seed and marketing investments. If this results in increased funding for research while the other projects drop out, research investments will not have the anticipated impact. The implication is that closely related investments should be evaluated as a package, if assessing components individually carries the risk that essential complementary investments will not be made (Schmid 1989, 130).

5.4. Calculation of the ARR

In BCI, quantitative assessments of the costs and benefits of the program are made by estimating the value of the increased production resulting from the investment (benefit) and the cost of carrying out the program. This study differs from conventional studies of research impact because it considers that investments in extension, the seed industry, and marketing and price policies, with research, generated the "benefits" of technology adoption. Therefore, the costs of these non-research programs are also included in the analysis.

5.4.1. Financial analysis

There are two steps in calculating the ARR, financial and economic analysis. The financial analysis considers the investment from the individual participant's point of view, showing the profitability to farmers of adopting the new technology. Financial analysis also provides the base data for economic analysis. Separate budgets were constructed for the different farmer type/technology combinations using market prices, the prices actually received or paid by farmers, including taxes or subsidies. These data show the costs to farmers of investing in a new technology, and the relative attractiveness of the new compared to other technologies (Appendix 7, Tables 63-88).

5.4.1.1. Net margin analysis

Production cost data from Appendix 7 (Tables 63-88) were used to calculate net margins for different farmer/technology combinations. Complete results are presented in Tables 63-88, Appendix 7; results from selected years are summarized in Table 19, below. The net margin is the difference between income realized from maize sales and the cash expenses incurred in production.[3] Expenses include seed, fertilizer, pesticide, labor, oxen or machinery rental, and costs of packing and transportation to the point of sale. Land costs are considered fixed costs and excluded. In this analysis, all labor, including family labor, is valued at the daily rate for casual labor, since there is a shortage of agricultural labor in Zambia and alternative employment opportunities for unskilled labor are available. The net margin shows how much a particular enterprise will contribute to the overall cost of running the farm. Since maize is the main enterprise for small- and medium-scale farmers, and for many large farms, a positive net margin for maize usually means that the farm is profitable. The results show positive net margins for nearly all farmer/technology combinations in almost every year (1986-87, a drought year, is an exception), although real net margins generally declined from 1985-90 (Figure 15). In the late 1970s-early 1980s, SR52 and non-Zambian hybrids with fertilizer offered higher net margins than local varieties. After Zambian

---

[3] The analysis here is called a net, rather than gross, margin because some expense items were included that are normally excluded from gross margin analysis, e.g. labor, and some costs were excluded because information was unavailable. In gross margin analysis expenses that are considered to be fixed costs are excluded; labor often falls into this category in more developed countries. However, in Zambia the labor input varies significantly with the farming system and technology used, so it is considered a variable cost here. Because of the lack of information on equipment ownership, tractor or oxen traction services were consistently valued at their rental rates, although some, especially large farmers, may own their own equipment. In a gross margin analysis, only the operating costs would have been deducted, not the fixed cost of the equipment itself. Interest charges were also excluded because of lack of information. In general, every effort was made to include known variable costs. Where a choice had to be made, e.g., valuing equipment at a rental rate rather than at its operating cost, valuing family labor at a constant wage rate, we sought to err on the conservative side, choosing the costlier way to value an expense item so that the resulting profitability estimates would, if anything, be downwardly biased (Harsh, Connor and Schwab 1981, 190-193).

improved hybrids became available, they had consistently higher net margins than local, SR52 or non-Zambian improved varieties.

Another measure of the attractiveness of technology adoption to farmers is break-even yield, the minimum yield required to just pay variable costs. Break-even yield is calculated by dividing total variable cost by product price. Break-even yields are lowest for technologies with the least costly input requirements, e.g., local varieties using no fertilizer and either hand hoes or oxen, reflecting the greater risk to farmers adopting technologies that require purchased inputs (Table 19).

The net margin return on variable cost is the net margin expressed as a percentage of variable costs, or the return left over after payment for seeds, fertilizer, oxen rental, etc., which can be applied to interest charges and other fixed costs, including the farmer's own labor and management. Through the mid-80s, the NM return on variable cost for Zambian varieties is14-24 percent higher than SR52 or non-Zambian hybrids, and 30-40 percent higher than for local varieties. In 1989-90 and 1990-91, however, because of rising input prices, NM return on variable cost is highest for local varieties without fertilizer, with or without oxen. Large farmer NM return on variable cost is much lower than for small/medium farmers. Returns for large farmers fluctuate, but show a general declining trend through the 1980s.

The net margin return to labor is calculated by adding the cost of labor back to the net margin and dividing the new net margin by the total number of labor hours. As a measure of the relative efficiency of labor use, the NM return to labor is especially important for small/medium farmers, who because of severe labor shortages need to make the best possible use of labor that is available. Comparing like systems, e.g., no oxen with fertilizer, and oxen with fertilizer, Zambian improved varieties consistently give the highest returns to labor in each year (Table 19).

In summary, the analysis of financial returns to farmers suggests that all types of maize production were profitable for small/medium and large farmers during the 1980s and early 1990s, except in drought years, although real net margins declined from 1985-90. After Zambian improved varieties became available, their net margins were consistently higher than other maize varieties. The inherent risk to small/medium farmers of adopting technology requiring purchased inputs was lessened because of the administered product and input pricing and marketing system as well as the excellent fertilizer response and drought tolerance of Zambian hybrids. Finally, the returns to labor analysis indicates that small/medium farmers can improve returns to scarce labor through adoption of oxen and fertilizer with local, SR-52 and non-Zambian hybrids, but adoption of Zambian improved varieties consistently gives the highest return.

5.4.1.2. Estimation of program benefits and costs

A quantitative assessment of the financial costs and benefits of research and related investments was made by establishing, for the with and without program cases, the market value of maize production, the production costs associated with each technology type (see 5.4.1.1.) and the costs of carrying out the various programs. Net benefits were calculated for each year by estimating the additional production value gained because of program implementation, and subtracting from this the total additional production and program costs incurred in the with-program case.

Total maize area is assumed to be the same in both with and without scenarios, although this assumption will be varied in chapter 6. Total estimated area under

Table 19: Financial returns to maize adoption

	SMALL/MEDIUM FARMERS										LARGE FARMERS	
	Local, no oxen, no fert.	Local, no oxen w/fert.	Local, oxen, no fert.	Local, oxen, w/fert.	SR52, non-Zam, no ox, no fert.	SR52, non-Zam, no ox, w/fert.	SR52, non-Zam, w/ox, no fert.	SR52, non-Zam, w/ox, fert.	Zambian imp, no ox, w/fert.	Zambian imp, w/ox, fert.	SR52, non-Zam	Zambian imp
1981-2												
Net Margin (NM)	74.84	89.41	79.26	94.99	80.11	122.72	84.54	128.3			568.29	
NM (real), 1985=100	167.4	200.0	177.3	212.5	179.2	274.5	189.1	287.0			1271.3	
Break-even yield	0.27	0.56	0.25	0.53	0.33	0.63	0.31	0.60			2.44	
NM return on variable cost (%)	154.49	89.22	180.04	100.38	134.78	109.61	153.64	120.61			131.10	
NM return to labor (ZK/day)	1.54	1.58	2.10	2.14	1.61	1.96	2.21	2.68			568.87	
1985-6												
NM	522.92	808.72	549.55	842.43	605.12	1081.62	631.74	1115.32	1218.57	1252.27	1425.71	1944.37
NM (real) 1985=100	522.9	808.7	549.6	842.4	605.1	1081.6	631.7	1115.3	1218.6	1252.3	1425.7	1944.4
Break-even yield	0.52	0.79	0.47	0.73	0.57	0.86	0.53	0.80	0.87	0.81	3.32	3.36
NM return on variable cost (%)	166.02	168.47	190.58	188.74	173.78	206.99	196.44	228.16	230.27	252.73	70.33	94.74
NM return to labor (ZK/day)	10.24	12.63	14.11	17.35	11.30	15.69	15.69	21.82	17.23	24.07	1429.25	1947.91
1987-8												
NM	641.73	913.55	689.79	974.42	735.92	1272.79	783.98	1333.66	1465.41	1526.29	1023.18	1366.56
NM (real) 1985=100	295.5	420.6	317.6	448.6	338.8	586.0	360.9	614.0	674.7	702.7	471.1	629.2
Break-even yield	0.64	1.07	0.59	1.0	0.72	1.17	0.67	1.10	1.18	1.11	4.50	4.5
NM return on variable cost (%)	112.58	96.14	132.15	109.56	114.66	122.58	132.03	136.44	139.54	154.28	25.59	33.99

	SMALL/MEDIUM FARMERS										LARGE FARMERS	
	Local, no oxen, no fert.	Local, no oxen w/fert.	Local, oxen, no fert.	Local, oxen, w/fert.	SR52, non-Zam, no ox, no fert.	SR52, non-Zam, no ox, w/fert.	SR52, non-Zam, w/ox, no fert.	SR52, non-Zam, w/ox, fert.	Zambian imp, no ox, w/fert.	Zambian imp, w/ox, fert.	SR52, non-Zam	Zambian imp
1988-89												
NM	845.15	1285.04	905.14	1365.04	968.0	1790.84	1028.0	1870.84	2070.26	2150.26	3273.99	3832.82
NM (real) 1985=100	250.2	380.4	268.0	404.1	286.6	529.9	304.3	553.8	612.9	636.5	969.2	1134.6
Break-even yield	0.61	0.95	0.57	0.90	0.70	1.05	0.65	0.99	1.06	1.00	3.30	3.31
NM return on variable cost (%)	99.28	97.05	114.39	109.72	99.85	122.73	113.03	135.65	140.70	154.54	71.59	83.36
NM return to labor (ZK/day)	20.84	24.44	27.41	32.38	22.41	30.12	29.77	40.67	33.26	45.25	3283.99	3842.82
1989-90												
NM	1847.94	1748.81	1787.94	1718.80	2072.29	2679.87	2012.29	2649.87	3199.43	3169.43	2015.78	3544.76
NM (real) 1985=100	278.6	263.6	269.5	259.1	312.4	404.0	303.3	399.4	482.3	477.8	303.9	534.3
Break-even yield	0.43	1.01	0.45	1.02	0.5	1.1	0.52	1.11	1.11	1.12	5.02	5.05
NM return on variable cost (%)	135.68	54.85	125.73	53.41	130.27	77.41	121.90	75.88	91.54	89.91	12.72	22.24
NM return to labor (ZK/day)	38.69	34.65	49.38	43.18	41.57	45.11	53.70	58.44	50.95	66.96	2030.78	3559.76
1990-91												
NM	4934.53	6207.04	4817.29	6129.8	5436.83	8230.39	5319.59	8153.15	9341.94	9264.70	10512.62	13142.4
NM (real) 1985=100	294.7	370.7	287.7	366.1	324.7	491.5	317.7	486.93	557.93	553.3	627.8	784.9
Break-even yield	0.31	0.72	0.33	0.74	0.38	0.80	0.40	0.82	0.81	0.82	3.76	3.77
NM return on variable cost (%)	286.94	154.11	262.24	149.33	256.61	184.37	237.91	179.53	208.0	202.79	50.29	62.68
NM return to labor (ZK/day)	83.26	89.74	112.64	120.49	89.70	112.48	122.30	153.66	124.97	171.88	10532.6	13162.4

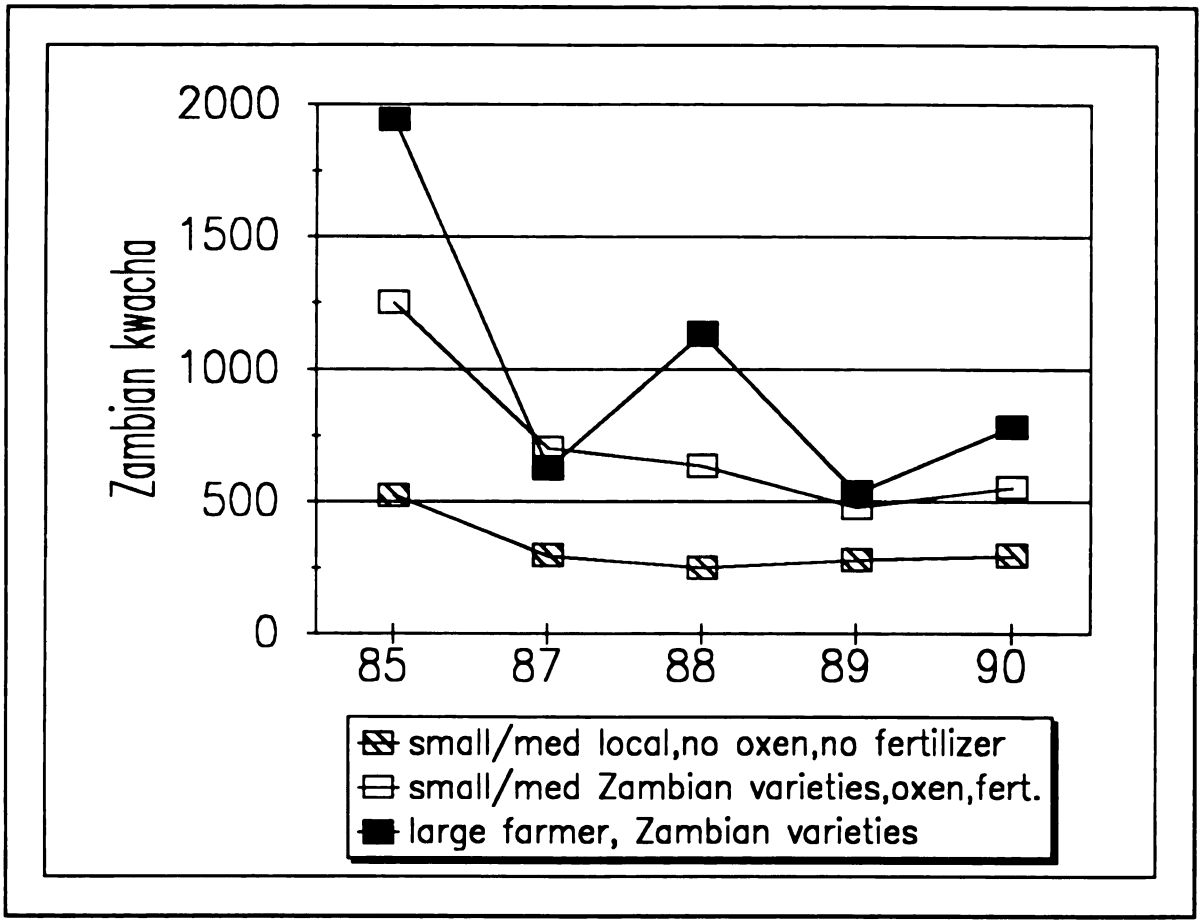


Figure 15: Real net margins, 1985-90

improved maize from 1983-2001 is shown in Table 12 (Chapter 4). The 1983-92 estimates are based on MSU/MAFF/RDSB Maize Adoption Survey data. For 1993-2001, it is assumed that the adoption rate remains constant at the 1991-92 level.

Maize yields and production levels differ between the with and without scenarios. In the without-program case, it is assumed that (1) large farmers have access to fertilizer for maize, but small/medium farmers do not; and (2) Zambian improved varieties are not available. Production and yield levels for the with-program scenario are calculated from actual production data, since programs to support fertilizer distribution as well as maize research were in place by the late 1970s. These maize yields were adjusted downwards for the without-program case based on estimates of variety-fertilizer response in Region II (Table 20). It was assumed that, in the with-program case, SR52 and non-Zambian improved hybrids were fertilized at the full recommended level, and half the local maize area was fertilized at the full level. In the without case, no fertilizer is available to small/medium farmers, but large farmers continue to fertilize at the same level as the with-program case. For small/medium farmers, this implies a 42.3 percent yield decline from the with-program to without-program case on half of local maize area, a 37.5 percent decline in SR52 yields, and a

Table 20: Small/medium farmer maize yields under different fertilization levels

Variety	Local			SR52			MM603/604			Zimb. hybrids[1]		
Fert. level	0	med.	full[2]	0	med.	full	0	med.	full	0	med.	full
tons/ha												
Reg. I	.7	1.3	1.5	.5	1.5	1.6	1	2.4	2.7	1	2.4	2.7
Reg. II	1.5	2.3	2.6	2.0	2.9	3.2	2.0	3.2	3.5	2.0	3.2	3.5
Reg. III	.7	1.4	1.6-1.7	.8	1.5	1.7	2.0	2.5	2.7	1.8	2.3	2.5

Source: personal communications, Gibson, November 1993; Waddington, February 1994
[1] R201, R215
[2] Full recommended level

42.9 percent decline in Zimbabwean hybrid yields. Assumptions regarding area, yield, and the value of maize production in with and without scenarios are detailed in the financial analysis benefit-cost tables, Tables 98-99 (Appendix 11).

Actual and estimated program expenditures for maize-related research, extension, seed and marketing made by GRZ and donor agencies, in current Zambian kwacha, are assembled in Appendices 2, 8, and 9, and summarized in Tables 98 and 99 (Appendix 11). Budget and expenditure data for agencies or programs were not reported as expenditures attributable to a particular crop such as maize. Methods used to estimate the proportion of expenditures on maize-related activities varied and are detailed in footnotes to the tables of Appendices 2, 8 and 9.

Research and seed industry expenditures included maize-research related expenditures incurred by MAFF since 1978 on salaries, general operating overheads and operating expenses for maize-related programs; USAID expenditures on ZAMARE between 1983-88; SIDA and Zamseed expenditures on research and seed beginning in 1979, FAO/UNDP program costs from 1978-92; and CIMMYT expenditures beginning in 1980 (Appendix 2).

Included in extension expenditures beginning in 1978 were MAFF extension-related staff salaries and overheads, operating expenses for maize-related programs such as Lima, radio extension programs; and portions of Integrated Rural Development Programs (IRDP) that included maize technology dissemination as a major element (e.g., direct support to extension, provision of fertilizer, rural road rehabilitation) funded by SIDA, NORAD, FINNIDA, IFAD, UK, and the German Government. For extension and IRDP expenditures there was no clear guideline for estimating maize-attributable costs, and a relatively conservative proportion of total expenditures, 40 percent, was chosen after discussions with MAFF personnel (Appendix 8).

Expenditures on marketing, beginning in 1978, included staff and operating expenses of the GRZ Department of Cooperatives and Marketing, an array of subsidies to Namboard, the Cooperative Unions and millers for input and maize marketing, milling, and consumer price subsidies. Also included are expenditures by SIDA in support of cooperative development, including training, construction of marketing sheds and other infrastructure, and technical assistance (Appendix 9).

5.4.2. Economic analysis

While the financial analysis takes the individual farmer's viewpoint, the economic analysis considers the impact of program costs and benefits on society as a whole. In practice, this involves adjusting financial prices to economic prices, in two steps. First, taxes and subsidies, which were counted in the financial analysis, are now treated differently depending on their function (Gittinger 1982, 247).

Taxes are part of the income generated by the project, transferred to the government for later distribution to the society. Therefore they are not treated as costs (as in the financial analysis), but as part of the benefits generated by the program.

Subsidies, depending on how they are used, may either be treated as costs or excluded entirely from the economic analysis. Some maize subsidies paid by the government or donors, such as those to establish and maintain the cooperative marketing system, were used by the government to provide local level marketing services and are treated as a cost to the society, since they represent an expenditure required in order for the whole maize program to operate. In financial analysis, these subsidies are a benefit received by the individual, e.g., as higher farm-level prices for maize in remote areas because the government pays the extra transportation costs. Other subsidies, such as the price differential subsidy paid to Namboard and the cooperative unions to cover the difference between the Namboard/PCU purchase and selling price of maize, are considered direct income transfers (here, to consumers) rather than a cost of production or marketing, and are not included in the economic analysis. These types of subsidies represent shifts in claims to goods and services from one group to another, and do not reflect a change in national income (Gittinger 1982, 19, 50). Details on how marketing subsidies were categorized in each year are given in the footnotes to Table 92 (Appendix 9).

The second step in financial to economic price conversion is adjustment for "distortions" that affect the market prices of traded items. In Zambia, "distortions" included subsidies, taxes, and artificially imposed official exchange rates. To remove the impact of the distortions, border prices are substituted for administered prices for maize and fertilizer, after adjustment for domestic transportation and marketing costs between the point of import or export and the project area.

The economic analysis in this chapter does not specifically address the issue of income distribution, other than calculating producer and consumer surplus at the national level. Here, what is counted as a benefit is any addition to national income, no matter who receives it. When income distribution is not explicitly considered, e.g., by assigning different weights to benefits or costs received or incurred by different population sectors, the effect is tacit acceptance of the current structure of income distribution as it exists in the society (Gittinger 1982, 20). This recognition is important because what are called "distortions" may represent an intentional weighting scheme for income distribution between different groups that perhaps should be incorporated in ARR analysis. This aspect, and other topics in income distribution, will be explored in Chapters 6 and 7.

5.4.2.1. Conversion of financial to economic prices

In the Zambia study, four steps were followed to convert financial to economic prices: (1) estimating the shadow exchange rate; (2) establishing what proportion of costs represent tradeable items; (3) converting that amount to local currency terms using the shadow exchange rate; and (4) estimating the import parity price for maize and other commodities such as fertilizer and seed whose market prices are significantly distorted, and substituting the import parity price for the market price in the economic analysis.

5.4.2.2. Shadow exchange rate

The cross-constant real ZK/USD rate is used as the shadow exchange rate (SER) to convert kwacha to dollar values in the economic analysis. Calculation of the SER is shown in Table 94 (Appendix 10). This method for estimating the SER follows Harber (1991,1992). The SER is based upon purchasing power principles, using a projection of what was considered an appropriate exchange rate in September 1985, a time when an auction system for foreign exchange briefly functioned. Harber (1991) calculated the "appropriate" exchange rate as follows:

> The parallel rate in September 1985 was approximately ZK8/USD1. A general rule of thumb to use in estimating appropriate or equilibrium exchange rates is to deduct 20-30 per cent from parallel rates to remove the risk premium included in the parallel rate. Assuming a 25 per cent risk premium in September 1985, the "appropriate" exchange rate for that time is estimated at ZK6/USD1 or ZK6.17/SDR1. To arrive at the "appropriate" rate for other periods, this rate is adjusted according to movements in Zambia's consumer prices and the Industrial Country price index from International Financial Statistics to find the nominal exchange rate that would maintain a constant real exchange rate of ZK6/USD1 in September 1985." (Harber 1991,10)

The ZK/SDR rate is converted back to U.S. dollar terms using the USD/SDR exchange rate to arrive at the cross constant real ZK/USD exchange rate, used here as the SER. T

USD again

rate calcula

The

research, t

financial a

show the p

prices usin

5.4.2.3. I

Th

that the of

of produci

maize was

Zambia w

in maize r

productio

the impor

which the

(Gittinger

Ca

10). In n

to Zambi

to the Zir

the SER. The cross constant exchange rate is used to eliminate the fluctuations of the USD against other (non-kwacha) currencies that would be reflected in a direct USD/ZK rate calculation.

The tables in Appendices 2, 7, 8, and 9 (GRZ and donor expenditures on maize research, the seed industry, extension, marketing, and production costs) show both financial and economic prices for expenditure items. Footnotes to the economic tables show the proportion of tradeable goods in each category that was converted to economic prices using the SER.

5.4.2.3. Import parity prices

The presence of both government subsidies and implicit taxes on maize means that the official maize price set by the government does not reflect the real resource cost of producing maize in Zambia. For the economic analysis, the import parity price of maize was substituted for the administrative price used in the financial analysis. Since Zambia was a net maize importer in most years between 1978-92, and the investments in maize research and dissemination were primarily intended to increase maize production for domestic consumption to replace imported maize, it seems logical to use the import rather than the export parity price. The objective is to find the price at which the import substitute can be sold domestically if it has to compete with imports (Gittinger 1982, 80).

Calculation of the import parity price for maize is shown in Table 95 (Appendix 10). In non-drought years, Zimbabwe has been the principal supplier of imported maize to Zambia, and the FOB price at the point of export from the Zimbabwean depot closest to the Zimbabwe/Zambia border is used as the basis for the calculation. Transport and

handling co
and Livings
border pric
The financ
percent of
at the SER

Th
and marke
Livingstor
marketing
market.
at the nea
intra-prov
price. F
each prov

T
of the m
The imp
Nitroger
national
Europe.
constant
calculat

handling costs are added to arrive at the border price. Transportation to Lusaka, Ndola and Livingstone, and insurance and unloading costs, estimated at 10 percent of the border price, are added to get the CIF price at each of these major consumption centers. The financial transportation rates are adjusted to economic prices by assuming that 75 percent of the cost of rail and truck transport is composed of tradeable goods and valued at the SER.

The alternative to domestic production of maize is importing it (from Zimbabwe) and marketing it directly at one of the major consumption centers, Ndola, Lusaka or Livingstone. The price the Zambian farmer would receive is the price at the nearest marketing center minus the cost of transporting the maize from his farm gate to the market. Farmgate prices are estimated for each province, starting with the market price at the nearest major consumption center, and subtracting the costs of 100 kilometers of intra-provincial transport and handling, again assumed to be 10 percent of the border price. Finally, an average farmgate price for the country was calculated by weighting each province's farmgate price by its national market share for each year.

Table 96 (Appendix 10) shows the calculation of the import parity price for two of the most widely-used fertilizers for maize, Compound D and Ammonium Nitrate. The import parity price is used because Zambia is a net importer of fertilizer: the Nitrogen Chemicals of Zambia (NCZ) fertilizer plant supplies less than 50 percent of national requirements (GRZ 1989, 200). Most of the commercial imports come from Europe. Starting from the CIF Lusaka price (available for 1988/89, and assumed constant for other years), the price of fertilizer at rural depots in each province was calculated by adding transport and handling costs (assumed to be 10 percent of the

Lusaka (

intraprov

by weigh

In

maize hy

prices we

Zimbabw

of rail tr

internal t

that most

kilometer

5.4.3. Re

Ta

the econo

methods,

additional

additional

implemen

amount of

any divide

In

years, are

to make th

Lusaka CIF price) from Lusaka to each provincial capital plus 100 kilometers of intraprovincial transportation. A countrywide average rural depot price was estimated by weighting each province's depot price by its share of national fertilizer consumption.

Import parity prices for the most commonly used Zimbabwean short-season maize hybrids, R201 and R215, are calculated in Table 97 (Appendix 10). Border prices were estimated by adding transport and handling charges from the nearest Zimbabwean depot. A CIF Lusaka/point of sale price was obtained by adding the cost of rail transportation from the border to Lusaka, then estimating additional insurance, internal transport and unloading costs as 20 percent of the border price. It is assumed that most imported seed is used in Central and Southern Provinces, within 100 kilometers of Lusaka.

5.4.3. Results of the economic rate of return analysis

Tables 100-103 (Appendix 11) show the data and calculations used in estimating the economic ARR for both the benefit-cost and Akino-Hayami methods. In both methods, a net benefit stream is derived for each year by estimating the value of the additional production generated in the with-program case, and subtracting from this the additional production and program costs incurred in adoption of the new technology and implementation of the programs supporting it. The net benefit stream represents the amount of resources available to pay back the investment (return of capital) and to pay any dividends for the use of resources in the project (return to capital).

In calculating the ARR, these annual net benefit streams, occurring in different years, are discounted to their "present worth." The ARR is the discount rate required to make the net present worth equal to zero, representing the maximum interest that a project(s

expenses

conside

I

calculate

fertilized

Zambian

Zambian

A

Table 21

(projecte

condition

return is

the adopt

W

new tech

marketing

Akino-Ha

a positive

the Akino

expenditu

governme

project(s) could afford to pay for resource inputs to recover its investment and operating expenses and still just break even (Gittinger 1982, 480-1). A project(s) is generally considered economically successful if the ARR exceeds the opportunity cost of capital.

In the Akino-Hayami method, the K-factor (shift in the production function) is calculated from (1) the proportion of total maize area that represents small/medium fertilized maize area plus (2) the proportion of total maize area planted to improved Zambian varieties, multiplied by (3) the yield gain from small/medium fertilizer use and Zambian improved maize varieties.

A summary of the results of the economic rate of return analysis is presented in Table 21. Rates of return were calculated for two periods, 1978-91 and 1978-2001 (projected), under a variety of cost scenarios. Estimating the ROR under different cost conditions is one type of sensitivity analysis, testing the hypothesis that the rate of return is sensitive to the inclusion of costs other than research that are associated with the adoption of new technology.

When all costs were included in the analysis (additional production costs of the new technology, and maize-related costs of research, extension, the seed industry and marketing) the ROR for the 1978-91 period was negative for both the benefit-cost and Akino-Hayami methods of calculation. Extending the analysis period to 2001 results in a positive ROR of 49.3 per cent using the benefit-cost method, and 42.1 per cent using the Akino-Hayami approach. The critical difference is the assumption that GRZ expenditures on maize marketing drop sharply after 1992, according to the new government's plan to completely liberalize the sector.

were s

periods

method

when a

and res

103.5 p

Table 2

Inclu prod seed
Inclu resea
Inclu resea
Inclu resea only

isolatio

ROR to

are cou

percent

When marketing costs were excluded from the calculation, the rates of return were sharply positive. Using benefit-cost analysis, for both the 1978-91 and 1978-2001 periods, RORs are all over 200 percent. RORs generated using the Akino-Hayami method were slightly lower. For the 1978-91 period, RORs ranged from 99.2 percent when all costs except marketing were included, to 113.9 percent, when only production and research costs were included. For the longer period 1978-2001, RORs ranged from 103.5 percent to 116.6 percent.

Table 21: Summary of results, economic rate of return (ARR) analysis

	Benefit-Cost Method		Akino-Hayami Method	
	1978-91	1978-2001	1978-91	1978-2001
	(percent)		(percent)	
Including all costs (additional production, research, extension, seed, marketing costs)	negative	49.3	negative	42.1
Including additional production, research costs only	200+	200+	113.9	116.6
Including additional production, research, extension costs only	200+	200+	101.8	105.8
Including additional production, research, extension and seed costs only	200+	200+	99.2	103.5

The Zambia results illustrate the danger in evaluating the impact of research in isolation from complementary support organizations. If the common assumptions for ROR to research studies are adopted, and only additional production and research costs are counted, the resulting ROR is extremely high, from 113.9 percent to over 200 percent. This compares very favorably with RORs calculated for research alone in other Afr

(Abidogu

149:1 (N

investmen

cent. Lo

research

Th

organizati

negative.

fact. the u

consumed

phaseout

5.4.4. Se

Se

regarding

method a

the elastic

assumptio

the ARR

and dema

T

small/me

other African countries. Cocoa research in Nigeria had a return of 42 per cent (Abidogun 1982), the ratio of benefits to costs of African cassava pest research was 149:1 (Norgaard 1988), and Evenson (1987) estimated that the overall ROR to investments in maize and staple crop research in Africa from 1962-80 was 30-40 per cent. Looking at the Zambian ROR, the conclusion would be that investments in maize research have been a tremendous economic success.

The picture changes completely when the costs of all complementary organizations are included in the analysis. For the 1978-91 period, the ROR is negative, suggesting that the general maize development program was uneconomic. In fact, the unsustainability of the maize marketing program, which by the late 1980s consumed almost 17 percent of the total government budget, resulted in its near total phaseout after the Chiluba government came to power in late 1991 (GRZ 1990, 15).

5.4.4. Sensitivity analysis

Sensitivity analysis, varying supply and demand elasticities, and assumptions regarding maize area in the 1993-2001 period, were carried out using the Akino-Hayami method and are summarized below in Table 22. In the base Akino-Hayami scenario, the elasticity of supply is .65 and the elasticity of demand is .10. Changing these assumptions did not change the ARR significantly, although all of the variations lowered the ARR somewhat, with the lowest ARR resulting when supply was perfectly inelastic and demand perfectly elastic.

The ARR was more sensitive to changes in the assumptions regarding total small/medium maize area in the post-market liberalization phase, from 1993-2001.

Table 22: ARR sensitivity analysis

	Elasticities	1993-2001 Area

Table 22: ARR sensitivity analysis

	Elasticities						1993-2001 Area	
	$\epsilon=0, \eta=1$	$\epsilon=0, \eta=1$	$\epsilon=.2, \eta=.4$	$\epsilon=.2, \eta=.4$	$\epsilon=.8, \eta=.6$	$\epsilon=.8, \eta=.6$	.24 mln ha	.74 mln ha
	78-91	78-01	78-91	78-01	78-91	78-01	78-01	78-01
All costs	negative	33.05	negative	38.3	negative	38.0	31.5	51.8
Prod. research costs only	87.8	93.2	100.9	104.7	100.0	104.0	116.0	118.0
Prod., research, extension costs only	79.1	86.1	90.7	96.0	90.0	95.4	104.8	107.9
Prod., research, extension, seed costs only	76.8	84.3	88.3	94.1	87.6	93.4	102.4	105.9

When sma

costs drop

million he

5.4.5. Di

Th

producer a

programs.

to S′ is re

BP_nP_0C. a

assume ma

Table 23 s

technology

the very lo

demand be

In

Similar to

governmen

period. If

supply fron

Q'_nQ_0. Wi

AC0. AC0

assumption

does not ch

When small/medium area was lowered from .44 to .24 million hectares, the ARR for all costs dropped to 31.6 percent. With a rise in small/medium maize area from .44 to .74 million hectares, the all-cost ARR rises to 51.8 percent for 1993-2001.

5.4.5. Distribution of benefits between producers and consumers

The Akino-Hayami formulas were used to calculate national-level changes in producer and consumer surplus resulting from the implementation of maize-related programs. In Figure 14, the change in consumer surplus from a shift in supply from S to S′ is represented as area ABC + area BP_nP_0C, producer surplus as area AC0 - area BP_nP_0C, and total social benefit as area ABC + area AC0. These surplus calculations assume market equilibrium and no maize imports. Under the assumption of autarky, Table 23 shows that consumers would have been the only beneficiaries from maize technology transfer, with producers made worse off. This result occurred because of the very low price elasticity of demand for maize in Zambia; had price elasticity of demand been infinitely elastic, producers would have captured all gains.

In fact, Zambia was not in autarky, but imported maize from 1978 until 1988. Similar to the situation Akino and Hayami analyzed in Japan (1975), the Zambian government sought to maintain a low consumer maize price, P_0, throughout the analysis period. If maize research and technology transfer programs had not shifted domestic supply from S to S′, the government would have had to import maize in the quantity Q'_nQ_0. Without the domestic supply shift, producer surplus would have decreased by AC0. AC0 represents producers' gains from maize technology programs under the assumption of a price stabilization policy through imports. Since the consumer price does not change significantly with the increase in domestic supply, the producer gain in

effect re
programs
GRZ for
saved, th
accounte
net econ
following
1989-90,
would ha
demand,

5.4.6. R

Th
of comple
developm
organizati
share the
technolog

It
accounted
lowers the

[4] ACE
AOC = K
COE = K*
Q'ₐ= total

effect represents the total social benefit from maize research and technology transfer programs (Akino and Hayami 1975). The increase in domestic production also saved GRZ foreign exchange in the amount of ACQ'_nQ_0. Although foreign exchange was saved, the costs of producing maize domestically rather than importing must be accounted for, and are represented by the area under S', or $AQ_0Q'_n$ E. Therefore, the net economic benefit to the society is area ACE[4]. GRZ continued to import maize following the introduction of new maize hybrids, but imports declined after 1984 and, in 1989-90, the country exported 270 million tons. This implies that in some years, S_0 would have been located to the left of A, the equilibrium of total market supply and demand, and in later years to the right of A.

5.4.6. ROR results in the context of comparative advantage

The argument supporting the calculation of an ROR to research plus a package of complementary organizations is that these investments together facilitate technology development and acceptance by farmers. The contributions of non-research organizations to the technology process are significant and difficult to disaggregate; they share the credit for the benefits arising from development and adoption of new technology.

It follows that the maize-related costs incurred by these organizations must be accounted for. The inclusion of marketing costs in the Zambian case dramatically lowers the ROR to the package of investments in maize variety development and

[4] ACE = A0C-C0E, where
AOC = $K*P_0Q_0$;
C0E = $K*P_0Q'_n$; and
Q'_n= total production in the without-research, other policies scenario

Table 23: Producer and consumer benefits from maize research and related programs 1978-2000

million ZK

	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94

Table 23: Producer and consumer benefits from maize research and related programs 1978-2000

million ZK

	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2000/01
Autarky																
Producer gains	-30.4	-24.0	-89.8	-85.0	-92.0	-116.8	-206.5	-384.5	-372.6	-926.2	-1829.4	-2077.2	-5332.0	-584.5	-38245.0	-23567.7
Consumer gains	60.3	47.0	181.9	169.4	183.3	234.0	420.1	812.1	784.0	2014.9	4094.8	4554.1	11601.8	1106.9	84384.8	49967.2
Total social benefits	29.8	23.0	92.1	84.3	91.2	117.2	213.5	427.7	411.4	1088.7	2265.4	2476.9	6269.8	522.3	6139.8	26400.0
Open Economy																
Tot. social benefit=																
Producer gains	29.4	20.0	74.9	70.9	76.7	97.3	172.1	320.4	310.5	771.9	1524.5	1731.0	4443.4	487.1	31871.0	19640.0
Foreign exchange saving	41.9	33.0	123.5	117.0	126.6	160.6	284.0	528.7	512.3	1273.6	2515.5	2856.2	7331.6	803.8	52587.1	32405.6
Net societal benefit	4.2	2.8	15.4	12.4	13.8	18.2	41.4	94.7	83.8	256.4	556.9	628.4	1659.9	26.5	11985.1	6724.7

adoption,

organizati

have also

the dissem

rarely spr

to researc

attributing

area) to th

joint resul

as well as

ROR calc

rate of ret

benefits of

research in

signals, if

farmers th

(in market

It d

other techn

Zambia. A

had little in

pivotal, and

subsidy prog

adoption, that is, investments in research, extension, the seed industry and marketing organizations. In other developing countries investments in technology development have also been accompanied by investments in an organizational infrastructure that aids the dissemination and adoption of the technology after it is developed. Technology rarely spreads on its own. However, when other studies have calculated rates of return to research without accounting for complementary investments, they are in effect attributing all of the benefits of technology adoption (increased yields and/or increased area) to the research organization alone. This study argues that these benefits are the joint result of investments in extension, the seed industry and marketing organizations, as well as research. Failing to include these costs as well as those of research in an ROR calculation is, at best, inaccurate. The Zambia study suggests that the results of rate of return to research studies are overstated if they calculate an ROR counting the benefits of technology adoption but only the costs of research. At worst, crediting research investments alone with a high ROR can send dangerously misleading policy signals, if it masks additional investments needed to facilitate adoption of technology by farmers that in turn affect economic feasibility. In Zambia, these additional investments (in marketing) made the entire maize investment package uneconomic.

It does not necessarily follow that the inclusion of complementary investments in other technology impact assessments will have such a dramatic effect on returns as in Zambia. Accounting for the additional costs of extension services and the seed industry had little impact on the ROR in Zambia (Table 21). Only the marketing programs were pivotal, and poor management made the maize marketing, input and consumer price subsidy programs in Zambia more expensive than they might have been.

E

(World I

controls,

and away

productio

in Table 2

Table 24:

Year
1966/7
1979/80
1984/85
1985/86
1986/87
1987/88
1988/89
1989/90

Source: W

inputs were

have distorti

1984-85 seas

of easier acc

these calcula

products for t

Beyond the budgetary impact of the maize marketing programs, a recent study (World Bank 1992) supports the contention that the impact of past government price controls, subsidies and taxes was to skew smallholder labor and land use toward maize and away from other crops. Distortion coefficients were derived from a multiple crop production function within a static equilibrium framework, and the results are presented in Table 24. A distortion coefficient greater than one indicates that less labor and land

Table 24: Factor (land and labor) distortion coefficients, 1966-90

Year	Maize	Virginia tobacco	Seed cotton	Sunflower	Soybeans	Groundnuts
1966/7	0.08	12.50	0.71	0.24	0.20	0.33
1979/80	0.00	1.15	1.96	0.29	0.69	3.33
1984/85	0.22	2.00	3.23	1.41	1.35	4.35
1985/86	0.68	11.11	4.00	8.33	5.56	1.79
1986/87	0.76	14.29	7.69	5.88	5.26	1.69
1987/88	0.45	25.00	14.29	16.67	12.50	4.00
1988/89	0.75	25.00	20.00	12.50	14.29	6.67
1989/90	1.52	33.33	33.33	10.00	11.11	10.00

Source: World Bank 1992, 41

inputs were being used than if no market distortions existed. All crops except maize have distortion coefficients greater than one in almost all years, especially after the 1984-85 season. The results might be even more skewed in favor of maize if the effects of easier access to product markets, extension advice, credit and seed were included in these calculations. Since the distortion coefficients also represent marginal value products for the individual crops, and these are not equal, this suggests that the smallholc

1992:40-

Re

25) also il

the cost in

substitutio

Table 25:

Source: Worl
aAssumes sma

A DRC below

and production

DRCs for Zam

smallholder agriculture sector in Zambia is not allocatively efficient (World Bank 1992:40-41).

Results of a domestic resource cost (DRC) analysis from the same study (Table 25) also illustrate the impact of policies on allocative efficiency. The DRC measures the cost in domestic resources to produce a unit of output for export or import-substitution.

Table 25: Effect of overvalued currency on domestic resource cost estimates, 1989

Commodity[a]	Exch. rate: ZK25= USD1	Exch. rate: ZK40=USD 1
Cassava	.70	0.44
Cotton	0.12	0.07
Groundnuts (Chalimbana)	0.70	0.44
Groundnuts (Makuru Red)	0.42	0.27
Maize	0.84	0.21
Millet	1.32	0.83
Paddy Rice	0.68	0.47
Sorghum	1.15	0.72
Soybeans	1.43	0.91
Sunflower	0.48	0.31
Wheat, rainfed	0.95	0.57
Beef cattle, native	0.54	0.26

Source: World Bank 1992, 45-46
[a] Assumes smallholders use existing technology

A DRC below one means that the commodity is being produced relatively efficiently, and production could be expanded for export or import substitution. Table 25 shows DRCs for Zambian smallholders under two scenarios, using the official exchange rate and one

have a c

rates, bu

adjusted

Zambian

sunflowe

delayed b

Ba

from the

issues. O

investment

associated

level of co

marketing a

organization

The

in one sub-s

---

[5] The Za
for maize. T
maize, adjus
accounting fo
additional co
estimates, the
adoption. In
implication is
programs -- w
efficiently imp
costs" require

and one adjusted for overvaluation.[5] The analysis shows that Zambian smallholders have a comparative advantage in producing almost all commodities under both exchange rates, but comparative advantage is strengthened markedly when the exchange rate is adjusted to market levels, by an average of about 40 percent (World Bank 1992). Zambian smallholders have strong comparative advantage in beef cattle, cotton, sunflower, and groundnuts, all of which are exportable, but diversification has been delayed because of the policy and organizational bias favoring maize production.

Basing policy recommendations on the ROR to research programs in isolation from the effects and costs of complementary organizations risks missing critical side issues. One set of issues concerns how dependent the success of the research investment is upon simultaneous investments in related organizations, and their associated costs. In Zambia, the rapid uptake of the new maize varieties, and the high level of contacts between improved maize adopters and extension and input/product marketing agencies, points to the critical importance of policies and complementary organizations in facilitating technology adoption.

The second set of issues involves allocative efficiency, the impact of investments in one sub-sector upon the efficiency of other sub-sectors. The distortion coefficient

---

[5] The Zambia ARR analysis incorporates an estimate of the domestic resource costs for maize. The use of economic (border) prices, including an import parity price for maize, adjusts for the effect of overvalued currency, as in Table 21. Beyond this, accounting for the costs of programs that facilitated adoption of technology reflects an additional component of "domestic resource cost" that is not included in traditional DRC estimates, the economic cost of implementing government programs that influence adoption. In the ex-post Zambia study, actual program costs were used. The implication is that a more realistic estimate emerges when the costs of supportive programs -- with the explicit acknowledgement that these programs may not be efficiently implemented -- are included as part of the package of "domestic resource costs" required to produce a commodity.

analysis c

been to sk

show that

crops besi

analysis confirms that the impact of government policies over the last two decades has been to skew incentives toward maize production. Domestic resource cost estimates show that Zambian smallholders have the potential to expand production of many other crops besides maize profitably.

6.1. I

that bro

isolated

policies

product r

Namboar

ensure an

(2) reduce

possibilitie

agriculture

the extensi

Party came

Dur

technology,

share of pro

maize comin

of the line-of

CHAPTER SIX

THE IMPACT OF POLICY INTERVENTIONS ON RETURNS TO INVESTMENTS IN RESEARCH

6.1. Introduction

Beginning in the 1970s, Zambia's government consciously implemented policies that brought farmers in the poorer, more remote Regions I and III, as well as more isolated areas of Region II, into commercial maize production for the first time. These policies -- pan-territorial, pan-seasonal pricing, and locally available credit, input and product marketing services -- were implemented by channeling subsidies through Namboard and the cooperative system. The dual objectives of this strategy were to (1) ensure and increase the supply of maize to the politically important urban centers, and (2) reduce the widening disparities in the society, in income and future development possibilities, that resulted from copper-led development and the concentration of agriculture along the rail corridor since colonial days. Political interest also motivated the extension of services to more remote rural areas: many leaders of Kaunda's UNIP Party came from Eastern Province (Bates and Collier 1993).

During the 1970s and 1980s, as a result of these policies and improving technology, the pattern of maize production changed. The small- and medium-scale share of production rose from 60 to 80 percent (GRZ 1990, 34), and the proportion of maize coming from remote provinces such as Northern and Eastern grew, while shares of the line-of-rail provinces, Central and Southern, declined (Table 3, Chapter 1).

suggest

farmers

Improved

extension

network

negative

Th

and produ

Region I a

leveled off

with the re

the governn

privately.

Central and

some outlyin

Chapter 1).

6.2. Impact

The A

technology wa

factor was the

economic in th

subsidies ended

Results from the MSU/MAFF/RDSB Maize Adoption Survey (Chapter 4) suggest that much of the increase in maize production from small- and medium-scale farmers was due to widespread adoption of improved maize varieties and fertilizer. Improved maize adopters in all regions made heavy use of marketing, credit and extension facilities. However, the cost of subsidizing fertilizer prices and the marketing network during the 1980s made the rate of return to the entire maize investment package negative during the period 1978-91 (Chapter 5).

The Zambian government's increasing inability to meet the costs of consumer and producer maize subsidies led to a deterioration in the quality of services available to Region I and III farmers in the late 1980s; adoption of improved maize in those areas leveled off after 1989-90 (Chapter 4). Liberalization of maize marketing began in 1992, with the result that local cooperatives in most areas were no longer authorized to buy on the government's behalf, nor could they access capital to purchase grain from members privately. The new policy led to a severe contraction of marketing services outside of Central and Southern Provinces, reflected in the decline of the national maize shares of some outlying provinces, e.g., Northern and Luapula, already in 1992-3 (Table 3, Chapter 1).

6.2. Impact of policies and organizations

The ARR analysis (Chapter 5) showed that the package of investments in maize technology was uneconomic from 1978-91, but economic from 1978-2001. The critical factor was the investment in marketing policies and organizations. The ARR turned economic in the longer period under the assumption that most government maize subsidies ended after 1992, and total maize area declined only slightly. This chapter examin

objecti

improv

organiz

more re

areas. T

of price

MSU/M

The sub-

revised A

without p

T

resemble

liberaliza

remote ar

conditions

prices. If

farmers m

for overall

improved r

examines the impact of marketing policies and organizations more carefully. The objective is to estimate what the adoption pattern, distribution of benefits and ARR from improved technology might have been in the absence of key marketing policies and organizations that encouraged commercial maize production by small/medium farmers in more remote areas.

To accomplish this, Zambia is disaggregated into eleven sub-regional analysis areas. The impact of research on production and distribution of benefits in the absence of price and marketing policies is simulated for each area, using primary data from the MSU/MAFF/RDSB Maize Adoption Survey, secondary data and sensitivity analysis. The sub-regional results are later aggregated to the national level and used to estimate a revised ARR in the absence of policies, and the distribution of benefits in the with- and without policy cases.

This analysis has more than historical relevance. The without-policy scenario resembles the situation facing remote farmers today, following maize market liberalization. In the short-term, liberalization has brought about marketing vacuums in remote areas which in some areas, e.g. Eastern Province, have created favorable conditions for private monopolists who pay lower than suggested government floor prices. If a more competitive private marketing structure does not evolve, remote farmers may move out of commercial maize production. What are the implications then for overall maize production, the ARR, and distribution of benefits from investments in improved maize technology development and dissemination?

6.3. Lit

6.3.1.

assumpt

that mos

are actu

distribut

therefore

target pr

governm

from res

governm

by as mu

interventi

Alston an

policies o

concludin

rates of i

productiv

Ti

the fertili

in encour

factors su

6.3. Literature review

6.3.1. Impact of policies on returns to research

The economic surplus approach to program evaluation often takes as an assumption that markets are in equilibrium (Figure 14, Chapter 5). However, the fact that most governments intervene in their agricultural sectors implies that these markets are actually not in equilibrium, or, if they are, that governments do not like the distributional consequences. The effects of government policy interventions should therefore be accounted for in ROR calculations. Comparing the impacts of quotas, target prices and production subsidies, Alston et al. (1988) found that the type of government intervention affects both the magnitude and the distribution of benefits from research. Oehmke (1988) concluded that when the costs and effects of government policies are not taken into effect, RORs to research may be overestimated by as much as 100 percent. Oehmke also suggests that the nature of the policy intervention affects the type of research projects chosen for the optimal portfolio (1991). Alston and Pardey (1993), on the other hand, found that the effects of commodity price policies on government and industry incentives to invest in agriculture were ambiguous, concluding that some factor other than price policy is more important in explaining low rates of investment in agricultural research generally and low rates of agricultural productivity growth in developing countries.

Timmer (1985) used econometric techniques to evaluate the economic impact of the fertilizer subsidy in Indonesia from 1968-82. The subsidy played an important role in encouraging farmers to use fertilizer more intensively, and, in conjunction with other factors such as irrigation investment and new rice varieties, brought about sharply increa

exper

rural c

the sul

policy,

of less

Indones

6.3.2.

the costs

benefits t

countries

of farmers

input supp

Ay

cotton rese

percent, to

research fo

benefits, co

on food crop

more benefits

worldwide sup

increased rice production in this period. The subsidy reduced the cost to farmers of experimenting with higher rates of fertilizer application, and it functioned as a substitute rural credit market, featuring low rates of interest. Timmer concludes that the effect of the subsidy was to convert Indonesia from an importer at its current domestic price policy, with a c.i.f. world price in excess of $250/ton, to an exporter at an f.o.b. price of less than $150/ton. The fertilizer subsidy was economically viable as long as Indonesia was a rice importer, but ceased to be so once the country began exporting.

6.3.2. Distribution of benefits

Research on the distribution of benefits from research has dealt with measuring the costs of labor displacement by improved technology (Schmitz and Seckler 1970), benefits to farmers as consumers (Hayami and Herdt 1977), gains from research across countries (Edwards and Freebairn 1984), division of benefits between different classes of farmers (Scobie and Posada 1978), and separating gains to farmers from those to input suppliers (Gardner 1988).

Ayer and Schuh (1972) estimated the distribution of benefits from Brazilian cotton research among farmers and consumers. They linked the high ROR, 80-100 percent, to organizational innovations that facilitated technology adoption, and to a research focus on both quality and yield. Producers received 60 percent of research benefits, consistent with other studies finding that consumers gain most from research on food crops and crops exported by large countries, and producers receive relatively more benefits from location-specific research on cash crops that has little effect on worldwide supply.

most

rice a

benefi

benefi

increa

Philipp

consum

reductio

Herdt sl

larger se

farmers

6.4. Me

T

began in

Zambia's

absence o

affected la

commercia

countrywid

pricing of f

remote area

Scobie and Posada (1978) found a high ROR to rice research in Colombia, with most benefits going to consumers, especially lower income groups who consume more rice and are taxed less than higher income groups. Upland farmers received fewer benefits than irrigated producers, who were able to adopt new technology earlier and benefit from their higher production before market prices dropped in response to increased supply.

Hayami and Herdt (1977) examined the impact of technological change in Philippine rice production on incomes of semi-subsistence farmers who both sell and consume their own produce. When technological improvements result in price reduction, both consumers and farmers who are also consumers benefit. Hayami and Herdt showed that farmers selling a small proportion of total produce benefit more than larger sellers, concluding that rice technology transferred income from large commercial farmers and landlords to the urban poor and rural landless.

6.4. Method

The use of price and marketing policies to influence maize production patterns began in colonial times. The pervasiveness of maize policy interventions through Zambia's history makes the task of estimating the impact of maize technology in the absence of policies very difficult. However, before the mid-1970s these policies mainly affected larger producers. Beginning in the early 1970s smallholders were drawn into commercial maize production by policies such as the guaranteed floor price for maize countrywide (1970-71), the introduction of fertilizer subsidies (1971-72), pan-territorial pricing of fertilizer (1974) and expansion of the product and input marketing network in remote areas (mid 1970s-80s).

repre

Popul

used t

1971-7

scenari

produc

are com

chosen f

height o

take thei

U

productio

percent ev

the availab

agriculture

1990), and

yield potent

purposefully

production is

increases mad

The approach is to take the 1971-72 season as a benchmark, broadly representing the behavior of the Zambian maize sector when few policies were in place. Population, production and per capita consumption estimates at the provincial level are used to determine the amount of maize exported, if any, from each analysis area in 1971-72. These estimates are projected forwarded to create a 1987-88 "without-policy scenario," incorporating population growth and the ratio of subsistence to export production estimated for 1971-72. The simulated "without-policy" 1987-88 scenarios are compared to the actual "with-policy" production results for each area. 1987-88 was chosen for comparison because it was a season of average weather conditions at the height of maize policy implementation, before dwindling government resources began to take their toll on parastatal service provision.

Underlying the "without-policy" scenario is the assumption that Zambian maize production was able to keep pace with an annual population growth rate of 2.0-2.5 percent even without the adoption of improved varieties and fertilizer by smallholders or the availability of smallholder marketing services. This is optimistic, since African agriculture as a whole grew at only 1.8 percent annually during the 1980s (World Bank 1990), and given the labor constraints faced by Zambian smallholders and the limited yield potential of local maize varieties (Table 20, Chapter 5). The analysis strategy is purposefully conservative: the simulated impact of technology and policies on maize production is probably an underestimate, representing the lower bound of production increases made possible through widespread adoption of maize technology.

For the analysis, Zambia is divided into the following eleven sub-regional areas:

Close to major consumption centers

1. Central Province, Region II, small/medium farmers
2. Central Province, Region II, large farmers
3. Southern Province, Region I, small/medium farmers
4. Southern Province, Region II, small/medium farmers
5. Southern Province, Region II, large farmers

Remote from major consumption centers

6. Eastern Province, Region I, small/medium farmers
7. Eastern Province, Region II, small/medium farmers
8. Northern Province, Region III, small/medium farmers

Urban consumption centers

9. Lusaka Province urban
10. Copperbelt Province urban

Rest of economy

11. Rest of economy

Two scenarios are described for each area in 1987-88, maize production "without improved technology, price and marketing policies" (S_0) (without ITPM) and "with improved technology, price and marketing policies" (S_{pol}) (with ITPM). The next objective is to measure the change in economic surplus from adoption of each of several maize technologies and the implementation of policies. The technique used is simulation of supply curve shifts based on estimates from primary and secondary data, and calculation of consumer and producer surplus changes in each analysis area using the Akino-Hayami approximation formulas (1975) (Chapter 5).

6.4.1. Disaggregation of S-S′ supply shift

The expansion of production in Zambia between 1987-88 (without ITPM) and 1987-88 (with ITPM) can be seen as a series of consecutive rightward shifts of the supply curve, intermediate between S and S′ (Figure 14, Chapter 5). This approach differs slightly from Akino and Hayami, who started from the with-ITPM supply curve S′ and shifted leftward to find the without-ITPM supply curve, S_0.

In Zambia, there were four main factors which acted to shift the supply curve: (1) adoption of SR52; (2) adoption of other Zimbabwean hybrids such as R201 and R215; (3) adoption of Zambian hybrids; and (4) policies of the Zambian government, including pan-territorial pricing of maize and fertilizer, and support for the system of marketing depots in rural areas operated by the parastatal marketing board together with the cooperative system.

6.4.1.1. S_0

Separate supply curves are constructed for the without-ITPM situation and each "shift." These are shown in Figure 16 as S_0, S_{SR52}, S_{Zimb}, S_{Zam}, and S_{Pol}. Quantities supplied under each technology, at the prevailing price, are estimated as Q_0, Q', Q'', Q''', and Q_{Pol}. S_0 represents estimated 1987-88 maize production without ITPM. For S_0, it is assumed that large and small/medium farmers continue to use the technology prevailing in 1971-72; production estimates are brought forward to 1987-88 by assuming that farmers in a given area continue to produce for domestic consumption and

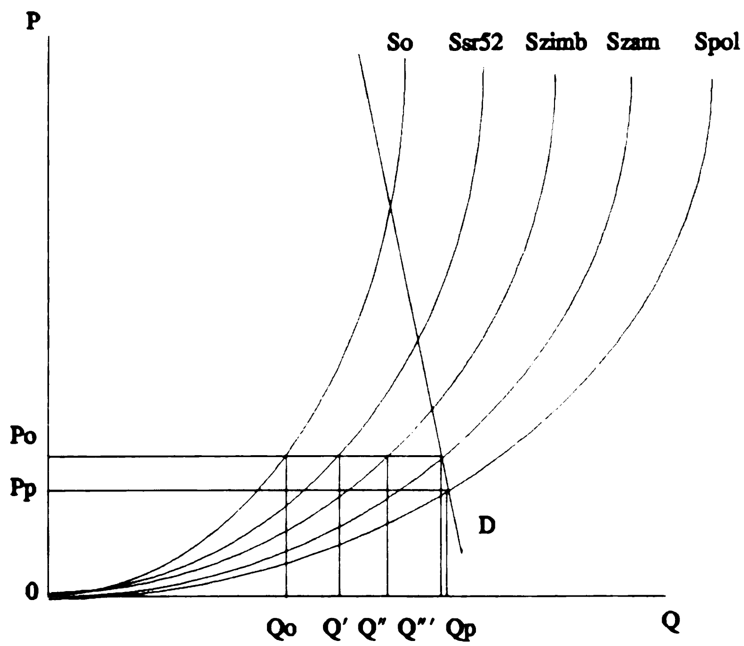


Figure 16: Estimated supply shifts from investments in maize research and policies

in the same proportions in 1987-88 as they did in 1971-72. For example, if in 1971-72 farmers in Area Z produced enough for Area Z's consumption needs and exported 1.5 times the amount consumed locally, it is assumed that in 1987-88 these farmers would also have supplied domestic needs (accounting for population growth) and continued to export 1.5 times this amount outside Area Z.

$$S_0 = a_1 P^{e};$$

where

a_1=scale parameter,

P=maize price received by farmers in the absence of price policies, and

e=price elasticity of supply

The prevailing technology in 1971-72, and therefore in the without-ITPM 1987-88 scenario, differs for large and small/medium farmers. Large farmers are assumed to have easy access to both SR52 and fertilizer, and to fertilize maize at full recommended levels. Small/medium farmers are assumed to use only local maize varieties and no fertilizer, although in reality some would have used these inputs even without government programs.

In the numerical simulation, Q_0 is the estimated maize production in a given area under the without-ITPM conditions detailed above. This amount is projected from actual production in 1971-72, adjusted for population but maintaining the ratio of domestic production to exports observed in 1971-72. The producer price for maize in the absence of policies, P, is the import parity price for areas where maize is traded (Table 95, Appendix 10), and the estimated local market price in autarkic areas. The import parity price is used because Zambia has been a net maize importer in most years since 1970.

The estimates of supply and demand elasticities used (e, n) throughout the analysis, for all areas, are .65 and .10, respectively. These are based on estimates made by Harber (1992) and Nakaponda (1992), of .12 and -0.04 for the price elasticity of demand, and .8 and .51 for the price elasticity of supply. The scale parameter is $a_{1,}$ derived after substituting the numerical values for all other parameters.

6.4.1.2. Estimation of S_{SR52}

$$S_{SR52} = (1+h_{SR52})a_1P^e;$$

where h_{SR52} = the rate of shift in the supply function due to adoption of SR52;

$$h_{SR52} \approx (1+e)k_{SR52};$$

and k_{SR52} = the proportion of maize area planted to SR52 * (yield increase of SR52 over local varieties) / yield of local varieties.[1] S_{SR52} is the increased production resulting from the availability of SR52 to small/medium farmers. h_{SR52} represents the rate of shift in the supply function due to the adoption of higher-yielding SR52. It is assumed that small/medium farmers using SR52 do not use fertilizer. h_{SR52} is approximated by $(1+e)k_{SR52}$ (see Akino and Hayami 1975); k_{SR52} is estimated by calculating the yield increase of SR52 over local varieties, weighted by the average small/medium area under SR52. This area was estimated from MSU/MAFF/RDSB Maize Adoption Survey data. Respondents gave a detailed description of their cropping patterns beginning the year before adoption of improved Zambian maize varieties. Cropping patterns from the year before adoption were assumed to represent cropping patterns of both adopters and non-adopters. These responses were pooled to get the average area under SR52 in each sub-regional analysis area before the release of Zambian improved maize varieties.

6.4.1.3. Estimation of S_{Zimb}

$$S_{Zimb} = (1+h_{Zimb})(1+h_{SR52})a_1P^e$$

---

[1] Since Akino and Hayami calculate leftward rather than rightward shifts of the supply curve, their denominator is the yield of the improved variety rather than the "unimproved" variety, as here. This results in a larger k-factor in our approach, in most cases.

where h_{Zimb} = the rate of shift in the supply function due to adoption of Zimbabwean hybrids; and

$$h_{Zimb} \approx (1+e)k_{Zimb};$$

and k_{Zimb} = the proportion of maize area planted to Zimbabwean hybrids * (yield increase of Zimbabwean hybrids over local varieties) / yield of local varieties. S_{Zimb} is the increased production resulting from the availability of (non-SR52) Zimbabwean hybrids to small/medium and large farmers. h_{Zimb} represents the rate of shift in the supply function due to the adoption of Zimbabwean hybrids. It is assumed that small/medium farmers using Zimbabwean hybrids do not use fertilizer, but large farmers apply the full recommended levels. h_{Zimb} is approximated by $(1+e)k_{Zimb}$; k_{Zimb} is estimated by calculating the yield increase of Zimbabwean hybrids over local varieties, weighted by the average small/medium and large farmer area under Zimbabwean hybrids. Large farmer area was estimated from responses to the MSU/MAFF/RDSB mail-in survey of large farmers. Small/medium area under Zimbabwean hybrids was estimated from MSU/MAFF/RDSB Maize Adoption Survey data, as described above for SR52 area.

6.4.1.4. Estimation of S_{Zam}

$$S_{Zam} = (1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_1P^e$$

where h_{Zam} = the rate of shift in the supply function due to adoption of improved Zambian hybrids;

$$h_{Zam} \approx (1+e)k_{Zam};$$

and k_{Zam} = the proportion of maize area planted to Zambian hybrids * (yield increase of Zambian hybrids over local varieties) / yield of local varieties. S_{Zam} reflects the increased production resulting from the availability of improved Zambian hybrids to small/medium and large farmers. h_{Zam} represents the rate of shift in the supply function due to the adoption of Zambian hybrids. It is assumed that small/medium farmers planting Zambian hybrids do not use fertilizer, but large farmers apply the full recommended levels. h_{Zam} is approximated by $(1+e)k_{Zam}$; k_{Zam} is estimated by calculating the yield increase of Zambian hybrids over local varieties, weighted by the average small/medium and large farmer area under Zambian hybrids. Large farmer area was estimated from responses to the MSU/MAFF/RDSB mail-in survey of large farmers. Small/medium area under Zambian hybrids was estimated from MSU/MAFF/RDSB Maize Adoption Survey data.

6.4.1.5. S_{Pol}

$$S_{Pol} = (1+h_{pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_1P'^{\epsilon}$$

where S_{Pol} = actual maize production in 1987/88 (with technology, policies);

h_{pol} = the rate of shift in the supply function due to fertilizer subsidies, credit programs and locally available input and product marketing services;

$$h_{Pol} \approx (1+e)k_{Pol};$$

and k_{Pol} is the residual in the S_{Pol} equation;

h_{fert} = the rate of shift in the supply function due to the yield increase in local varieties resulting from the availability of fertilizers to small/medium farmers;

$$h_{fert} \approx (1+e)k_{fert};$$

and k_{fert} = the proportion of maize area allocated to fertilized local varieties * (yield increase of local fertilized varieties over local (unfertilized) varieties) / yield of local (unfertilized) varieties;

h'_{Zam} = the rate of shift in the supply function due to the yield increase in Zambian improved varieties resulting from the availability of fertilizer to small/medium farmers;

$$h'_{Zam} \approx (1+e)k'_{Zam};$$

and k'_{Zam} = the proportion of maize area planted to fertilized Zambian hybrids * (yield increase of fertilized Zambian hybrids over fertilized local varieties) / yield of fertilized local varieties;

h'_{Zimb} =the rate of shift in the supply function due to the yield increase in Zimbabwean varieties resulting from the availability of fertilizer to small/medium farmers;

$$h'_{Zimb} \approx (1+e)k'_{Zimb};$$

and k'_{Zimb} = the proportion of maize area planted to fertilized Zimbabwean hybrids * (yield increase of fertilized Zimbabwean hybrids over fertilized local varieties) / yield of fertilized local varieties;

and P' = the actual panterritorial, panseasonal producer price for maize in 1987-88.

S_{Pol} is the actual, known maize production in the "with-policy" situation, 1987-88. The difference between S_{Zam} and S_{Pol} represents the change in maize production resulting from (1) the availability of fertilizer to small/medium farmers for use on local, Zimbabwean hybrids and improved Zambian varieties because of price subsidies, credit programs and distribution systems that made inputs available through local depots; (2) pan-territorial, pan-seasonal pricing for maize; and (3) the establishment of a countrywide system of local depots where small/medium farmers could sell their maize, and, in some cases, have their maize collected from the farm gate. Thus the shift between S_{Zam} and S_{Pol} incorporates interactive effects between fertilizer and local and hybrid maize varieties, as well as the impact of price policy and availability of marketing depots.

In this "with-policy" case, it is assumed that Zambian and Zimbabwean hybrids replace SR52, which drops out of the analysis. For h_{fert}, secondary estimates of the proportion of local maize area fertilized vary widely, from none, to half, to all (ARPT 1983; ARPT 1987; Jha et al. 1991; ARPT 1988). In this analysis, it is assumed that half of local maize area is fertilized in all analysis areas. All small/medium and large Zimbabwean and Zambian hybrid area is assumed to be fertilized at full recommended levels, based on MSU/MAFF/RDSB survey estimates and secondary reports that indicate high levels of fertilizer application to maize by Zambian farmers (CIMMYT 1990; Jha et al. 1991).

Estimates of h_{fert}, h'_{Zimb}, h'_{Zam} supply function shifts are made for small/medium analysis areas, but not for large farmer areas, since large farmers are assumed to fertilize at recommended levels without fertilizer subsidies or local marketing outlets. h_{Pol} is the residual in all areas, where

$$h_{Pol} = S_{Pol} - (1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_l P'^{\epsilon}.$$

6.4.2. Calculation of k factors

There are two steps in estimating the k factors (shifts in the production function) associated with each technology type. First, the increase in yield associated with adoption of SR52, Zimbabwean hybrids and Zambian improved varieties under different levels of fertilization is estimated from data in Table 20 (Chapter 5) for small/medium farmers. For large farmers, the following average yields are assumed (full fertilization), based on Gibson (personal communication, March 1993) and Ristanovic (1988):

SR52: 5.45 tons/ha

Zimbabwean hybrids: 5.85 tons/ha

Zambian improved hybrids: 6.06 tons/ha

The second step is estimating the proportion of maize area under a given technology, with and without policies. Since the proportion of large farmer maize area planted to hybrids (first non-Zambian, then Zambian) remained relatively constant in the 1970s and 1980s, and these farmers were already using fertilizer, it was assumed that large farmers would plant the same proportion of maize area to improved varieties, with or without policies.

However, total small/medium maize area, and the proportion of small/medium maize area planted to hybrids, grew significantly in the same period, implying that farmer area decisions were affected by the policy environment. There is no clear way to estimate the proportion of area that would have been planted to SR52, Zimbabwean or

Zambian hybrids in the absence of policies since actual primary and secondary adoption data are "contaminated" by the policies in force since the 1970s.

Given this constraint, the approach followed is to calculate the average proportion of maize area under a given technology, e.g., SR52, in the year before adoption of Zambian improved varieties, from the pool of MSU/MAFF/RDSB respondents for a given analysis area, e.g., Central Province, Region II, small/medium farmers. Three possible scenarios are analyzed: the case where the area planted to SR52 in the without-policy case is (a) 25 percent of the area planted in the with-policy situation; (2) 50 percent of the area planted with-policy; (3) 75 percent of the area planted with-policy.

6.5. Results of simulation

Detailed calculations are presented below for two analysis areas, Central Province Region II small/medium farmers, and Central Province Region II large farmers. Calculations for other analysis areas can be found in Appendix 12. All results are summarized in Table 28.

6.5.1. Central Province, Region II

Actual maize production in Central Province (CP) grew from 315,810 tons in 1971-72 to 511,686 tons in 1987-88, an increase of over 60 percent. CP is one of Zambia's most important maize areas; the province produced 37.1 percent of total maize production, and 46.3 percent of all maize purchased through the official marketing board in 1971-72. Because of CP's usual maize surplus and proximity to major consumer markets, trade between CP and deficit provinces must be taken into account. Key parameters and assumptions are detailed in Tables 26 and 27.

Estimation of provincial maize consumption and exports, 1971-72 and 1987-88

The population of Central Province in 1971-72 is estimated as 373,877 (CSO 1985b). Per capita consumption of maize is estimated at 190 kg annually (CIMMYT 1990). Total CP consumption in 1971 is estimated as 373,877*190 kg=71,037 tons. It is assumed that CP exported maize to other provinces before improved varieties became available and before policies took effect. In 1971-72, CP supplied 272,682 tons of officially marketed maize. This amount was 3.8 times its provincial consumption requirement.

Central Province's 1987-88 population is estimated as 681,566 persons. Total consumption of maize in CP in 1987/88 is estimated at 681,566*190 kg=129,498 tons. Assuming that these relationships hold constant, it is estimated that in the absence of policies, in 1987/88, CP farmers would have produced their own consumption needs, or 129,498 tons plus 3.8 times this amount for export, or 492,090 tons, for a total of 621,588 tons. With actual production at 511,686, this implies an overall decrease of 17.7 percent due to policies and improved technology.

Of total maize production in CP in 1971-2, small farmers produced 41.9 percent and large farmers produced 58.1 percent (Table 27). Assuming this proportion would have held constant in the absence of policies, of the total 621,588 tons (assumed) produced in 1987/88 (without policies), small farmers would have produced 260,632 tons and large farmers would have produced 360,956 tons.

Between the early 1970s and the late 1980s, the small/medium share of maize production rose to 80 percent nationwide and large farmer production declined to 20 percent (GRZ 1990). This suggests that the technology/policy package had a differential impact on large vs. small/medium-scale producers.

Large farmers, CP: In the projected without-ITPM situation for 1987-88, total production is estimated at 621,588 tons. If large farmers were still producing 58.1 percent of this, their production would have been 360,956 tons. In the actual, with-ITPM case for 1987-88, large farmer production is estimated at 20 percent of total production (511,686), or 102,337. This represents a decline of 71.6 percent after policies/improved technology.

Small/medium farmers, CP: If small/medium farmers were producing 41.9 percent of the total projected production in the without-ITPM scenario for 1987/88, their production would have been 260,632. In the actual, with-ITPM case, small/medium farmer production is estimated at 80 percent of total production (511,686), or 409,349, an increase of 57.1 percent in small/medium production due to policies/improved technology.

6.5.1.1. Central Province, Region II, small/medium farmers

Tables 26 and 27 show the basic parameters used for estimation of the supply curves under different technology and policy assumptions. S_0 is the estimated small/medium maize production in the absence of technology and policies (Table 27). Here, small/medium farmers use only local maize varieties and no fertilizer.

Table 26: Maize production parameters, Central Province

	(1) Population	(2) Per cap. maize cons.(kg)	(3) Provincial cons. requirement (mt)	(4) Actual amt. maize marketed (mt)	(5) Estimated maize production without policies (mt)	(6) Est. % change in production after policies,imp. technology
1971-2	373,877[1]	190[3]	71,037[4]	272,682[5]		
1987-8	681,566[2]	190[3]	129,498[4]	511,686[6]	621,588[7]	-17.7

[1] Based on 1969 population estimate of 358,655 (CSO 1985) and 2.1 percent growth rate for Central Province between 1969-74)(CSO 1985)
[2] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that Central Province had 9.05 percent of the country's population (CSO 1985). The population estimate for the province for 1987-88 assumes that this proportion has not changed.
[3] CIMMYT 1990. Per capita total maize utilization, 1986-88.
[4] [(1)*(2)]/1000
[5] CSO 1976, 1978
[6] GRZ 1990.
[7] Estimated provincial consumption requirements = 681,566 (inhabitants)*190 kg = 129,498 tons. Estimated provincial exports in absence of policies based on 1971-2 exports that were 3.8 times greater than provincial consumption requirements. Assuming the relationship would hold in the absence of policies in 1987-88, estimated exports are 129,498*3.8=492,091 tons. Estimated total production = 129,498+492,091=621,588 tons.

Table 27: Production by small/medium and large farmers, Central Province

	Actual small/ med. share (%)	Actual large share (%)	Actual prod., sm/ med (mt)	Actual prod., large (mt)	Est. sm/med prod. w/o policies, technology	Est. lg prod. w/o policies, technology	Est. change in sm/med production, with policies, technology (%)	Est. change in large prod. with policies, technology (%)
1971-2	41.9[1]	58.1[2]						
1987-8	80.0[3]	20.0[3]	409,349[4]	102,337[4]	260,632[5]	360,956[6]	+57.1	-71.6

[1] CSO 1978 ; Central Province estimate
[2] CSO 1976; Central Province estimate
[3] GRZ 1990; countrywide estimate
[4] GRZ 1990
[5] Estimated total CP production in absence of policies, technology=621,588 tons (Table 26). Assumes small/medium share of production for 1971-72 would not have changed without policy/technology intervention. 621,588 metric tons* 41.93=260,632.
[6] Estimated total CP production in absence of policies, technology=621,588 tons (Table 26). Assumes large share of production for 1971-72 would not have changed without policy/technology intervention. 621,588 metric tons* 58.07=360,956 tons.

$$S_0 = a_I P^e$$

$$Q_o = 260{,}632$$

The producer price in the without-policy case is assumed to be the economic import parity price minus transport costs from Kabwe (farm gate) to Lusaka for the 1987-88 season (ZK/ton) (Table 95, Appendix 10).

$$P = 1952$$

The supply elasticity e is based on .65 from Harber (1992) and Nakaponda (1991). Thus

$$260{,}632 = a_I * 1952^{.65}$$

$$a_I = 1893.3$$

Estimation of S_{SR52}

S_{SR52} is the gain in maize production when small/medium farmers adopt SR52 without fertilizer.

$$S_{SR52} = (1 + h_{SR52}) a_I P^e$$

Without fertilizer, SR52 has an estimated 33.3 percent yield advantage over unfertilized local in Region II (Table 20, Chapter 5). From MSU/MAFF/RDSB survey data it is estimated that the average proportion of small/medium maize area in Central Province under SR52 in the year before adoption was 31.4 percent. Three scenarios are analyzed: the case where the area planted to SR52 in the without-policy case is (1) 25 percent of the area planted in the with-policy situation; (2) 50 percent of the area planted with-policy; and (3) 75 percent of the area planted with-policy. Thus

$$\text{(a) } k_{SR52,.25} = (.314/4) * .333 = .03^{2}$$

$$h_{SR52,.25} = (1+e)*k_{SR52,.25}$$

$$h_{SR52,.25} = (1.65)*.03 = .04$$

$$S_{SR52,.25} = (1+.04)a_{i}P^{e}$$

Substituting,

$$Q_{SR52,.25} = 271,885$$

$$\text{(b) } k_{SR52,.5} = (.314/2).*.333 = .05$$

$$h_{SR52,.5} = (1+e)*k_{SR52,.5}$$

$$h_{SR52,.5} = (1.65)*.05 = .09$$

$$Q_{SR52,.5} = 283,138$$

$$\text{(c) } k_{SR52,.75} = (.314*.75)*.333 = .08$$

$$h_{SR52,.75} = (1+e)*k_{SR52,.75}$$

$$h_{SR52,.75} = (1.65)*.08 = .13$$

$$Q_{SR52,.75} = 283,138$$

---

[2] Calculations summarized here and in Appendix 12 show only two or three decimal places, but the spreadsheet program used up to ten places for the actual calculations.

Estimation of S_{Zimb}

S_{Zimb} represents the additional production attributable to the availability of non-SR52 Zimbabwean hybrids, principally R215 and R201, to small/medium farmers, who use no fertilizer. Without fertilizer, the yield advantage of Zimbabwean hybrids over locals is approximately 33.3 percent. The average proportion of small/medium maize area in Central Province under non-SR52 Zimbabwean hybrids in the year before adoption was 1.2 percent, according to MSU/MAFF/RDSB Maize Adoption Survey estimates.

$$S_{Zimb} = (1+h_{Zimb})(1+h_{SR52})a_l P^e$$

(a) $k_{Zimb.25}=(.012/4)*.33=.001$

$$h_{Zimb.25}=(1+e)*k_{Zimb.25}$$

$$h_{Zimb.25}=(1.65)*.001=.002$$

$$S_{Zimb.25} = (1+h_{Zimb.25})(1+h_{SR52.25})a_l P^e$$

Substituting ,

$$Q_{Zimb.25}=272,333$$

(b) $k_{Zimb.5}=(.012/2)*.33=.002$

$$h_{Zimb.5}=(1+e)*k_{Zimb.5}$$

$$h_{Zimb.5}=(1.65)*.002=.003$$

$$S_{Zimb.5} =(1+h_{Zimb.5})(1+h_{SR52.5})a_l P^e$$

Substituting ,

$$Q_{Zimb.5}=284,072$$

(c) $k_{Zimb.75}=(.012*.75)*.33=.003$

$$h_{Zimb.75}=(1+e)*k_{Zimb.75}$$

$$h_{Zimb.75} = (1.65)^{*}.003 = .005$$

$$S_{Zimb.75} = (1 + h_{Zimb.75})(1 + h_{SR52.75})a_1P^c$$

Substituting,

$$Q_{Zimb.75} = 295,848$$

Estimation of S_{Zam}

S_{Zam} represents the supply shift resulting from the availability of improved Zambian hybrids (unfertilized) to small/medium farmers. MM603/604, the most popular and widely adaptable hybrid, is used as a proxy for all Zambian hybrids. With no fertilizer, the estimated yield advantage of Zambian varieties over locals is 33.3 percent, and the average proportion of small/medium maize area in Central Province under Zambian hybrids in 1987-88 was about 35.3 percent (MSU/MAFF/RDSB Maize Adoption Survey).

$$S_{Zamb} = (1 + h_{Zam})(1 + h_{Zimb})(1 + h_{SR52})a_1P^c$$

$$\text{(a) } k_{Zam.25} = (.353/4) * .33 = .03$$

$$h_{Zam.25} = (1 + e)^{*}k_{Zam.25}$$

$$h_{Zam.25} = (1.65)^{*}.03 = .05$$

$$S_{Zam.25} = (1 + h_{Zam.25})(1 + h_{Zimb.25})(1 + h_{SR52.25})a_1P^c$$

Substituting,

$$Q_{Zam.25} = 285,552$$

$$\text{(b) } k_{Zam.5} = (.353/2) * .33 = .06$$

$$h_{Zam.5} = (1.65)^{*}.06 = .10$$

$$S_{Zam.5} = (1 + h_{Zam.5})(1 + h_{Zimb.5})(1 + h_{SR52.5})a_1P^c$$

Substituting,

$$Q_{Zam.5} = 311{,}648$$

$$\text{(c) } k_{Zam.75} = (.353*.75) * .33 = .09$$

$$h_{Zam.75} = (1+e)*k_{Zam.75}$$

$$h_{Zam.5} = (1.65)*.09 = .15$$

$$S_{Zam.75} = (1+h_{Zam.75})(1+h_{Zimb.75})(1+h_{SR52.75})a_1P^c$$

Substituting,

$$Q_{Zam.75} = 338{,}927$$

Estimation of S_{Pol}

S_{Pol} represents the shift in supply from:

a) the availability of subsidized fertilizer at pan-territorial prices. Based on ARPT reports, and results of the MSU/MAFF/RDSB survey (Chapter 6), this is assumed to result in the application of **full** recommended levels of fertilizer to locals, Zimbabwean hybrids, and Zambian hybrids. In Central Province, the yield advantage of both Zimbabwean and Zambian hybrids over local varieties, if all receive full fertilization, is 34.6 percent. 35.3 percent of small/medium maize area in Central Province is planted to improved Zambian hybrids; 1.2 percent of maize area is in Zimbabwean hybrids.

b) the availability of very locally situated buying points for maize produced for export outside the province, and for purchase of fertilizer and seeds.

c) the availability of credit used for the procurement of purchased inputs.

d) pan-territorial maize prices.

The assumed price is the full pan-territorial price, ZK 889, because GRZ now pays the costs of maize marketing.

$$S_{Pol} = (1+h_{Pol})+(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_l P'^{e}$$

$$P'=889$$

$$k'_{Zam}=.353*.346=.122$$

$$h'_{Zam}=(1+e)*k'_{Zam}$$

$$h'_{Zam}= 1.65*.122=.2$$

$$k'_{Zimb}=.012*.346=.004$$

$$h'_{Zimb}=(1+e)*k'_{Zimb}$$

$$h'_{Zimb}= 1.65*.004=.01$$

k'_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer to local varieties results in a 73.3 percent yield increase (Table 20, Chapter 5). It is estimated that 63.5 percent of small/medium maize area in Central Province was under local varieties in 1987/88. While secondary ARPT and other reports generally agree that almost all maize area under the improved hybrids is fertilized, estimates of the amount of local maize area fertilized in Central and other provinces varies widely, from none, to half, to all (ARPT 1983; ARPT 1987; Jha et al. 1991; ARPT 1988). For this analysis, it is assumed that half of local maize area is fertilized, or 31.8 percent of Central Province small/medium maize area.

$$k'_{fert}=.3175*.733=.23$$

$$h'_{fert}= (1+e)*k'_{fert}$$

$$h'_{fert}= 1.65*.23=.38$$

$$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_l P'^e$$

Substituting,

$$Q_{Pol}=409,349$$

$$h_{Pol}= [S_{Pol}/(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_l P'^e] - 1$$

$$h_{Pol} = .57$$

6.5.1.2. Central Province, Region II, large farmers

The base supply curve (S_0) for large farmers assumes the use of fully fertilized SR52, not local varieties. In the without-ITPM scenario, it is assumed that large farmers have the resources to obtain and use hybrids with fertilizer on their own. S_0 is the estimated maize production by large farmers in the absence of government policies such as pan-territorial pricing, fertilizer subsidies and local marketing depots (Table 27).

$$S_0=a_l P^e$$

$$Q_o= 360,956$$

$$P=1952$$

The supply elasticity is based on e=.65 (Harber 1992; Nakaponda 1992). Since Central Province exports maize to other provinces, the producer price in the no-policy case is the economic import parity price minus the transport costs to Kabwe farm gates for the 1987/88 season (Table 95, Appendix 10).

Solving for a_l,

$$360,956=a_l 1952^{.65}$$

$$a_l=2622.1$$

Estimation of S_{Zimb}

S_{Zimb} represents gains in production through yield increases realized when large farmers plant a portion of their maize area in Zimbabwean hybrids, using full recommended levels of fertilizer. From MSU/MAFF/RDSB large farmer survey data, the average proportion of maize area under non-SR52 Zimbabwean hybrids in the year before adoption was 13 percent. Unlike small/medium farmers, large farmers are assumed to plant the same proportion of maize area to Zimbabwean and Zambian hybrids in both with and without-policy cases. The estimated yield increase of fully fertilized Zimbabwean hybrids over fully fertilized SR52 in Region II is 7.3 percent (Table 20, Chapter 5). Thus

$$S_{Zimb} = (1 + h_{Zimb})a_l P^e$$

$$h_{Zimb} = (1 + e)k_{Zimb}$$

$$k_{Zimb} = .13 * .073 = .0095$$

$$Q_{Zimb} = 366{,}639$$

Estimation of S_{Zam}

S_{Zam} reflects increases in production resulting from yield gains when large farmers plant a part of their maize area to Zambian improved varieties. The average proportion of large farmer maize area under Zambian hybrids in 1987/8 was 88.4 percent, from MSU/MAFF/RDSB survey data. The estimated yield increase of fully fertilized Zambian hybrids over fully fertilized SR52 is 11.2 percent (Table 20, Chapter 5).

$$S_{Zamb} = (1 + h_{Zam})(1 + h_{Zimb})a_l P^e$$

$$h_{Zam} = (1 + e)k_{Zam}$$

$$k_{Zam} = .884 * .112 = .099$$

$$Q_{Zam} = 419{,}885$$

Estimation of S_{Pol}

S_{Pol} is actual maize production in 1987-88, in the with-policy environment. S_{Pol} reflects the change in maize supply as a result of:

a) the imposition of guaranteed, pan-territorial producer prices which are below border prices, and mandatory marketing of maize through the parastatal marketing branches.

b) pan-territorially priced, subsidized fertilizer.

$$S_{Pol} = (1 + h_{Pol})(1 + h_{Zam})(1 + h_{Zimb})a_l P'^e$$

where

P' is the pan-territorial maize price

h_{Zam} and h_{Zimb} have the same values as above. Unlike the small/medium case, h_{Zam} and h_{Zimb} do not change in the with-policy case, since it is assumed that large farmers are already fertilizing both maize types at full levels in the without-policy case.

Substituting,

$$Q_{Pol} = 102{,}337$$

$$h_{Pol} = [S_{Pol}/(1 + h_{Zam})(1 + h_{Zimb})a_l P'^e]\text{-}1$$

$$k_{Pol} = -.36$$

$$h_{Pol} = -.6$$

Table 28: Summary of supply estimates with/without technology, policies

	Reg.2 Central Province sm/med	Reg.2 Central Province large	Reg.1 Southern Province sm/med	Reg.2 Southern Province sm/med	Reg.2 Southern Province large	Reg.1 Eastern Province sm/med	Reg.2 Eastern Province sm/med	Reg.3 North. Province sm/med	Rest of econ.	National
P^a	1952	1952	1923.9	1923.9	1923.9	1572.4	1572.4	1405	2200.1	
P'^b	889	889	889	889	889	889	889	889	889	
Q_0	260,632	360,956	8,606	296,886	189,016	11,777	170,532	98,582	155,252	1,552,239
$Q_{SR52}(25\%)$	271,885	...	8,492	307,010	...	11,727	177,965	99,593	158,971	1,585,615
$Q_{SR52}(50\%)$	283,138	...	8,379	317,134	...	11,676	185,398	100,604	162,690	1,618,991
$Q_{SR52}(75\%)$	294,390	...	8,265	327,257	...	11,626	192,831	101,615	166,409	1,652,365
$Q_{Zimb}(25\%)$	272,333	366,639[c]		307,981	191,992[c]	...	178,406	102,563	160,781	1,600,914
$Q_{Zimb}(50\%)$	284,072			319,140		...	186,316	106,604	166,396	1,641,214
$Q_{Zimb}(75\%)$	295,848			330,362		...	194,263	110,705	172,094	1,682,064
$Q_{Zam}(25\%)$	285,552	419,885[c]	8,898	332,591	219,874[c]	11,868	186,820	130,220	186,534	1,782,242
$Q_{Zam}(50\%)$	311,648		9,179	369,984		11,957	203,890	164,096	219,700	1,930,213
$Q_{Zam}(75\%)$	338,927		9,449	409,064		12,045	221,749	200,261	254,789	2,086,043
Q_{pol}	409,349	102,337	19,490	320,397	80,099	20,572	430,592	194,404	256,760	1,834,000

[a] P=economic import parity price minus transportation costs, except for Northern Province, which is the estimated local market price
[b] pan-territorial price
[c] large farmer analysis assumes area planted to specified variety is the same with or without technology and policies

6.6. Distribution of benefits

6.6.1. Estimated changes in production 1987-88, with and without maize technology and policies

If no new technology had been available and no policies had been in effect in 1987-88, the estimated total production of maize would have been 1.55 million tons of maize. With technology and policies, the actual production was 1.83 million tons, an overall increase of 18.4 percent. In that year, an additional 63,900 tons were imported. Without technology and policies, the additional shortfall would have been more than 280,000 tons. If technology were available but no policies had been in place, the analysis shows that under certain assumptions, national-level maize production would have been higher. Table 29 shows that, in the without-policy scenario, if small/medium farmers planted 50 percent or more of the maize area they planted to Zambian hybrids in the with-policy case, national maize production would have been higher than the actual 1987-88 levels. This finding suggests that Zambia's pursuit of dual national goals, increased overall production (foreign exchange savings) and bringing remote smallholders into commercial maize production, resulted in a trade-off of production for equity.

The main assumption underlying the calculation of production in the absence of new technology and policies was that producers in a given area would continue to produce their local consumption requirements and additional maize for export to other provinces in the same ratio as they did in 1971-72. This is optimistic, given the labor constraint, limits of the available local technology, and the inability of agricultural production in other African countries to keep pace with population growth. Therefore the estimate of an 18.4 percent overall increase after policies and technology is probably quite conservative.

Table 29 shows the estimated changes in production for each analysis area, under the varying assumptions that 25 percent, 50 percent and 75 percent of the area planted to a given variety in the with-policy situation would be planted in the no-policy case. Naturally, at the 25 percent level the influence of policies on production increases appears greatest in all cases.

Among the different analysis areas, the greatest production increases, in terms of percent change over the without-ITPM scenario, were small/medium farmers in Eastern Province Region II (152.4 percent), Southern Province Region I (126.5 percent), and Northern Province Region III (97.2 percent). This finding supports the hypothesis that the major impact of technology and policies was to facilitate maize production in more remote areas (Northern, Eastern Provinces) and among farmers in drier areas who, with the introduction of shorter-season maize hybrids, were motivated to produce maize on a much larger scale (Southern Province Region I). In all cases except Southern Province Region II, Northern Province, and "other" areas, the impact of policies on production clearly outweighed the impact of the unfertilized maize variety technologies.

Increases in production in other small/medium farmer analysis areas were also substantial: the production increase in Eastern Province Region I was 74.5 percent, in other areas was 65.5 percent, and in Central Province Region II was 58.7 percent. The production increase in Southern Province Region II was relatively small, only 7.9 percent. Production by large farmers in Central and Southern Provinces declined sharply between the without ITPM and with ITPM scenarios. Central Province large

Table 29: Production changes with and without policies and technology, 1987-88

	NPR3, S/M,25% a/	NPR3, S/M,50% b/	NPR3, S/M,75% c/	CPR2, S/M,25% d/	CPR2, S/M,50% e/	CPR2, S/M,75% f/	CP,R2, LG g/	EPR2, S/M,25% h/	EPR2, S/M,50% i/	EPR2, S/M,75% j/
Prod. change with technology, policies (% change from no policies, no technology)	97.2	97.2	97.2	58.7	58.7	58.7	-71.6	152.4	152.4	152.4
Technology contribution (SR52, Zimb.,Zamb. hybrids)%	33.0	68.4	106.1	16.3	33.4	51.2	22.8	6.3	12.8	19.7
Policy contribution	66.98	31.63	-6.11	83.7	66.6	48.8	-122.8	93.7	87.2	80.3
Sum pct	100	100	100	100	100	100	100	100	100	100

a/ Northern Province Region III small/medium farmers, assuming maize area is 25% of with-policy case
b/ Northern Province Region III small/medium farmers, assuming maize area is 50% of with-policy case
c/ Northern Province Region III small/medium farmers, assuming maize area is 75% of with-policy case
d/ Central Province Region II small/medium farmers, assuming maize area is 25% of with-policy case
e/ Central Province Region II small/medium farmers, assuming maize area is 50% of with-policy case
f/ Central Province Region II small/medium farmers, assuming maize area is 75% of with-policy case
g/ Central Province Region II large farmers
h/ Eastern Province Region II small/medium farmers, assuming maize area is 25% of with-policy case
i/ Eastern Province Region II small/medium farmers, assuming maize area is 50% of with-policy case
j/ Eastern Province Region II small/medium farmers, assuming maize area is 75% of with-policy case

Table 29 (con't)

	EPR1, S/M, 25% k/	EPR1, S/M, 50% l/	EPR1, S/M, 75% m/	SPR2, S/M, 25% n/	SPR2, S/M, 50% o/	SPR2, S/M, 75% p/	SPR1, S/M, 25% q/	SPR1, S/M, 50% r/	SPR1, S/M, 75% s/	SP,R2, LG t/	OTHER 25% u/	OTHER 50% v/	OTHER 75% w/
Prod. change with tech., policies (% change from no policies, no tech.	74.5	74.5	74.5	7.9	7.9	7.9	126.5	126.5	126.5	-57.7	65.5	65.5	65.5
Tech. contrib. (SR52, Zimb., Zambian hybrids)%	1.03	2.05	3.06	151.8	310.9	477.1	2.7	5.3	7.7	28.32	30.8	63.4	97.9
Policy contrib.	99.0	98.0	97.0	-51.8	-210.9	-377.1	97.3	94.7	92.3	-128.3	69.2	36.6	2.09
Sum pct	100	100	100	100	100	100	100	100	100	100	100	100	100

k/ Eastern Province Region I small/medium farmers, assuming maize area is 25% of with-policy case
l/ Eastern Province Region I small/medium farmers, assuming maize area is 50% of with-policy case
m/ Eastern Province Region I small/medium farmers, assuming maize area is 75% of with-policy case
n/ Southern Province Region II small/medium farmers, assuming maize area is 25% of with-policy case
o/ Southern Province Region II small/medium farmers, assuming maize area is 50% of with-policy case
p/ Southern Province Region II small/medium farmers, assuming maize area is 75% of with-policy case
q/ Southern Province Region I small/medium farmers, assuming maize area is 25% of with-policy case
r/ Southern Province Region I small/medium farmers, assuming maize area is 50% of with-policy case
s/ Southern Province Region I small/medium farmers, assuming maize area is 75% of with-policy case
t/ Southern Province Region II large farmers
u/ All other areas, assuming maize area is 25% of with-policy case
v/ All other areas, assuming maize area is 50% of with-policy case
w/ All other areas, assuming maize area is 75% of with-policy case

farmers produced 71.6 percent less than predicted if there had been no new technology or policies. The decline in Southern Province large farmer production was 57.7 percent. Decreased production by large farmers close to the line-of-rail, and increased production by more remote farmers, resulting in more expensive transportation costs, thus increased subsidies from GRZ, contributed to the negative ARR reported for the package of research and complementary expenditures from 1978-91.

Figures 17-26 show, for the national level and individual areas, what actual production was in 1971-2 and 1987-88, and estimated production under different assumptions, (1) without improved technology, pricing or marketing policies (ITPM), (2) no price/marketing/fertilizer policies but SR52 area at 50 percent of with-policy levels, (3) no price/marketing/fertilizer policies but SR52 and Zimbabwean hybrid area at 50 percent of with-policy levels (4) no price/marketing/fertilizer policies but SR52, Zimbabwean and Zambian hybrid area at 50 percent of with-policy levels.

At the national level, the projections show that 1987-88 production would have been higher than the actual, with-policy levels if farmers had planted improved varieties on 50 percent or more of the area planted to improved varieties in the with-policy case (Figure 17). The major reason for this is that actual large farmer production in Central and Southern Provinces declined sharply between 1971 and 1987 (Table 29; Figures 19, 21). Large farmer production would have been much higher in any of the projected no-policy scenarios. In all other small/medium analysis areas, with the exception of Southern Province Region II and Northern Province (75 percent), production was higher in the actual, with-policy case than in any of the without policy cases (Table 29, Figures 17-26).

Figures 27 and 28 show clearly that the impact of policies was to encourage maize production in remote provinces (Northern, Eastern) and discourage it to an extent in areas closer to consumption centers (Central, Southern). With policies and improved technology in place, close areas produced 51 percent of actual maize production in 1987/88. Remote areas produced 35 percent, and other provinces produced 14 percent. If improved technology had been available, with no marketing/price/fertilizer policies in place, closer provinces would have provided 69-72 percent of total maize production, with 18-20 percent from remote provinces, and 10-11 percent from other areas.

The policy environment also facilitated a shift of production from large to small/medium farmers (Figures 29-30). Figure 29 shows that large farmers produced 10 percent of maize in the actual, with-policy scenario of 1987-88. This proportion is too low, probably because the analysis omitted large farmer production in provinces other than Central and Southern. According to GRZ (1991), large farmers produced about 20 percent, and small/medium farmers 80 percent of total maize production. Without policies, however, the results show that large farmers would have produced more than a third of the total, while small/medium farmer share would have dropped to 65-70 percent.

6.6.2. Distribution of benefits between producers

Changes in producer surplus resulting from the implementation of maize-related programs were calculated using the Akino-Hayami formulas. Figure 31 shows the

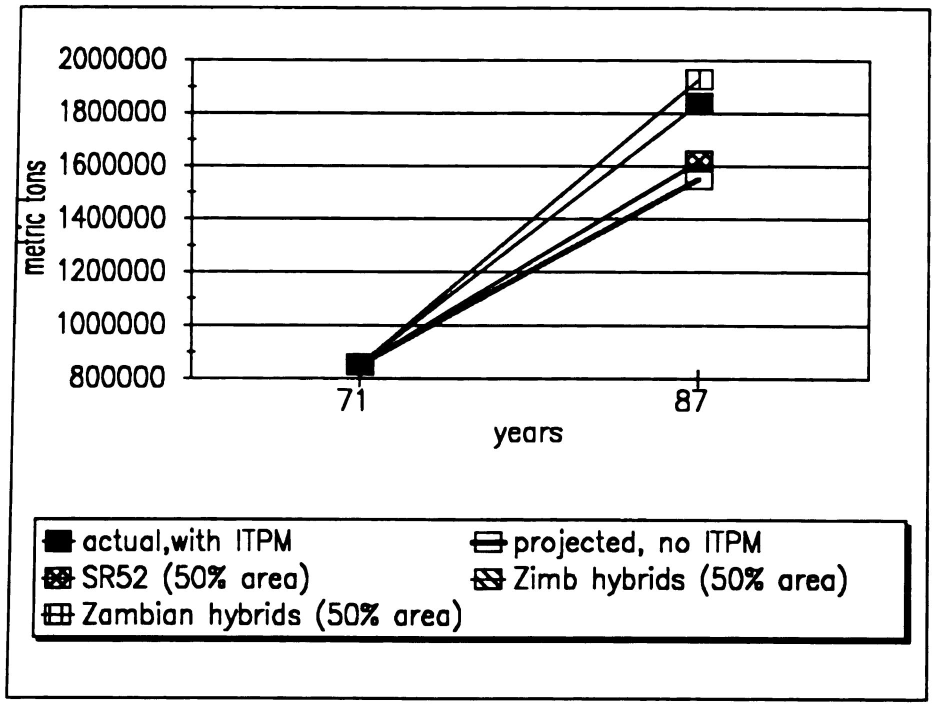


Figure 17: Production changes 1971-88, national

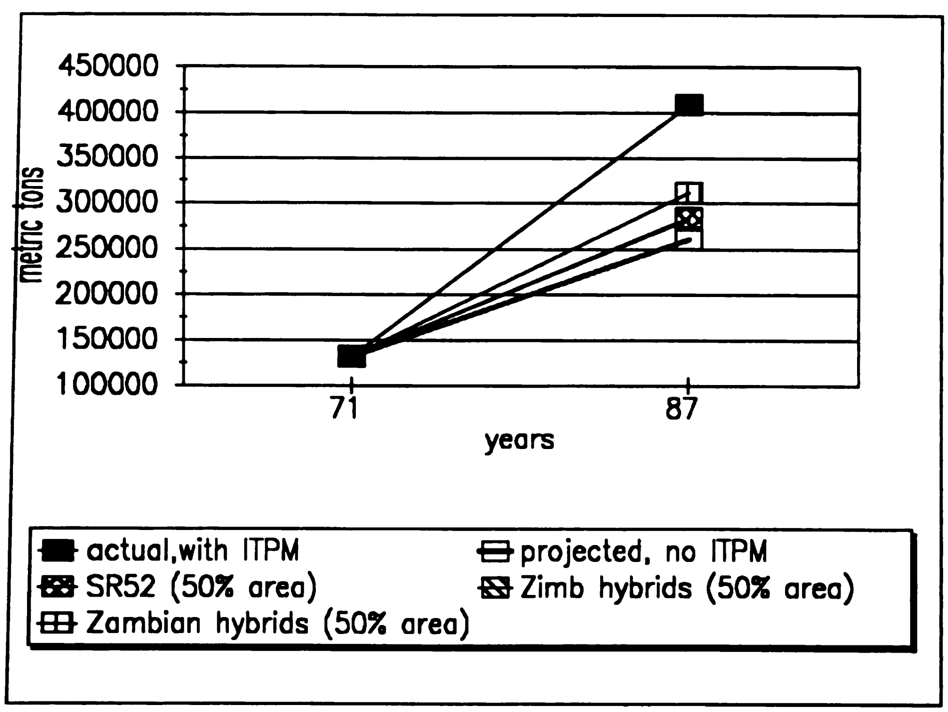


Figure 18: Production changes 1971-88, Central Province Region II sm./med. farmers

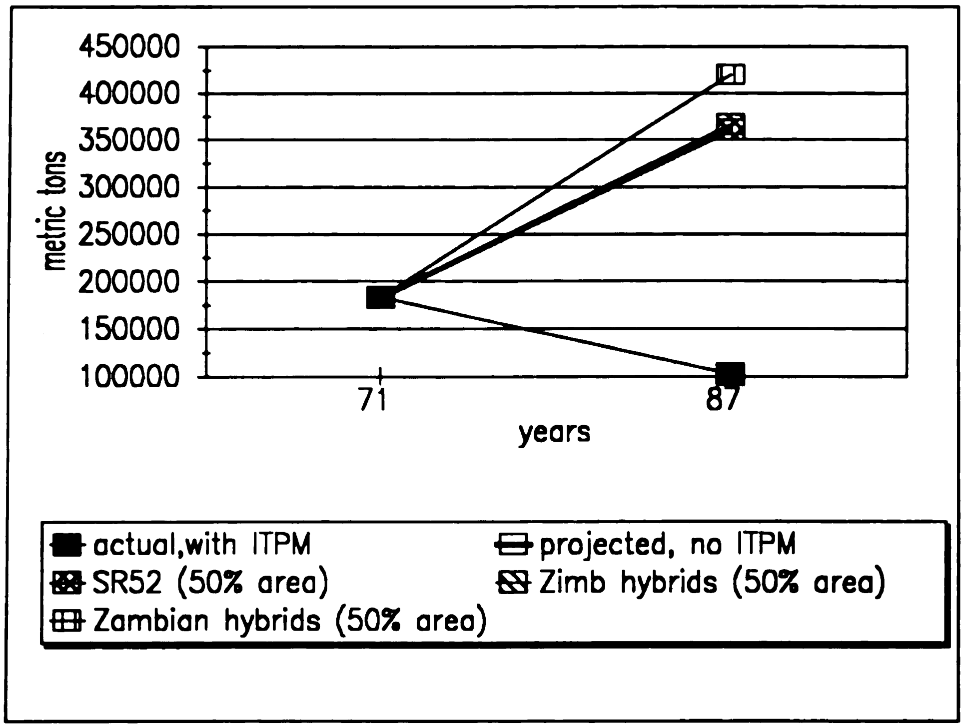


Figure 19: Production changes 1971-88, Central Province Region II large farmers

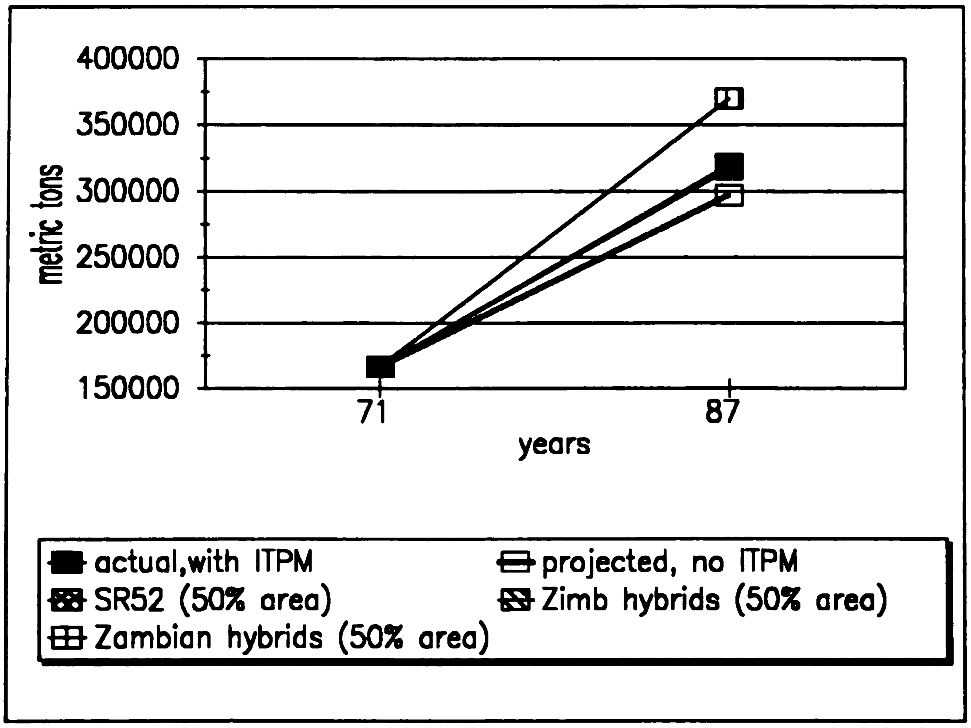


Figure 20: Production changes 1971-88, Southern Prov. Region II sm./med. farmers

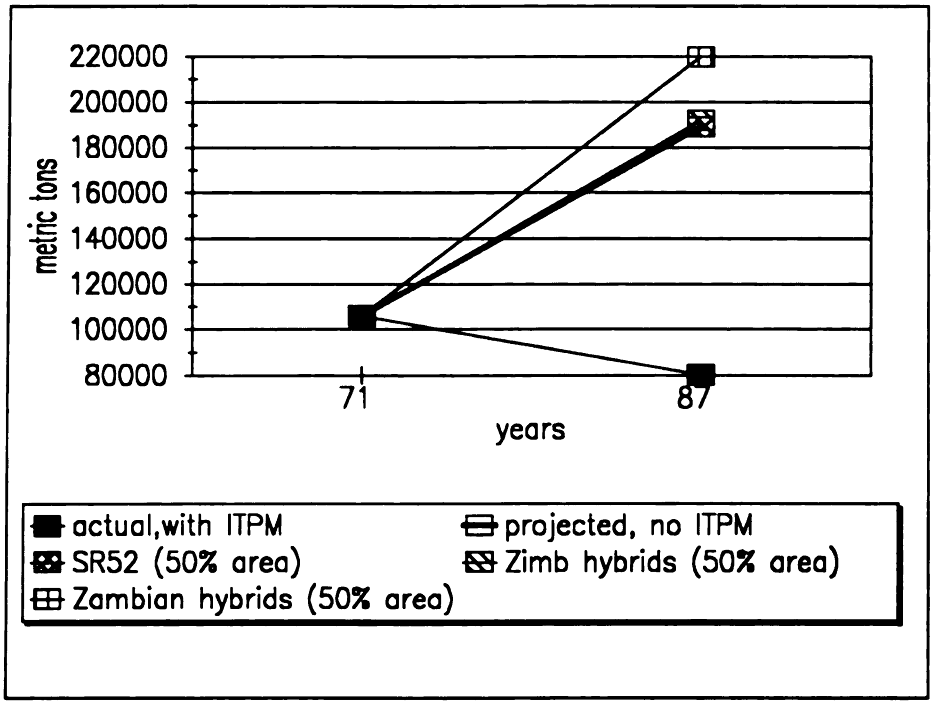


Figure 21: Production changes 1971-88, Southern Province Region II large farmers

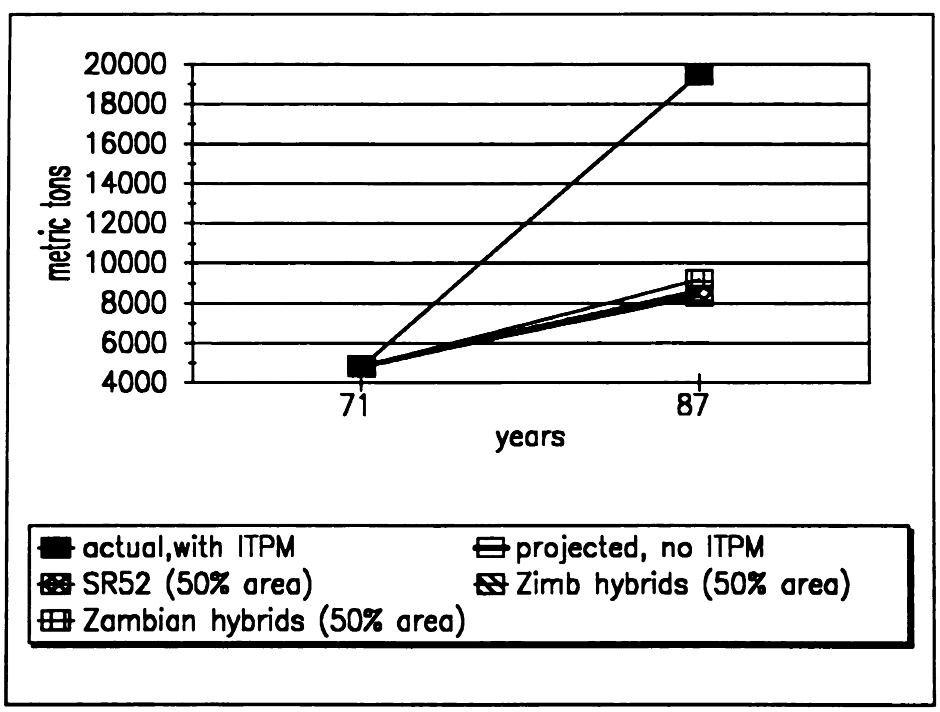


Figure 22: Production changes 1971-88, Southern Province Region I sm./med. farmers

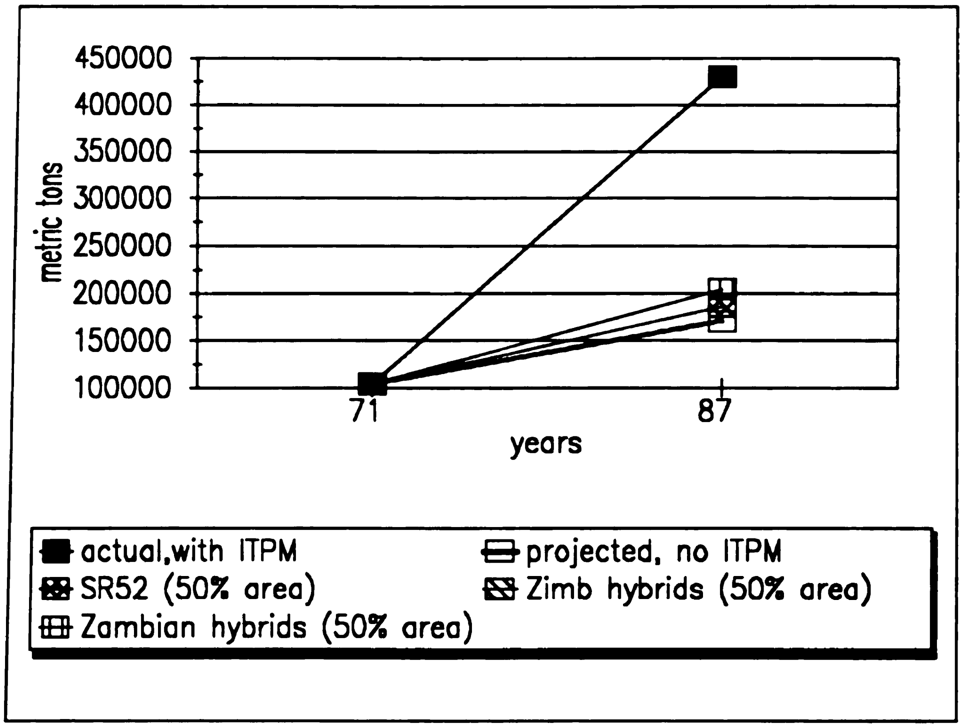


Figure 23: Production changes 1971-88, Eastern Province Region II sm./med. farmers

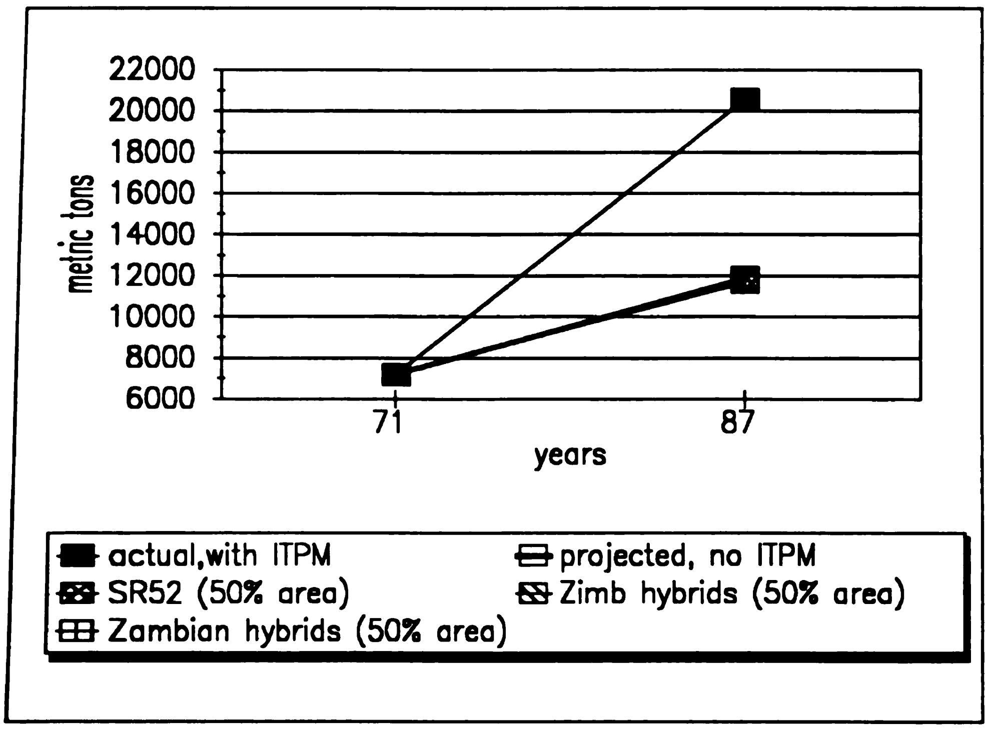


Figure 24: Production changes 1971-88, Eastern Province Region I sm./med. farmers

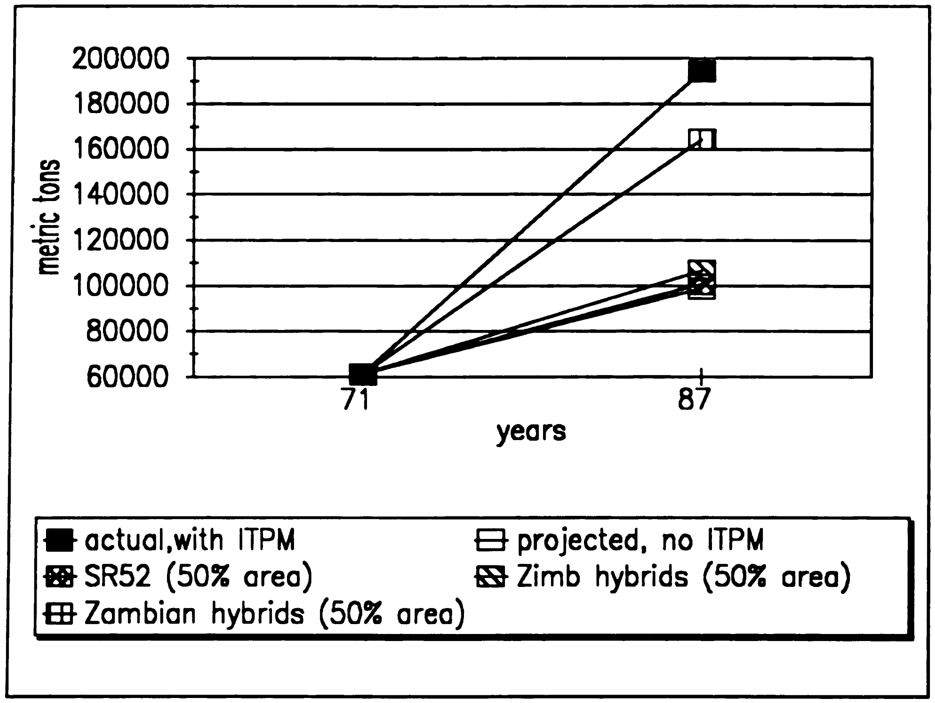


Figure 25: Production changes 1971-88, Northern Province Reg. III sm./med. farmers

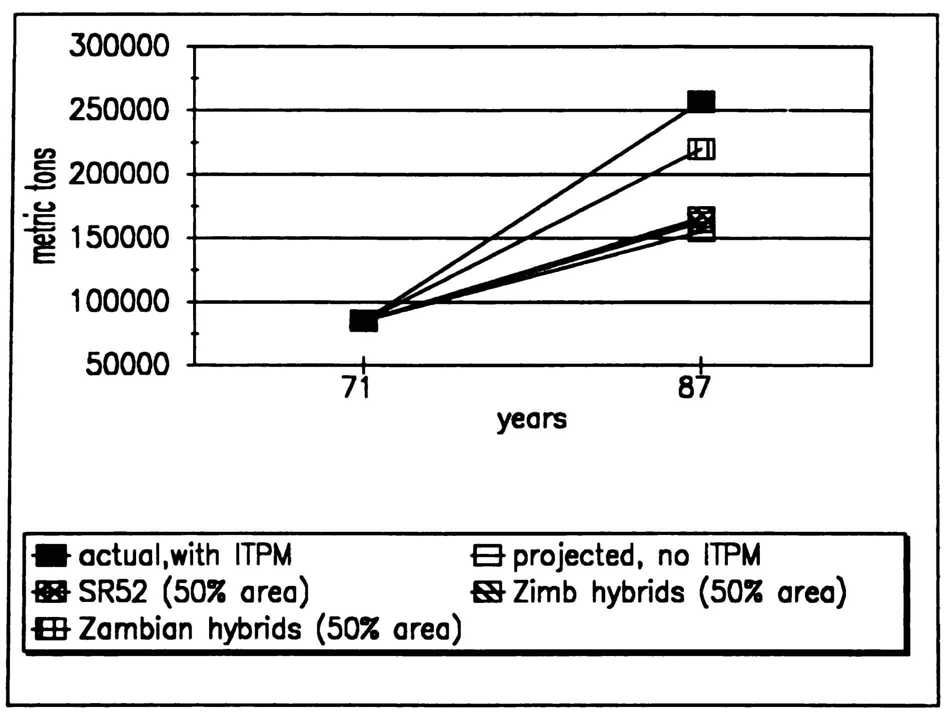


Figure 26: Production changes 1971-88, rest of economy

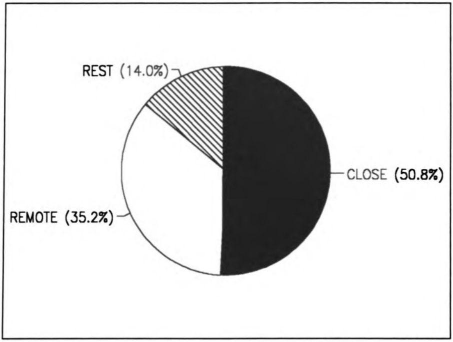


Figure 27: Actual production, 1987-88, close/remote/rest distribution

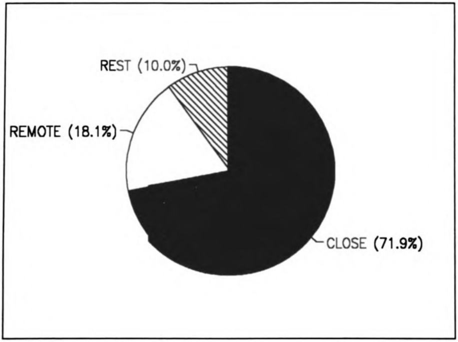


Figure 28: Estimated distribution of production close/remote/rest, 1987-88, no ITPM

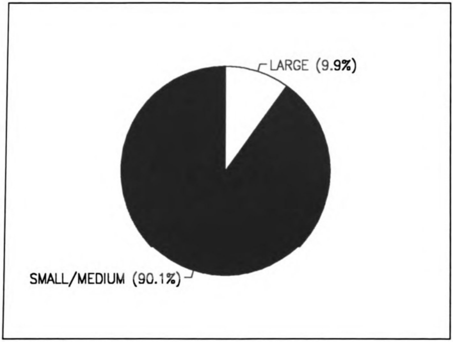


Figure 29: Distribution of production 1987-88, with ITPM

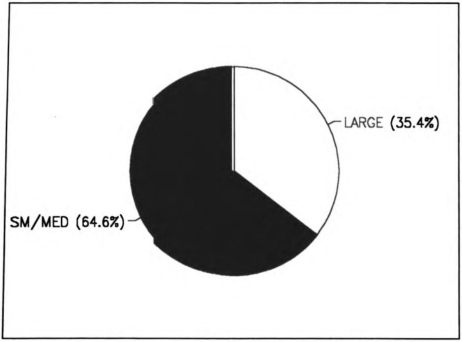


Figure 30: Estimated distribution of production 1987-88, without ITPM

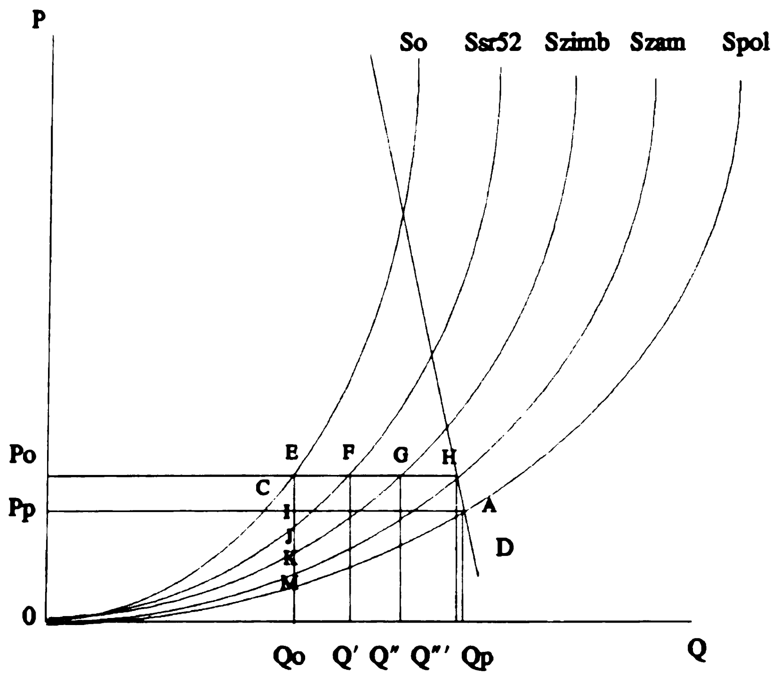


Figure 31: **Changes in producer, consumer surplus resulting from improved technology, policies**

surplus areas from changes in technology and implementation of policies graphically. With no price policies in effect, the change in producer surplus from a shift in supply from S_0 to S_{SR52} is represented as area EF0; change in surplus from a shift from S_0 to S_{Zimb} is area EG0; and from S_0 to S_{Zam} is EH0. When improved technology is available and policies are in effect, additional surplus from S to S_{Pol} is area AOC - area P_0HAP_p, where P_0 is the import parity price, and P_p the pan-territorial maize price. Because of increased domestic production, Zambia saved foreign exchange, since less maize had to be imported to satisfy consumer demands for maize. The foreign exchange saving in the without-policy case, with the adoption of SR52 by smallholders, is Q_0 EFQ'. When

Zir

Zam

excha

rather

under

with

SR

Zimbabwean hybrids become available, savings are Q_0 EGQ″. With adoption of Zambian hybrids, savings are Q_0EHQ‴. With policies and technology, foreign exchange savings are Q_0CAQ_p.

Although foreign exchange was saved, the costs of producing maize domestically rather than importing should be accounted for. These costs are represented by the area under the corresponding supply curve. Therefore, the net economic benefit to society, with improved varieties and policies, is area ACM[3]. With no policies and adoption of SR52, the net benefit is area EFI; with adoption of Zimbabwean hybrids, it is EGJ; with Zambian hybrids, it is EHK. Results of the calculation of producer surplus, foreign exchange savings and net economic benefit are shown in Table 30.

Table 31 summarizes these results by close/remote/other and large/small categories. In the without-ITPM case, farmers in close areas have the highest share of producer surplus under every assumption. The proportion of remote and other area producer surplus increases as area planted to improved varieties rises. When policies and improved technology are in place, producer surplus for close areas is negative, but positive for remote and other areas. Large farmers are in the close category, and their maize area and production drop sharply with the implementation of policies and corresponding fall in prices. Most remote and other farmers continue to expand production with the implementation of policies, resulting in increased surplus.

---

[3] ACM = A0C-C0E, where
A0C = $K^*P_0Q_0$;
C0E = $K^*P_0Q'_n$; and
Q'_n = total production in the without-research, without-policies scenario

Table 30: Producer surplus, foreign exchange savings and net economic benefit under different technology/policy assumptions

	PS change SR52,25%	FX change SR52,25%	Net econ. benefit SR52,25%	PS change SR52,50%	FX change SR52,50%	Net econ. benefit SR52,50%	PS change SR52,75%	FX change SR52,75%	Net econ. benefit SR52, 75%
NP,R3,S/M	869,555	14,347,665	8,826	1,756,761	2,898,656	35,302	2,661,619	4,391,671	79,430
CP,R2, S/M	13,887,080	22,913,683	574,759	28,923,680	47,724,072	2,299,038	45,109,798	74,431,167	5,172,835
CP,R2,LG	0	0	0	0	0	0	0	0	0
EP,R2,S/M	7,392,095	12,196,956	308,745	15,401,680	25,412,772	1,234,982	24,028,757	39,647,449	2,778,709
EP,R1,S/M	-47,809	-78,884	205	-95,206	-157,091	822	-142,193	-234,619	1,849
SP,R2,S/M	12,207,148	20,141,794	402,537	25,219,371	41,611,962	1,610,149	39,036,668	64,410,502	3,622,835
SP,R1,S/M	-130,710	-215,671	1,748	-257,923	-425,573	6,994	-381,639	-629,704	15,736
SP,R2,LG	0	0	0	0	0	0	0	0	0
OTHER	5,077,701	8,378,207	118,789	10,392,981	17,148,419	475,157	15,945,840	26,310,636	1,069,103

	PS change Zimb,25%	FX change Zimb,25%	Net econ. benefit Zimb,25%	PS change Zimb,50%	FX change Zimb,50%	Net econ. benefit Zimb,50%	PS change Zimb,75%	FX change Zimb,75%	Net econ. benefit Zimb,75%
NP,R3,S/M	2,604,107	4,296,776	101,066	5,413,406	8,932,120	407,324	8,432,489	13,913,608	923,366
CP,R2, S/M	531,592	877,127	22,841	1,109,011	1,829,869	41,676	1,732,475	2,858,583	206,221
CP,R2,LG	6,828,465	11,266,967	105,835	6,828,465	11,266,967	105,835	6,828,465	11,266,967	105,835
EP,R2,S/M	420,779	694,286	18,570	878,872	1,450,139	74,454	1,374,540	2,267,990	167,912
EP,R1,S/M	0	0	0	0	0	0	0	0	0
SP,R2,S/M	1,135,695	1,873,897	40,912	2,353,687	3,883,583	75,836	3,654,684	6,030,229	370,337
SP,R1,S/M	0	0	0	0	0	0	0	0	0
SP,R2,LG	3,524,365	5,815,202	54,625	3,524,365	5,815,201	54,625	3,524,365	5,815,201	54,625
OTHER	2,441,480	4,028,443	83,965	5,053,463	8,338,214	338,432	7,839,807	12,935,681	767,260

Table 30, con't

	PS change Zambian, 25%	FX change Zambian, 25%	Net econ. benefit Zambian, 25%	PS change Zambian, 50%	FX change Zambian, 50%	Net econ. benefit Zambian, 50%	PS change, Zambian, 75%	FX change, Zambian, 75%	Net econ. benefit Zambian, 75%	PS change other pol	FX change other pol	Net econ. benefit other pol
NP,R3,S/M	29,900,657	49,336,085	7,264,460	75,358,700	124,341,855	30,086,306	137,950,415	227,618,185	70,041,824	189,308	312,357	93,340
CP,R2, S/M	16,396,682	27,054,525	1,430,920	35,790,332	5,905,409	5,858,808	58,384,577	96,334,552	13,487,291	88,778	146,483	46,746
CP,R2,LG	81,094,854	133,806,509	74,372,224	81,094,854	133,806,509	74,372,224	81,094,854	133,806,509	74,372,224	-52,178,105	-86,093,873	- 84,200,249
EP,R2,S/M	8,396,340	13,853,961	732,022	18,327,099	30,239,714	2,998,464	29,898,544	49,332,598	6,905,591	140,326	231,539	97,534
EP,R1,S/M	135,953	224,323	1,038	273,954	452,024	4,123	413,961	683,036	9,215	723,564	1,193,880	406,607
SP,R2,S/M	32,314,238	53,318,493	3,469,100	71,894,518	118,625,954	14,204,242	119,232,599	196,733,788	32,697,185	586,282	967,365	46,746
SP,R1,S/M	495,217	817,108	16,238	1,021,704	1,685,811	63,746	1,577,650	2,603,122	140,713	3,962,768	6,538,566	2,653,007
SP,R2,LG	41,855,357	69,061,338	38,385,617	41,855,357	69,061,338	38,385,617	41,855,357	69,061,338	38,385,617	-14,390,354	-23,744,083	-10,814,93 0
OTHER	39,839,027	65,734,395	6,681,127	93,844,708	154,843,768	27,528,907	163,249,719	269,362,037	63,776,018	338,399	558,358	46,746

Table 31: Producer surplus changes under different technology/policy assumptions for close vs. remote and large vs. small/medium farmers

	PS change SR52,25%	PS change SR52,50%	PS change SR52,75%	PS change Zimb,25%	PS change Zimb,50%	PS change Zimb,75%	PS change Zam,25%	PS change Zam,50%	PS change Zam,75%	PS change pol.and tech.
CLOSE	25,963,519	53,885,128	83,764,827	12,020,116	13,815,527	15,739,988	172,156,348	231,656,765	302,145,036	**-61,930,631**
REMOTE	8,213,841	17,063,235	26,548,182	3,024,886	6,292,278	9,807,029	38,432,951	93,959,753	168,262,921	1,053,198
OTHER	5,077,701	10,392,981	15,945,840	2,441,480	5,053,463	7,839,807	39,839,027	93,844,708	163,249,719	338,399
SUM	39,255,061	81,341,344	126,258,849	17,486,483	25,161,269	33,386,824	250,428,326	419,461,226	633,657,676	**-60,539,035**
% close	66	66	66	69	55	47	69	55	48	
% remote	21	21	21	17	25	29	15	22	27	
% rest	13	13	13	14	20	23	16	22	26	
LARGE	0	0	0	10,352,829	10,352,829	10,352,829	122,950,210	122,950,210	122,950,210	**-66,568,458**
SMALL/ MEDIUM	39,255,061	81,341,344	126,258,849	7,133,653	14,808,439	23,033,995	127,478,115	296,511,015	510,707,465	6,029,424
SUM	39,255,061	81,341,344	126,258,849	17,486,483	25,161,269	33,386,824	250,428,326	419,461,226	633,657,676	**-60,539,035**
% LARGE	0	0	0	59	41	31	49	29	19	
% SM/MED	100	100	100	41	59	69	51	71	81	

Comparing producer surplus of large and small farmers, in the without-policy case, large farmers gain half or more of total producer surplus when small/medium farmers are assumed to plant a small proportion of maize area (25 percent of the with-policy area) in improved varieties. Small/medium farmer share of producer surplus rises as area planted to improved maize varieties increases. In the actual, with-ITPM case, large farmer producer surplus is negative, and small/medium surplus is positive.

6.6.3. Benefits to urban consumers

Urban consumers in Zambia benefitted from government pricing policies that kept urban consumer prices lower than the import parity price. In Figure 31, Q_p can also represent urban consumption of maize in 1987-88. The transfer to urban consumers is represented by the area P_oHAP_p. P_oHAP_p is equal to the import parity price-consumer price of maize. The import parity price is assumed to be the average CIF Ndola and CIF Lusaka prices, weighted by consumption shares (68 percent, 32 percent respectively), or ZK 2520.05/ton (Table 95, Appendix 10).

The consumer price of maize (whole grain equivalent) is calculated as follows: 100 kg whole maize is equivalent to 90 kg roller meal or 61 kg breakfast meal (GRZ 1991). The retail price of 25 kg roller meal, or, equivalently, 27.5 kg whole meal in May 1988 was ZK 14.85 (GRZ 1990). Thus the roller meal whole grain equivalent price is equal to ZK 540/ton. The retail price of 25 kg breakfast meal, or 34.75 kg whole meal in May 1988 was ZK 19.15 (GRZ 1991). Therefore the breakfast meal whole grain equivalent price is equal to ZK 551/ton.

Of total meal production, 38.8 percent was roller and 61.2 percent breakfast in 1990 (GRZ 1991). The weighted consumer price was ZK 546/ton. The height of the near- rectangle P_oHAP_p is 2520.05-546 = 1974.05; its length is equivalent to Qp, or Lusaka urban consumption (136,166 tons) + Copperbelt urban consumption (288,987 tons) = 425,153 tons.

Therefore, urban consumer surplus = area P_oHAP_p

= 425,153*1974.05 = ZK 839,273,280.

Total urban consumer surplus of ZK 839,273,280 compares to total producer surplus of **negative** ZK 60,539,035 in the with-ITPM case. This shows that, when the whole package of maize policies, including consumer subsidies, are considered, consumers were by far the greatest beneficiaries. Aggregate producer surplus calculated here is lower than the national-level producer surplus results reported in Table 23 (Chapter 5), ZK 772 million, because the Chapter 5 calculation did not reflect losses to producers when the producer price dropped from import parity levels to the government-enforced producer price.

6.7. Estimated ARR to investments in technology development and transfer in the absence of fertilizer and marketing policies

This section incorporates information from the preceding analysis to estimate a revised ARR to technology investments in the absence of key price and marketing policies. The revised estimates represent the returns to investments in development and dissemination of Zambian improved hybrids when fertilizer is available to large, but not small and medium farmers. The economic benefit-cost calculation of Chapter 5 (Tables 100-103, Appendix 11) is modified (Tables 109-111, Appendix 13) and the results are compared to the results from Chapter 5 in Table 32, below.

Since in the Zambia case there are no observations of production behavior in the no-policy case, a sensitivity analysis approach is again used. In Table 109 (Appendix 13), the ARR is calculated under the assumption that farmers plant 25 percent of the small/medium farmer with-policy maize area to SR52, Zimbabwean hybrids and Zambian varieties. Tables 110 and 111 (Appendix 13) present the ARR estimate under assumptions that 50 percent and 75 percent of small/medium farmer with-policy area is planted to these varieties.

The "without" case assumes that large farmers plant SR52 and Zimbabwean hybrids with the full recommendation of fertilizer. Small/medium farmers plant local maize, and 25 percent of with-policy areas of SR52 and Zimbabwean hybrids, but use no fertilizer. The "with" case assumes that large farmers use fertilized Zambian varieties in addition to SR52 and Zimbabwean varieties. Small/medium farmers plant 25 percent of the with-policy area of Zambian varieties, in addition to locals and 25 percent of SR52 and Zimbabwean hybrids, all unfertilized.

Estimated production in the "without" case is based on the aggregated total of $Q_{Zimb.25}$ estimates from Table 28, 1.6 million tons. This amount is modified in the drought years of 1986-87 (-41 percent) and 1991-92 (-60 percent) based on estimated production losses in those years (CSO 1988, 1992). Prices used are the same economic import parity prices used in Chapter 5's ARR analysis. "With" and "without" case production levels are identical from 1978-79 to 1983-84. The aggregated total of $Q_{Zam.25}$ estimates from Section 6.5., 1.78 million tons, is used in 1987-88. An adoption curve from 1984-87 is simulated from differences in yearly production levels from the actual with-policy, no improved technology case in Chapter 5. The difference between 1987-

88 and 1986-87 production was -41 percent, between 1986-7 and 1985-86 was 38 percent, and between 1985-86 and 1984-85 was -7 percent. It is assumed that 1987-88 represents the peak adoption year, and production remains at the 1.78 million ton level through 2001.

Since large farmers use the same level of fertilizer in the without and with cases, and small/medium farmers use no fertilizer in either case, there are no differences in production costs between the with and without cases. Research, extension and seed costs are the same as in the Chapter 5 analysis, but marketing costs are omitted here. The ARR for the 25 percent case is 65 percent in the 1978-2001 period and 77 percent for 1978-91 (Table 32).

Calculation of the revised ARR in the cases where 50 percent and 75 percent of with-policy areas are assumed to be planted in SR52, Zimbabwean hybrids and Zambian hybrids differs from the 25 percent case only in the aggregated Q_{Zimb} and Q_{Zam} estimates used. Calculations are presented in Tables 110 and 111 (Appendix 13). The revised ARR in the 50 percent case is 85 percent and 68 percent in the 1978-2001 and 1978-91 periods. In the 75 percent case, the ARRs are 96 percent and 84 percent, respectively. All without-policy ARRs are substantially higher than the with-policy ARR. The with-policy ARR is negative in the 1978-91 period and 49 percent from 1978-2001, while the without-policy ARRs range from 68-96 percent (Table 32).

Table 32: Comparison of estimated ARRs to improved Zambian maize development and dissemination, with and without policies (benefit-cost method)

percent

	With policies	Without policies (25% area)	Without policies (50% area)	Without policies (75% area)
1978-91	negative	65	68	84
1978-2000	49	77	85	96

CHAPTER SEVEN

THE POLITICAL ECONOMY OF MAIZE RESEARCH AND COMPLEMENTARY INVESTMENTS

7.1. Introduction

The preceding chapters described Zambia's maize paradox. New maize technology was developed, disseminated and adopted by most of the country's farmers. But for many, sustained adoption was contingent on a maize price and marketing structure that was heavily subsidized by the government. Despite high adoption and returns to individual farmers from the technology, the rate of return to society of the overall investment in maize technology and dissemination was negative between 1978-91 (Chapter 5). If the new maize technology had been disseminated without fertilizer subsidies and marketing assistance, the ARR would have been higher, but the pattern of adoption and distribution of benefits much different (Chapter 6).

The introduction of structural adjustment policies beginning in 1991 sparked optimism that many problems would be solved automatically when government withdrew from maize marketing and the geographic pattern of production reverted to regions where maize has a "natural" comparative advantage. However, if the package of maize investments was not simply an example of economic ineptitude, but served a function beyond increasing maize production, the suspension of investments may carry consequences beyond realignment of maize production back to the line-of-rail.

This chapter explores the maize paradox, and the grounds for post-liberalization optimism, in three sections. The first explores the historical development of maize-related institutions and organizations in Zambia. The second asks why the newly independent government of Zambia chose to implement policies that redistributed development opportunities (property rights) away from the traditional line-of-rail corridor. Third, given the redistribution decision, the chapter analyzes how the structure and interaction of institutions and organizations affected the sustainability of these policies, and implications for the future.

7.1.1. Analytical framework

In his work Institutions, Institutional Change and Economic Performance (1990), North outlines a theory of institutions that builds on the neoclassical framework. He keeps other tenets of standard economic theory while relaxing the assumption of perfect knowledge, and examines human behavior in a world of imperfect information, particularly human adaptations to uncertainty, which make transactions more costly and constrain transactions and transformation (production). North's thesis is that the differential performances of economies through time can be explained by a society's success in evolving institutions and organizations that remove uncertainty and thus diminish transactions costs.

Institutions are the "rules of the game" in a society; they refer both to formal constraints such as the legal system and informal laws like social mores. Organizations are the "players" in the game, including political, economic, social and educational units, such as political parties, cooperatives, churches and schools. In the short term, the actions or opportunity sets of organizations are limited by institutions and constraints of standard economic theory; their strategies for achieving specific objectives for their group must fit within the universe of acceptable conduct defined by existing institutions. However, over time, through their interaction with institutions, organizations themselves can influence the evolution of institutions.

The path of institutional change, or the development path, is affected by the "lock-in" character of the "symbiotic" institution-organization relationship that results because organizations develop in response to the incentive structure provided by institutions. This means that the development path of institutions may result in an environment of persistently high rather than steadily decreasing transactions costs, or a path toward an efficiency point with distributional implications that are ultimately unacceptable to the society.

Institutional economists recognize the existence and validity of a number of efficient points toward which an economy could move, all with varying property rights structures, with different long-term implications for social stability. The structure of property rights matters, because post-production redistribution is difficult in a typical, friction-laden economy. Robert Bates argues:

> ... two systems of property rights may thus both produce efficient outcomes. But they will yield different distributions of income and ones that would result in major differences in the structure of demand, the composition of industries, and the kinds of jobs and skills that are socially rewarded. While equivalent in terms of the degrees of economic efficiency, the two institutional bases thus yield radically different developmental outcomes (1989, 9).

Bates suggests that attention to reducing the transactions costs of political and economic actors is of equal importance if a society is to move toward a dynamic and politically sustainable development path. Political institutions form the incentives for the organization of interest groups, and thus help determine which economic interests in the society become effective interests (1989, 8).

Incremental change comes about when actors in political and economic organizations see that they could be better off by altering the institutional framework at some margin. Whether the change leads the economy in the long run to a path of increasingly lower transactions costs, towards an efficiency point with a socially viable distribution of property rights, depends on the completeness of the economic and political information the actors receive, the way they process the information (North 1990), and which groups win key political contests.

An important behavioral assumption of neoclassical economics is that actors have **true** models of the environments about which they make decisions, or, if actors start with divergent models, that they eventually receive information that leads to model convergence. North rejects this assumption, holding that these subjective models are individually derived and very different. Because information is so imperfect, it is much more likely that individuals persist with different models than that they converge (North 1990, 17).

Culturally derived informal constraints underlie mental models and affect the processing of information, and are therefore a source of path dependence. These culturally rooted informal constraints will not change immediately in response to a change in formal rules, and the give-and-take play between new formal rules and informal constraints also has an important effect on the development path. In Zambia, the strongest influence on subjective models is tribal culture, with its extensive set of formal and informal institutions and organizations to reinforce particular patterns of behavior.

The costliness of economic exchange and the institutional/organizational constructs humans develop to negotiate property rights and then reduce the exchange costs associated with a property rights structure are at the core of the new institutional economics theory. Transactions are costly because getting information is costly. Two kinds of costs are important: the costs of measurement, which tell the buyer about the characteristics of what is being exchanged, and the costs of enforcement, policing agreements once they are made and protecting property rights (North 1990).

A key insight is the recognition that the costs of transacting are part of production costs. The total costs of production are the sum of transformation and transaction costs:

> ...the resource inputs of land, labor, and capital involved both in transforming the physical attributes of a good (size, weight, color, location, chemical, composition, and so forth) and in transacting -- defining, protecting, and enforcing the property rights to goods (the right to use, the right to derive income from the use of, the right to exclude, and the right to exchange) (North 1990, 28).

7.2. Historical development of Zambian institutions and organizations

North outlines three development phases of economic exchange. The first stage is personalized and repeated exchanges characterized by small-scale production and localized trade, unenforced by a third party. As trade expands over a larger geographical area, a second, more impersonal level of trade develops, enforced by kinship, exchange of hostages, bonding, or merchant codes of conduct. At the third level, impersonal exchange is enforced by third parties, e.g., a legal system effectively backed by the state, which facilitates complex contracting (North 1990, 34-35).

7.2.1. Pre-colonial period

Historical studies of pre-colonial Zambia paint a world of many tribes, with different resource bases, and continuous struggle and adaptation in political and economic relationships. Strong tribes moved into Zambia from the Angola-Congo area and from East Africa, and pushed the resident, weaker tribes to more marginal agricultural areas (Ranger 1971).

Exchange in some tribes was at the first stage of localized, personalized transactions, but in others had evolved to the second, involving impersonal exchange over longer distances. In the late 1800s the Senga of Eastern Province reportedly grew and traded highly valued tobacco and woven cloth with other tribes. The Lozi of Western Province used commodity trade to enhance a centralized political system and develop a highly complex agricultural system that drew and organized slave labor from other tribes. In northern Zambia, the Bemba tribe used its great military strength to capture slaves for export in the 19th century ivory and slave trade, and received food as tribute from weaker chiefs. Other tribes sold surplus food to the trade caravans for cash or barter goods (Ranger 1971).

7.2.2. Colonization

Three key development pillars were built during the colonial era that continue to influence Zambian maize policies in the 1990s. First, copper's overwhelming dominance in the economy established agriculture as a subordinate sector whose primary function was to provide food for mine workers. Second, an early precedent was set for extensive state intervention to achieve policy objectives, the most important of which was to ensure the urban food supply through control of prices and market channels. Third, the stability of the state marketing system for maize relative to other crops attracted small African farmers into commercial maize production.

European colonization of Zambia dates from the 1890s, when mining and trading companies began to establish posts in the territory, then known as Northern Rhodesia. By the early 1900s, the territory had been included in the charter granted to Rhodes' British South Africa Company (BSA). BSA administered the territory until 1924, after which the British government began to govern it directly (Jansen 1977, 6).

BSA's primary interest was to develop the territory's mining potential. Migration of African workers to the mines was encouraged by the assessment of a territory-wide head tax and the subsequent need for Africans to earn cash. Agriculture was a subsidiary activity, necessary for feeding the mine workers in Northern Rhodesia's Copperbelt and Katanga (present-day Zaire). BSA encouraged European farmers to settle in farming areas the company alienated from Africans, through a series of treaties negotiated with chiefs that granted the company land rights over most of the territory. The European farmers (700 by 1921), settled in two areas: along the BSA-owned railway line that had been extended northward from (Southern) Rhodesia by 1910 to serve the mining areas of Northern Rhodesia and the Congo, and in Eastern Province, close to BSA's headquarters. Agricultural research during the colonial period primarily met the needs of these European settlers, focusing on maize, export crops such as coffee and tobacco, and fruit and vegetables (Baldwin 1966, 146, cited in Jansen 1977, 7; Eylands and Patel 1990, 309).

African farmers' maize market share increased from 14 percent in 1920-25 to 43 percent by 1935-40 (Makings 1966, 203). European farmers' concern over the growing importance of African maize production led to the 1936 establishment of the Maize Control Board, which was given authority to buy and sell all maize at fixed prices in eight districts close to the line of rail. The North Western Rhodesia Farmers Cooperative Society functioned as the Board's agents for the actual physical handling, storage and distribution of the maize, setting a pattern for parastatal-cooperative collaboration in marketing that would endure for more than fifty years. African producers were allotted one-quarter and European producers three-quarters of the internal market pool. Maize prices received by Europeans were 25-50 percent higher than African prices in most years until the system was abolished in 1957, with the African differential used to finance conservation projects and later marketing services (Jansen 1977, 10, 14, 33).

After World War II, the colonial government began to implement programs that promoted African farmers as partners rather than competitors in agricultural production (Makings 1966, 211). A policy of directing African agricultural assistance to progressive farmers in the more favorable areas was formulated in 1951 and guided the Department of Agriculture's work for the next decade, primarily through the improved farmer and peasant farmer schemes. Extension agents focused on soil conservation methods like contour ridges and grass strips and crop rotation, and introduced more intensive cash crops for export such as tobacco, confectionery groundnuts, and cotton (Makings 1966, 229).

The ancestry of Zambia's current pan-territorial market pricing system, and the extension of marketing services to rural areas, can be traced to a 1945 report by the colonial government's joint development adviser, G.F. Clay. He suggested that marketing policies be used to promote production in remote areas, partly to encourage more equitable development, but mainly because existing policies were leading to overproduction and soil degradation in areas close to the line of rail. Clay proposed offering a flat producer price for maize in each region from which a uniform charge for handling and transporting the maize to the line of rail, regardless of actual distances, was deducted. Marketing services financed through the African maize price differential were provided through a system of rural depots to all African farmers in Southern Province beginning in 1951-52 and to Central Province the next season (Makings 1966, 211, 216-218; Jansen 1977, 32).

7.2.2.1. Effects of colonization

A dual set of institutions and organizations emerged in Zambia, the new one serving the mining economy and the existing one the tribal society and economy. The interactions between the two sets accomplished control of the latter by the former, not an evolutionary synthesis such as North describes for the North American colonies. Unlike Southern Africa, there was no cultural bar in North America between the rulers and the ruled after the Native American population was vanquished. Where the native population remained important after colonization, in Latin America and Africa, "local control" did not evolve; Spain dealt with its colonies through bureaucratized central control, and Britain reserved control to the minority of white settlers until independence.

How did colonial institutions/organizations affect traditional tribal society? One striking impact was the loss of political power by the dominant tribes before colonization, the Lozi (Western Zambia) and the Bemba (Northern Zambia). Development of transport infrastructure and the commercial maize marketing system along the line-of-rail did not touch either tribe's area, instead granting a permanent reduction in transaction and transformation costs to Europeans and tribes along the rail line, especially the Tonga (southern Zambia) and Ila (central Zambia) peoples (Ranger 1971).

With colonial rule, the large chief's villages of the Bemba people began to disband. This was partly because colonialism brought an end to the 19th century tribal wars and to the military advantage of these large groupings. Also, the extensive chitemene, or slash-and-burn, agriculture practiced by the Bemba was better suited to small, scattered housing clusters (Ranger 1971, 14-15).

The advanced, labor-intensive agricultural practices of the Lozi, featuring vast drainage systems on the floodplains, depended on slavery and tribute labor, both of which were abolished by the colonial government in 1906. The labor was needed for the mines, but its movement out of Barotseland undermined the viability of the floodplain agricultural system and converted the area to a net food importer (Ranger 1971, 15).

Effects of the new colonial institutions were especially severe for the Ngoni tribe in eastern Zambia. Their area, near Chipata, was already one of the most densely settled areas of the country. The demarcation of Native Reserves and resettlement of tribes into fixed areas left the Ngoni with too small an area to support their population, without the safety valve that the traditional freedom of shifting agriculture had given them before. The results were food shortages and an over-intensification of agriculture that led to severe erosion and fertility depletion.

In summary, colonization had two main impacts: it established a dualistic exchange system, and the ascendance of copper fundamentally changed relative prices in the economy. The colonial government set up organizations such as the Maize Control Board and supported them through a new Western-based legal system. In North's exchange hierarchy, these institutions and organizations enabled impersonal exchange enforced by third parties and facilitated complex contracting. Because the colonial system affected only certain parts of the economy, however, more personalized tribal exchange systems (first and second-order) persisted alongside the colonial one. Since colonization disrupted existing tribal hierarchies, e.g., substantially weakening the Lozi and Bemba empires, these and other tribes which had evolved second-order long-distance exchange systems regressed to more localized, personalized first-level trading patterns after colonization.

The pillars supporting copper--the new railway line, urban migration by Africans, settlement of white farmers, and organizations such as the Maize Control Board--have been the most important new institutions/organizations driving Zambian development in the colonial and post-colonial periods. Investments made by BSA, the British government and Zambians themselves in the railway line, roads, and research and market infrastructure clearly demarcated the line of rail and adjacent land as areas of comparative advantage for agricultural production. These investments established a new set of relative prices underlying a new efficiency point toward which the agricultural sector moved in the colonial era, with particular distribution implications.

7.2.3. Independence

At independence, the new Zambian government inherited both a copper fortune and the socioeconomic problems resulting from copper-led development. The urgent need to diversify an economy so heavily dependent on copper exports was recognized, but not effectively addressed, before independence. A related and difficult task was mending societal divisions that were created by copper and urban-dominated growth during the colonial period, which inhibited movement toward a broader-based development. Urban wage earners and rural farmers were divided. Within the rural sector, there were divisions between European settler farmers and African farmers, and between African farmers close to the line of rail and those in more remote regions.

The magnitude of the social and political divisions at independence meant that much energy was expended in building coalitions among disparate groups that could form a base for governance. The strongest uniting force was antipathy towards anything colonial. As a result, fledgling political organizations kept interests associated with colonialism, which were those with experience in running the most productive parts of the economy, effectively out of governance positions after independence (Bates and Collier 1993). The institutional and organizational innovations introduced in the colonial times, while promoting economic growth, had distributional implications that were politically unacceptable after independence.

Important for understanding why the development path stagnated in Zambia is the recognition that the credibility of formal institutions, which structure opportunities for organizations and influence economic growth, rests on societal agreement or coercion regarding the distributional implications of the chosen path. Agreement was not so important in pre-colonial tribal economies because the intensity of cooperation demanded at the tribal economy level was not as great as in the post-colonial industrial economy, and cooperation could be coerced through military force. The European settlers were able to establish and maintain third-party controls over the part of the Zambian economy they industrialized. The colonial power was recognized by Zambian tribes as a legitimate ruler backed by military force, but once it was gone, there was a power vacuum. Tribes that had dominated different areas of Zambia before independence, the Bemba and the Lozi, saw their resource bases collapse during colonial times.

The effective transfer of the industrial part of Zambia's economy at independence to Zambians also required the transfer of the third-party enforcement and information institutions that operated during the colonial period. This was not automatic because they depended on the development of an underlying political consensus on distribution that would in turn lend legitimacy, inspiring credible commitment to the enforcing institutions and organizations of the state. North describes the long process of the evolution of capital markets in Europe as critically influenced by policies of the state and its ability to convince merchants and citizens that it would not confiscate assets or use coercive power to increase uncertainty in the exchange process.

> ...the shackling of arbitrary behavior of rulers and the development of impersonal rules that successfully bound both state and voluntary organizations were a key part of this institutional transformation (1990, 129).

Zambia faced a similar dilemma after independence, rooted in the lack of political consensus and the absence of commitment to the state as an enforcing agent. The colonial state was not a credible agent for the whole economy. Institutions and organizations had been used in favor of colonial interests, e.g., African farmers were discriminated against in the maize market, confined to Native Reserves, and taxed to force them into the labor market. Similarly, after independence, Kaunda's UNIP party captured government organizations to serve member interests and secure a political base without creating at least some institutions and organizations, e.g., a working legal system, that could play a credible enforcement role for the whole society.

7.2.3.1. UNIP's government and post-independence agricultural policies

Large-scale interests, including business, labor, and commercial farmers, are able to organize interest groups to lobby for advantageous economic policies in most countries. However, they were effectively excluded from President Kaunda's UNIP party and the government, which was heavily dominated by UNIP. This profoundly shaped the direction of economic policies after independence (Bates and Collier 1993, 393).

Kaunda's supporters were urban dwellers and those who had been excluded from economic development during the colonial period. The large-scale commercial farmers were regarded as remnants of colonialism and enemies of UNIP. Emergent African farmers along the line-of-rail, the Tonga and Ila, who benefitted from the concentration of economic development during the colonial period, supported UNIP's opponent party, the ANC, and were marginalized when UNIP came to power. Instead, UNIP was strongly supported by farmers in remoter regions of Eastern and Northern Provinces and the Copperbelt. As time went on, UNIP leaders, many from Eastern Province, Kaunda's home, developed more interests in agriculture, buying large farms for commercial production.

Beginning in the late 60s, UNIP's popularity and geographical base shrank. The establishment of pan-territorial pricing, subsidized fertilizer and marketing services was a way of strengthening support for the party in the remote areas with the effect of taxing farmers along the line of rail, who were mostly settler commercial farmers or Zambians who had supported the ANC. Maintenance of low consumer prices for maize was essential for continued urban voter support (Bates and Collier 1993, 393-4).

As it was about to become a minority party, UNIP banned its main rival, UPP, making Zambia a single-party state. With this move, UNIP was alienated from the key economic interests in Zambia, especially those in the private sector. This affected policy-making in two ways. First, those groups who were most directly tied to production, commercial and emergent farmers, business, and trade unions, were outside of UNIP's core constituency and influence. There was little immediate negative feedback or consequences within the party when UNIP made economic policies that hurt production incentives. Second, with the loss of business and labor interests on the Copperbelt, UNIP could not use its good relations to broker relations between labor and industry and thus guide economic adjustment (Bates and Collier 1993, 399).

7.2.3.1.1. Marketing and pricing policies

Parastatal marketing of most major crops along the line of rail continued after independence under the newly renamed Grain Marketing Board of Zambia (GMB), established in 1964. Soon afterwards, the Agricultural Rural Marketing Board (ARMB) was formed to serve the more remote regions, marketing seeds, fertilizers and other inputs as well as agricultural commodities. FNDP introduced the policy of providing subsidies to ARMB outlets where the volume of sales could not support the provision of a full range of marketing services, although it was anticipated that the subsidies would end when production increased (Jansen 1977, 59; World Bank 1984).

The power of the GMB gradually expanded in the late 1960s. In 1969 the GMB and ARMB were amalgamated to form the National Agricultural Marketing Board (Namboard). Namboard inherited country-wide monopolies on the purchase, sale, import and export of maize, purchase and processing of cotton, and on the distribution and sale of fertilizers. Namboard also distributed other agricultural inputs such as seeds and until 1973 functioned as a residual buyer, wholesaler, retailer and monopoly importer of fruits and vegetables (Jansen 1977, 83-84, 88). By the late 1970s, however, the agency came under heavy criticism because of late deliveries of inputs, and its high handling and marketing costs: 30 percent of the landed cost of imported fertilizer, and 40 percent of the maize producer price (Jansen 1977, 83-84, 88).

Since independence, producer and consumer prices have been set annually based on several often-conflicting criteria inherited from colonial times. These include the cost of production and fair return to producers (primarily based on large-scale farmers' costs and returns), "reasonable" consumer prices, relation to import/export parity, relative crop profitability, and food security.

The most important consideration has been consumer price and its effect on urban political stability (World Bank 1983, 14; Jansen 1988, 47). Urban consumer pressure was real: pressure from the IMF to maintain subsidy spending at budgeted levels resulted in a 100 percent increase in the price of breakfast meal, the only type then available, in December 1986. Serious rioting erupted in the Copperbelt and Lusaka following the increases. The social unrest contributed to the government's decision to break with the IMF and the reform program in May 1987, followed by the introduction of a maize meal coupon system in January 1989 (Wood 1990, 53-54). This was intended to be a targeted subsidy, initiated with the intention of easing a gradual removal of maize subsidies without jeopardizing the food security of the urban poor. However, by 1991, the volume of coupons being printed and distributed was enough to cover the entire urban population of the country.

Before the 1970-71 season, maize prices varied regionally, and reflected the surplus or deficit position of the region. In 1970-71, the government guaranteed a floor price of ZK 3.20 per bag at all depots countrywide, throughout the season. This was purportedly intended as a measure to ensure equity for all farmers, including those in remote rural areas, but the immediate effect was to encourage production in surplus Eastern Province, where the new price was 50 ngwee above the previous year's, while it was lower in most other provinces. The move toward uniform pricing may have partly resulted from lobbying efforts by Eastern Province politicians. In the following season, the price was increased by 30 ngwee, even in Eastern Province, where over half the previous year's production had to be shipped to the line-of-rail markets, at great expense to the government (Jansen 1988:65-66).

Adoption of fertilizer was seen as a crucial step in getting small farmers to engage in commercial agriculture. Beginning in 1971-72, fertilizer subsidies were introduced, cutting prices by an average of 30 percent of the landed cost. A further incentive for fertilizer use came with the introduction of pan-territorial pricing in 1974. The subsidy was reduced to 15 per cent of landed cost during 1972-3 to 1973-74, then increased again in 1975 and 1978. By 1982, the average subsidy was 60 per cent (Jansen 1977, 101; McPhillips and Wood 1991, 92; Jansen 1988, 71).

As important as the subsidy, the fertilizer distribution network was expanded during the early 1970s to make it more accessible to farmers in remote areas. Expansion of credit programs, with debt collection coordinated with the cooperative marketing system, further eased farmer access to inputs (GRZ 1991b:21-26). Only 15 percent of all fertilizer was consumed outside the line-of-rail provinces in 1975; by 1987, it was 39 percent (Sipula 1993, 29). The price subsidies and expanded distribution quadrupled fertilizer consumption between the late 1960s and the late 1980s (Figure 32, Appendix 14). Contributions by donors did much to boost this trend. By the late 1980s, about half of all fertilizer consumed in the country was donated.

Maize price policy did not change much between the 1970s and early 1990s. Producer prices were below import or export parity prices, remaining constant or increasing slightly in years of excess supply (early 1970s), and going up substantially in years when imports were required to meet local needs (1979-86) (Table 112, Appendix 14) (Jansen 1988, 65; Wood 1990, 26).

7.2.3.2. Agricultural policies in the Chiluba government

In October 1991 a new president was elected: Frederick Chiluba, a former labor union leader with close ties to labor and business interests in the Copperbelt. Deterioration of economic conditions by the late 1980s made it obvious that the self-styled package of reforms the government set up following the break with the IMF was not working. Chiluba pledged during his campaign to work with the IMF to carry out major structural reforms of the economy, including the agriculture sector.

The new government allowed the exchange rate to float freely, and it fell from ZK 90=USD 1 in 1991 to ZK 560=USD 1 by July 1993. Privatization of the many government parastatals began, the price of most staple foods was decontrolled, and the ban on agricultural exports was lifted in June 1993. The social impact of the economic reforms has been severe: inflation reached 200 percent annually by mid-1993.

Initiation of maize marketing reforms was delayed by the 1991-92 drought, but in early 1993 the government outlined its new plan. Marketing subsidies on maize and other crops were eliminated and into-mill and transport rates were now to be liberalized, although a floor price for maize was "suggested." The government was to get out of direct marketing through parastatals, and to act only to facilitate private sector efforts and provide market information (Guyton and Temba 1993, 5).

7.3. Characteristics of post-Independence institutions and organizations

The foregoing analysis suggests that a key motivation behind policies favoring urban consumers and remote small farmers implemented by Kaunda's government was solidification of political support. Remote Eastern Province and Northern Province (for a time) were Kaunda's political bases. Drawing the political connection does not diminish the strategic importance of the set of policies. At independence Kaunda sought to govern a society divided into haves and have-nots by the colonial economic boom as well as by tribal affiliations. The policies implemented by the Kaunda government, intended to redistribute wealth and development opportunities more broadly, may have contributed to Zambia's relative social stability from independence until now.

This section addresses the third theme of the chapter: given the decision by Kaunda and UNIP to pursue redistributive policies, what institutional and organizational factors affected how policies were implemented, and contributed to their economic nonsustainability? Finally, what are the implications for the future?

7.3.1. Increasing returns

The basic premise underlying increasing returns is that once random economic events select a particular technological "path," this choice may become locked in, even if an alternative and superior technology is or becomes available (Arthur 1990, 92). The persistence of the "qwerty" alignment of keyboard letters, of narrow-gauge rails, the victory of gas over steam engine cars and VHS over Beta format videocassette recorders are all examples of increasing returns. Small chance events give an advantage to one technology, which establishes a monopoly position, although new, or abandoned, technologies may be better. Four self-reinforcing characteristics lead to increasing returns: (1) large initial costs, which lead to falling unit costs as output grows; (2) learning, which as it increases improves products or lowers production costs; (3) coordination, which rewards cooperation with other agents involved in similar activities; and (4) adaptive expectations, in which the increased presence of one technology on the market encourages beliefs about future prevalence (Arthur 1988, 10, cited in North

1990, 94). North argues that, although the concept of increasing returns has been applied to technologies, increasing returns is less about technologies than about decision-making in the organizations that are producing competing technologies (North 1990, 94-95).

In Zambia, two examples of increasing returns in maize-related organizations are relevant. First, the heavy emphasis on maize and the organizational model initiated by the colonial government to ensure control of the maize market was adopted virtually intact and then expanded by the newly independent government. The organizational structure included the parastatal marketing board, cost-plus calculation of guaranteed producer prices, independently set consumer prices, a flat producer price in each region, and close coordination with marketing cooperatives.

The underlying institutional (rights) premise of maize policy changed at independence. While continuing to ensure a dependable supply of maize to urban areas, now, rather than protecting the European settler market share, the objective was promotion of a more equitable pattern of development. Before independence, under a policy of settler and industrial rights, efficiency required a stream of payments from small farmers and urban residents to commercial farmers and mine owners. After independence, rights passed to urban consumers and remote farmers, with the stream of payments reversed. However, despite the change in institutions, the formal organizational structure remained the same because of increasing returns to staying with the familiar rather than creating a new organization.

Of the self-reinforcing characteristics noted above, learning and established patterns of coordination, especially with the cooperatives, were important in the government's decision to continue with the marketing mechanisms introduced during the colonial period. In addition, the wave of support for socialism in newly independent African countries in the late 1960s, and the availability of donor support for strengthening cooperatives, may also have encouraged perseverance with a marketing system that featured cooperatives as the primary marketing unit.

The second instance of increasing returns in the maize sector was continuing research and promotion of hybrid rather than open-pollinated maize. Once hybrid SR52 was introduced to small farmers through their large commercial neighbors, there were increasing returns to continued promotion of hybrids plus fertilizer by the extension service because farmers had already learned about hybrid potential. However, in areas without a reliable source of seed open-pollinated varieties are preferable for farmers because their characteristics and yield potential remain stable when replanted in successive seasons, unlike hybrids.

Also, the simultaneous funding of Zambia's seed industry and hybrid maize research by the same donor, SIDA, facilitated close cooperation between the maize research team and seed company. High initial costs for the seed industry, and Zamseed's mandate to operate at a profit, gave additional impetus to "lock in" research and sales of hybrid maize seed. It was always clear that maize seed would be Zamseed's most important product. Hybrid maize seed, which was cheaper to produce, higher yielding, and had to be repurchased by farmers every year, was seen as potentially more profitable than open-pollinated maize, for which seed could be saved and replanted in successive seasons.

7.3.2. Transformation and transaction costs

Maize policies implemented by the post-independence government influenced production incentives in two ways. Fertilizer subsidies reduced production costs for all farmers. Pan-territorial pricing and the establishment of countrywide marketing/credit depots reduced transaction costs for some farmers and increased them for others. North recognized that the costs of transacting are part of production costs: the total costs of production are the sum of transformation and transaction costs (1990, 28). This supports the inclusion of costs of complementary organizations and policies that facilitate technology adoption, as well as research costs, in the calculation of a rate of return to technology investments (Chapter 5).

The Zambia case provides a good illustration of this point. There has been a market for additional commercial maize in urban centers in most years, evidenced by the record of maize imports (Table 114, Appendix 14). Net margin analysis (Chapter 5) showed that small farmer maize production was profitable countrywide under the assumption of a nearby market where guaranteed producer prices were paid. The lack of such market and credit facilities in remote regions limited maize production there to subsistence levels until the 1970s, however. When pan-territorial pricing and market depots in non-line-of-rail areas were introduced, commercial maize production by remote small farmers boomed.

As in Timmer's analysis of the impact of Indonesian fertilizer subsidies (1985), reviewed in Chapter 6, Zambian fertilizer and marketing subsidies reduced some of the risk to small farmers of adopting new technology. Parastatal marketing, and credit programs implemented through local cooperative societies, substituted for private marketing and rural credit services. Private marketing of maize was illegal until the mid-1980s, but even after it was legalized, private entrepreneurs did not serve remote areas that were able to market through the cooperatives.

As in Indonesia, the fertilizer subsidy reduced the costs of experimentation, encouraging Zambian farmers to use fertilizer more intensively. The subsidies may have introduced undesirable new incentives, however. Data from the MSU/MAFF/RDSB survey (Chapter 4) and other studies suggest that heavy fertilizer subsidies motivated farmers to exceed recommended application rates, in effect substituting fertilizer for scarce weeding labor. Fertilizer consumption quadrupled between the late 1960s and the late 1980s (Figure 32, Table 113, Appendix 14). Because up to one-half of fertilizer was donated by other countries during the 1980s, the costs to the Zambian government of maintaining the fertilizer subsidy were considerably reduced.

The bundle of maize programs implemented during the 1970s and 1980s, including the establishment of countrywide parastatal maize marketing depots, guaranteed panterritorial prices, and credit programs, transferred the burden of some transformation and transaction costs from small remote farmers to the state. In effect they were borne by effective taxes on the copper sector and de facto taxation of farmers along the line-of-rail. Transformation/transactions costs costs included physical transportation and storage, and costs associated with uncertainty about future demand and supply conditions. The costs to GRZ were substantial, absorbing up to 17 percent of the total government budget by the late 1980s (Table 118, Appendix 14). Additional costs were covered by donors who supported the marketing system through subsidized credit programs, the construction of storage sheds and training of cooperative personnel (SIDA 1980-92).

Comparing production in the with and without policy/technology scenarios (Chapter 6) suggests that the strongest response to the maize program came from small farmers in remote and dry areas (Eastern Province Regions I and II, Northern Province Region III, Southern Province Region I). Maize production by large farmers in Central and Southern Provinces declined sharply as a result of policy implementation. The effect of the maize policies for the large farmers, and Southern Province small farmers, was a reduction in producer prices after the establishment of the pan-territorial pricing system. Transactions costs for Central and Southern Province farmers also increased for these farmers after the 1970s. Line-of-rail farmers generally had good access to marketing depots before implementation of the 1970s and 1980s policies. Expansion of the demands on Namboard and the cooperative system resulted in the declining availability of credit and fertilizer, and worsening delays in input delivery and payment for produce by the late 1980s.

The removal of subsidies, and uncertainty over marketing arrangements beginning in 1992-93 has already drawn some production away from the more remote areas. The shares of remote Northern and Copperbelt Province as a proportion of the total marketed production declined from 16.1 percent and 7.8 percent in 1990-1 to 8 percent and 4.8 percent in 1992-93, respectively, although Eastern Province's share of production, about 20 percent, has not changed.

Zambia's maize programs were unsustainable (Chapter 5) because they merely shifted the high transformation/transaction costs from one societal group to another, rather than lowering transformation/transaction costs for society as a whole. Transformation and transaction costs were lowered for some groups of farmers, but increased for other groups who were effectively taxed and the money redistributed to provide services for the favored farmers in remote areas. Was anything gained from the programs?

A major objective achieved by the maize programs during the 1970s and 1980s was to redistribute development opportunities, by drawing up-to-then excluded farmers into commercial agricultural production using improved technology. The programs may have contributed to defusing social tensions at Independence by assuring low consumer meal prices in the cities and increasing remote farmer incomes. Remote small farmers "learned" about fertilizer, credit, and marketing cash crops. As Zambia makes the transition to private sector marketing, commercial maize production will no longer be economically viable in some areas where it was encouraged in the 1970s and 1980s. However, the lessons learned about commercialization may be transferable to other, higher value, cash crops such as coffee in Northern Province and tobacco in Eastern Province.

7.3.3. Incremental change and the development path

7.3.3.1. Communication and bargaining channels

North suggests that the key to continuous incremental adjustments in organizations is an institutional environment that enables continuous bargaining between the main economic and political actors (1990, 89). This sort of dialogue existed before independence between large-scale settler farmers and the government. The establishment of the Maize Control Board was a response to settler concerns about encroachment on the maize market by African producers. The close relationship between the colonial government and the European farmers facilitated evolutionary changes in the organization of maize marketing.

At independence, the fragile political coalition formed by Kaunda pointedly excluded the European farmers who had influenced previous decisions on maize marketing, as well as the small and medium-scale farmers along the line-of-rail who benefitted from colonial marketing policies. Unlike the large commercial farmers, who lobbied for their interests through the strong Commercial Farmers Bureau, small farmers were not effectively organized.

During the colonial period, the European farmers influenced marketing policies to serve their interests, but in a way that encouraged productivity-increasing activity by European farmers, not simply a redistribution of state resources in their favor. The Maize Control Board eliminated uncertainties for the European farmers and some African farmers that encouraged an expansion of production. The post-independence expansion of marketing services to remote areas similarly decreased uncertainty and increased production by the remote small farmers, but in a way that heavily taxed the cheaper maize producers closer to consumption centers, discouraging their production.

Increasing returns motivated continuation of the colonial maize marketing organization post-independence. With the new political environment, however, channels of communication between farmers and the government that operated during colonial years were closed. Political groups who benefitted from the expansion of services acquired a stake in maintaining the services, but not the economic incentives to ensure that the services were provided in an efficient way.

7.3.3.2. Effects on the development path

> If markets are incomplete, information feedback fragmentary and transactions costs significant, then the subjective models of actors modified both by very imperfect feedback and by ideology will shape the path (North 1990, 93).

The First National Development Plan (FNDP) emphasized the formation of cooperatives, and the expansion of parastatal marketing services to poor, remote areas, as a way to bring farmers into the commercial market and increase their incomes. New cooperative organizations were given over ZK 14 million between 1964-69 in loans for animals and animal traction equipment, tractors, subsidized fertilizer and seeds (Sipula 1993).

At the critical juncture of independence, when the new government promoted forms of organization such as cooperatives, information about the objectives and management of these new organizations was skewed as they were used by the governing political party to solidify support. For example, cooperatives were to be a major vehicle for development of rural areas, but beneficiaries of support saw them as a political reward.

> ...(there was) a belief on the part of some of the more influential (cooperative) members that the money government was pumping into the cooperatives was in actual fact a reward for their participation in the freedom struggle a few years back (Sipula 1993, 71).

In the 1960s, members of new producer cooperatives were promised full control of their businesses with minimal government supervision. Incentives led to the registration of some cooperatives that were only family groups who cleared large amounts of land in isolated areas, much of it unsuited to cultivation. Others were formed by Parent-Teacher Associations or by unemployed persons inexperienced in farming. SIDA also began to channel development assistance to the cooperative movement in 1976. By 1990, more than half a million cooperative members were registered, representing 80 percent of the total number of small and emergent farmers (Sipula 1993, 69, 73).

Throughout the maize production and marketing system, organizations persisted or were formed without a sense of credible commitment, because of the lack of incentives to members, and the government's failure to effectively enforce rules or recognize the devastating economic consequences of failing to do so. Organizations like cooperatives became shells that farmers belonged to in order to take advantage of marketing and credit services. Despite frequent allegations of mismanagement and poor accounting, cooperative members were generally apathetic, rarely attending society meetings (Sipula 1993). Donors complained of having to hire cooperative members to perform tasks such as road maintenance or assist with storage shed construction, when it had previously been agreed that cooperatives would provide this labor as their contribution to a project (Hedlund, personal communication, February 21, 1992).

With inadequate third party rule enforcement from the bureaucracy above or pressure from the primary society membership below, management and exchange reverted to patterns of the tribal economy, characterized by personalized exchange and reliance on kinship relationships. A frequent source of discord in cooperatives was the practice by cooperative officers of hiring relatives for paid positions (Sipula1993).

Marketing organizations have been characterized by lack of communication between the centralized parastatal bureaucracy and field units, and by the powerlessness of the primary societies. MAFF and cooperative personnel in the main maize-growing provinces spoke with frustration of their inability to obtain desired seed varieties, even after completing formal input requests season after season, and of the continual shortages of grain bags, and a deteriorating record of seed and fertilizer delivery and credit availability through the 1980s (GRZ 1990, Chapter 4). Signals to Namboard and the cooperatives about responsibility for cost containment were confused. In some years cooperatives were reimbursed outright for all extra costs they incurred, but in others they had to absorb the losses themselves (Jansen 1988, 48; Shawa and Johnson 1990, 374).

In several seasons, Namboard was compelled to buy from producers at prices higher than the price at which it was allowed to sell (Table 119, Appendix 14) (Jansen 1988, 48; Shawa and Johnson 1990, 374). Namboard and the cooperatives also had to expand their operations to cover the whole country, whatever the financial viability of doing so. It was government policy to have marketing depots within relatively short distances of all farms to promote maize production in remote areas of the country. This worked: by the mid-1970s, there was no substantial area of the country where less than 50 percent of small farmers grew maize (Schultz 1976, cited in Klepper 1980, 2). It meant that Namboard had to send trucks over long distances and bad roads to collect a few bags of maize, paying the same price as if the farmer had brought the grain to the depot (Dodge 1988, 48; Shawa and Johnson 1990, 374). The pan-seasonal pricing system also encouraged farmers to sell their crop immediately after harvest, short-circuiting the already-inadequate buying, financial, transport and storage facilities of Namboard and the cooperatives.

As a result, these organizations became heavily dependent on subsidies, and government delays in transferring funds owed to them caused cash flow problems down the line as cooperatives in turn were unable to pay transporters, input dealers, or farmers until several months after they delivered their produce, with the problems frequently carried over to the following season (Jansen 1977, 50).

The twisted scenario resulting from these policies is well illustrated in the problems faced by the Eastern Province Cooperative Marketing Association (EPCMA):

> By the end of 1972 EPCMA had accumulated losses of ZK1.8 million, largely because it has to operate within a statutory price framework that leaves no profit margin. For example, in 1972 it purchased maize at village markets for ZK 4 per bag and at main depots for ZK 4.30 per bag; it kept what was needed for milling and sold the surplus to NAMBOARD-at ZK4.30 per bag. The maize retained for milling was wholesaled as roller meal at ZK 5 per bag, which left no margin to cover milling costs. Based on 1972 operations, in 1973 the government gave EPCMA a subsidy of ZK 1.30 per bag of maize purchased, but this subsidy was not based on a specific formula which calculated EPCMA's handling and transport costs for bags sold to NAMBOARD or its handling and milling costs for maize milled locally; furthermore, no allowance was made for overhead. The accumulated loss for 1973 was ZK 400,000 greater than for 1972, including ZK 158,000 which was spent servicing EPCMA's overdraft. Because of this perilous financial position, EPCMA must obtain a special guarantee from the Ministry of Finance for crop buying each season. The guarantee is invariably delayed while the ministry considers EPCMA's prepared cash flow. As a result, EPCMA markets often open in late July or early August instead of June, causing serious marketing problems and production disincentives to farmers (Jansen 1977, 89).

The low price of maize and maize meal also made the business of smuggling maize into neighboring countries profitable. In 1990, Zaire paid $240/ton for South African maize landed in Lubumbashi, near the Zambian border. This contrasts sharply with the $30-$44 dollars/ton millers in the Copperbelt paid for Zambian maize (GRZ 1990).

7.4. The future

Implementation of structural adjustment policies since 1991 has sparked optimism in Zambia that many problems will disappear when government withdraws from maize marketing and the geographic pattern of maize production reverts to regions where maize has a "natural" comparative advantage. The analysis of this chapter suggests different points about the future.

First, legitimate concerns about growing societal divisions at independence were an important motivation behind government intervention in maize production and marketing, and the policies were successful in spreading development opportunities to neglected areas, albeit in a very expensive way. If privatization of maize marketing results in a retraction of maize marketing services and production to line-of-rail areas, the issue of strengthening the social fabric will need to be dealt with in another way. One option would be to build on the gains made in drawing remote farmers into commercial production, by inducing them to shift to higher-value export crops such as coffee and tobacco, or perhaps encouraging direct and legal exportation of maize in areas where international consumption centers are closer than Zambian cities.

Second, the institutional and organizational structure and subjective mental models which have influenced Zambia's agricultural development path up to now will continue to affect its transition to a freer agricultural market. A debilitating problem under the parastatal maize marketing system was the state's inability to secure adequate financing, enforce contracts and pass and receive information quickly and reliably through the system. The deficiencies in the underlying institutional/organizational structure which brought these problems for the public sector persist and are already causing similar difficulties for the liberalized market. The abrupt shift to more liberalized maize marketing in 1992-93 resulted in a debacle in which the lack of private and state financing, the difficulty of enforcing contracts with buying agents, and uncertainty over the disposition of government-owned storage facilities severely limited the private sector's ability to purchase maize in a timely way (Guyton and Temba 1993).

Other than Southern Province Cooperative Marketing Union (SPCMU), none of the other cooperative unions were appointed as buying agents for the government in the 1992-93 season. Since cooperatives are no longer receiving government support, many have dramatically and suddenly curtailed their marketing services. The Economist noted that small maize farmers in eastern Zambia have no option but to sell to private monopolists, at prices well below those the state used to pay (Oct. 30 1993, Vol. 329, No. 7835, p. 52).

The institutional/organizational foundation for freer markets is weak in Zambia, as in many other developing countries. These include a stable currency; a functioning legal system that can enforce contracts and property rights; working capital markets, and credit and banking systems that enforce repayment; and a reliable transport and communication infrastructure (Klitgaard 1991, 5). Private firms develop in response to the incentives provided to them by the institutional/organizational environment, as did farmer cooperatives under the parastatal system. If property rights remain insecure, if contracts cannot be enforced, and there are barriers to entry and monopolistic restrictions, private firms will remain small, with short planning horizons and little fixed capital. The most profitable private sector activities will be in trading and redistribution, rather than productive activities (North 1990, 67).

7.4.1. Distortion vs. sustainability

Mellor and Johnston (1988) suggest that "the indirect, long-term effects of price distortions on the orientation of research and the bias of technical change may well be more important than their adverse effects on short-run, allocative efficiency." Talk of distortion, however, masks the fact that the distortion is to a **particular** structure of property rights. In Zambia, the structure of property rights in agriculture was fundamentally altered by the development of the copper mines and railway construction, which gave rights, or comparative advantage, to farmers who lived near the railway corridor. After independence, policies were introduced that were intended to give more rights to farmers in remote, underdeveloped areas. These were "distortions" away from the existing post-colonial pattern of comparative advantage. However, comparative advantage is not static, but dynamic.

In hindsight, Zambian policies extending urban population and the railway or other transportation infrastructure east or northeastward might have been cheaper and more effective in reallocating property rights in the long term than the course of policies actually pursued. Like the extension of the railway from Southern Rhodesia to the Copperbelt, this one-time investment would soon after have been viewed as a sunk cost, with costs and benefits of projects that benefitted from the railway, e.g., market improvements, calculated exclusive of the costs of railroad construction (Schmid 1989, 130).

Non-sustainability is a more useful and less value-laden term than distortion. The problem with the package of maize policies pursued by the Zambian government is that they encouraged a transfer of transformation and transaction costs from some farmers and consumers to the government, not an eventual reduction. This was unsustainable after copper revenues began to fall in the 1970s, and without an effective tax system for commercial farmers. The economic cost of the programs was subsidized for years by copper revenues, then by government borrowing from abroad rather than taxation of commercial farm rents or consumers.

Contributing to this unsustainability during the UNIP years was the exclusion of those interest groups most directly linked to production, commercial farmers, business and labor unions, from UNIP's core constituency. They were not in position to provide feedback to party leaders about the negative effects of economic policies that hurt production incentives (Bates and Collier 1993, 399).

Another factor was a policy environment that distanced users from the economic cost of inputs and commodities and prevented them from making production and consumption decisions on that basis. The remote farmer was insulated from the economic cost of fertilizer and product marketing, and the consumer from the economic cost of mealie meal. And, just as the Zambian government disguised the economic cost of fertilizer, marketing and mealie meal to its citizens, donor agencies, in giving fertilizer and technical assistance, hid the economic cost of sustaining these programs from the government.

7.4.2. The state as a credible third party

In the long term, creation of credible political and legal systems, and a functioning capital market, to reduce the transactions costs of both political and economic actors, will be critical to improving the performance of Zambia's agricultural sector. Establishment of these systems is not a benign, value-free process: the pattern of rights they set and enforce results from the struggle between competing interest groups in the society. Resource bases, thus power, will vary for different groups. But opening up the political process, legitimizing and encouraging the formation of diverse political groups, and strengthening local governments will provide fora for ensuring the continuing evolution of these systems, with many interest groups exerting pressure on the most powerful and feeling that they are stakeholders in the systems even if they do not dominate them (personal communication, A. Schmid, June 22, 1994). Opening the political process will facilitate movement toward an economically dynamic and politically sustainable development path. The aim is to avoid repeating the mistakes of the colonial and post-independence periods. Northern Rhodesia's colonial leaders achieved an economic dynamism from which a small proportion of the population benefitted, while alienating the majority. The post-independence Zambia path was unproductive because the disaffected from the colonial era, now the leaders, reacted to their colonial alienation by shutting the leaders of the most important productive parts of the economy out of the policy-making process, with devastating economic effects for the whole country.

The state itself will not be impartial, because in order to maintain power it will favor the interests of some supporting groups over others, and this choice among competing interests will affect the development path. But it can set up and enforce a legal system that at least applies rules equally to all members of a category, legitimized by the check of a functioning political system (Schmid 1992, 708). Establishment of a polity that acts as a third party, policing and enforcing agreements through coercion, has significant scale economies. It creates an environment of reduced transactions costs for economic actors, where contracts are self-enforcing. Parties have an incentive to fulfill contracts because the benefits of doing so outweigh the costs of violating agreements (North 1990, 55, 58).

The press can play an important role in strengthening the political process, increasing government and private sector accountability by providing better information about their activities. Since 1991, the Zambian press has emerged as a powerful force for increased accountability in government. The elections of October 1991 that brought President Chiluba to power also ushered in new freedoms for the press, which had until then been controlled by the UNIP government. The written press, especially the relatively new Weekly Post, has been aggressive in reporting on the new government. For example, exposure of the involvement of several government ministers in the lucrative narcotics trade eventually ended in their resignations in 1993. The press also increased the effectiveness of government and private food aid efforts during the severe drought of 1991 by quickly relaying information about areas of the country that were suffering from critical food shortages.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

8.1. Introduction

This study examined the impact of research investments that led to the development and adoption of ten improved maize varieties in Zambia beginning in the mid-1980s. A key assumption was that the success of the research investments, reflected in technology adoption by smallholders, was integrally tied to concurrent state and donor investments in extension, the seed industry, and marketing and price policies. These complementary investments critically influenced small farmer decisions about adoption of new maize varieties.

The issue of how complementary investments influence the scope and pattern of technology adoption is very relevant today. Liberalization of maize marketing, beginning in the 1992-93 season, brought about sweeping changes in the availability of inputs and marketing services that have already begun to affect the geographical distribution of maize production.

The specific objectives of the study were to:

1) calculate the rate of return to previous investments by the GRZ and donors in maize technology development and dissemination in Zambia;

2) determine the distribution of benefits from these investments between different producer groups, and between consumers and producers; and to

3) examine the impact of key policy and other institutional and organizational factors on maize research and technology transfer.

This study approaches the problem of assessing research impact from three different levels. The core of the study is an adoption survey and rate of return (ROR) analysis, the traditional tools for assessing research impact. In this case, however, the ROR analysis was expanded so that the costs of programs that facilitated farmer adoption of new technology were also included, and compared to the RORs resulting when only research costs are counted, the more common method of ROR calculation.

At the second level, the study simulated what would have happened to the ROR, production levels, the adoption pattern, and the distribution of benefits from the new technology, if certain marketing and pricing policies had not been in place. These included pan-seasonal, pan-territorial pricing of maize, fertilizer subsidies, and, especially, policies that assured smallholder access to marketing services through subsidization of local depots. Third, the study examined the historical interplay of institutional and organizational factors that led to the choice of policies favoring remote smallholders and urban consumers in the first place, and then affected how, and how well, research and complementary policies were implemented.

8.2. Summary of findings

8.2.1. Technology development, adoption and complementary investments

Development and adoption of improved Zambian maize hybrids and open-pollinated varieties has been a qualified success story for Zambia and foreign donors. The new short-season hybrids such as MM603/604 were drought-tolerant, disease-resistant and less management-intensive than SR52, the most popular hybrid until the mid-1980s, and Zimbabwean in origin. The new open-pollinated variety MMV400's extremely short season made it an ideal source of green maize for the hungry season.

These characteristics made it possible and less risky for all small farmers, and especially those outside the established maize-growing areas of Region II, to adopt improved maize.

Post-independence agricultural policies balanced between often-conflictive objectives. The general aim was to sustain the copper development engine, while using copper revenues to stimulate economic diversification and move toward a more equitable, broader-based pattern of growth. The policies aimed, first, to increase domestic maize production in order to supply the densely-populated urban mining areas with cheap maize meal. A second objective was to reduce reliance on the European commercial farmers by increasing the participation of African farmers in commercial agriculture, raising rural incomes simultaneously. A third objective was the improvement of regional equity by increasing the market involvement of farmers in less agriculturally advanced provinces, especially those in Eastern and Northern Provinces who were key supporters of then-President Kaunda's UNIP party.

Beginning in the mid-1970s, government policies and organizations created a facilitative environment that drew smallholders into commercial maize production by providing price incentives and essential services. Pan-territorial and pan-seasonal pricing enforced through an effective parastatal monopoly on maize marketing, substantial fertilizer subsidies, and the countrywide establishment of local depots for sales of inputs and collection of maize were most important.

These policies and organizational innovations laid the groundwork for the successful introduction of Zambian improved varieties. By the time the improved varieties were released in the mid-1980s, many small and medium farmers had already adopted fertilizer or SR52 and had been motivated to increase their maize area for commercial production. Zambia's maize area rose from 212,000 hectares in the 1974-75 season to nearly 800,000 hectares by 1988-89. In the same period production more than tripled, from 600,000 to almost two million metric tons.

Adoption of improved maize varieties by small and medium-scale farmers was rapid and extensive following their introduction in the 1984-85 season, and resulted in an estimated 20 percent increase in overall maize yield levels. Yields of Zambian improved hybrids have an estimated 60 percent and 20 percent yield advantage over locals and SR52, respectively. By 1988-89, almost half the total small/medium maize area was planted to improved varieties, and the proportion climbed to nearly 60 per cent by 1991-92. Adoption rates differed dramatically between regions: improved maize was planted on almost three-quarters of maize area in Region II, but on less than a quarter of dry Region I maize area, and on about 40 percent of area in high-rainfall Region III.

Access to resources distinguished adopters from non-adopters. Improved maize adopters have larger farms, more labor (larger households), a higher level of formal education, are more likely to use animal traction or farm machinery, and tend to live close to service centers and major roads.

Adoption of improved maize hybrids and varieties in Zambia is impressive by any standard. Malawi is agroecologically similar but has never had more than 20 percent of aggregate maize area sown to improved hybrids or open-pollinated varieties. In Eastern and Southern Africa (excluding South Africa), only Zimbabwe, where improved varieties are planted on almost all of the maize area, and Kenya (65 per cent of total maize area) have higher adoption rates.

Complementary investments had a striking impact on small farmers. Nearly all improved maize adopters, 88 percent of small and 97 percent of medium farmers, had used fertilizer in at least one season, and fertilizer application rates for maize are the second highest in Africa. In addition, 64 and 90 percent of small and medium farmers sold maize; 42 and 68 percent had received credit for maize, and 47 and 58 percent of small and medium farmers had been visited by an extension agent. The dependence of small and medium farmers on local, as opposed to regional, depots is an indication of how widespread and localized service provision became throughout Zambia's maize-growing areas. Eighty-two percent of improved maize users got their fertilizer at local depots, 86 percent sold their maize there, and 80 percent purchased maize seed locally.

8.2.2. Average rate of return to maize research and related investments

Net margin analysis indicated that all types of maize production were profitable for small/medium and large farmers during the 1980s (except in drought years), but net margins for Zambian improved varieties were consistently higher than for other maize varieties. Adoption of Zambian improved varieties also gave the highest returns to scarce labor.

When all costs were included in the economic rate of return analysis (additional production costs associated with the new technology, and maize-related costs of research, extension, seed industry and marketing) the average rate of return (ARR) for the 1978-91 period was negative. Extending the analysis period to 2001 results in a favorable ARR of 49.3 percent using the benefit-cost method, and 42.1 percent using the Akino-Hayami approach. The critical difference is the assumption that GRZ expenditures on maize marketing drop sharply after 1992, following the government's announced intention to liberalize the sector. When marketing costs are excluded from the calculation, the rates of return are sharply positive, over 100 percent for both the 1978-91 and 1978-2001 periods.

These results reflect the assumption that the economic cost of maize technology development and transfer in Zambia was much higher than what is implied by the costs of research and extension alone; in the 1978-91 period, the cost of additional investments in marketing made the entire maize investment package uneconomic. The Zambia study suggests that the results of other rate of return to research studies may be overstated if they calculate an ARR counting the benefits of technology adoption but only the costs of research, if technology transfer to targeted groups depends on concurrent investments in complementary policies and organizations. At best, not accounting for all costs is inaccurate. At worst, crediting research investments alone with a high ARR can send misleading policy signals, if this masks additional investments needed to facilitate adoption of technology by farmers that in turn affect economic feasibility.

8.2.3. In the absence of policies and complementary organizations

Since it was the cost of maize marketing policies and organizations that made the whole maize investment package uneconomic, numerical simulation was used to project, for a representative year, what might have happened to production, technology adoption, distribution of benefits, and the ARR in the absence of price and marketing policies. The projected ARR to investments in research, extension and the seed industry without these policies is substantially higher than the actual, with improved technology, price and marketing policies (ITPM) ARR. The with-ITPM ARR is negative in the

1978-91 period and 49.3 percent from 1978-2001, while the without-policy ARRs range from 126-139 percent.

If no new technology had been available and no policies had been in effect in 1987-88, the estimated total production of maize would have been 1.55 million tons of maize. This compares to actual production, with ITPM, of 1.83 million tons, an increase of 18.4 percent. Results of the simulation suggest, however, that aggregate national production would have been even higher if technologies had been available but no price/marketing policies had been in place, providing small/medium farmers continued to plant at least 50 percent of the area they planted to improved maize in the actual, with-ITPM case.

Results of the simulation reflect the assumption that the major impact of technology and policies was to shift maize production from large to small farmers, and from areas adjacent to the line-of-rail to more remote and drier regions. The greatest production increases, in terms of percent change over the without-ITPM scenario, were for small/medium farmers in Eastern Province Region II (152.4 percent), Southern Province Region I (126.5 percent), and Northern Province Region III (97.2 percent).

Large farmers produced about 20 percent, and small/medium farmers 80 percent of total maize production in the actual, with-ITPM case. With technology but without policies, however, the results show that large farmers would have produced more than a third of the total, while small/medium farmer share would have dropped to 65-70 percent. With ITPM, close areas produced 51 percent of actual maize production in 1987-88. Remote areas produced 35 percent, and other provinces produced 14 percent. The projections show that, with improved technology but no marketing/price policies in place, closer provinces would have provided 69-72 percent of total maize production, with 18-20 percent from remote provinces, and 10-11 percent from other areas.

Although economic surplus for some groups of producers increased with ITPM, urban consumers were the primary beneficiaries of the global package of maize policies that included heavily subsidized maize meal prices in urban areas. Urban consumer surplus in the actual, with-ITPM case was almost ZK 839 million, compared to total producer surplus of **negative** ZK 61 million. The primary reason for loss of producer surplus in the with-ITPM case was that producer prices were set below import parity levels for farmers in the major maize-producing areas of Region II.

8.2.4. The impact of maize investments on Zambia's development path

As a calculation of impact that includes the benefits of technology adoption without accounting for all costs is inaccurate, so is one that fails to consider benefits of the package of maize technology and policies beyond increased maize production. At independence, the new government faced the difficult task of mending societal divisions that were created by copper and urban-dominated growth during the colonial period.

The costs of sustaining the maize policies eventually overwhelmed the copper sector's ability to support it, but this analysis suggests that the programs were successful in increasing the market participation and incomes of small farmers in general, and of the poorer remote farmers in particular. It may not be too much to suggest that the dogged pursuit of programs to redistribute development opportunities has had something to do with the relative stability of post-independence Zambia compared to its African neighbors. Independent Zimbabwe similarly, and successfully, turned to a system of administered maize prices and expansion of support services to small farmers to meet its daunting post-war needs: resettlement of large numbers of refugees and creation of a stable environment for agricultural growth and increased smallholder participation in the market.

The current emphasis on and mode of liberalizing agricultural marketing in Zambia risks setting aside the developmental gains achieved (if expensively) during the 1970s and 1980s. The removal of subsidies, and uncertainty over marketing arrangements, have already drawn some maize production away from the more remote areas and back to the line-of-rail provinces, similar to the without-policy impact simulation in this study. The shares of Northern and Copperbelt Province as a proportion of the total marketed production declined from 16.1 and 7.8 percent in 1990-91 to 8 and 4.8 percent in 1992-93, respectively, although the Eastern Province share remained the same.

The decline of maize production in areas where it is uneconomic to produce and transport it to Zambia's major urban areas is not to be mourned, but the window of opportunity for implementing aggressive policies and programs that could encourage a mixed public-private sector to build on gains of the last two decades, to boost subsistence and commercial production of more economic crops and livestock in these areas, may be closing. Zambian smallholders have a strong cost advantage in the production of beef cattle, cotton, sunflower, and groundnuts, all of which are exportable. Diversification has been delayed in the past because of the policy and organizational bias favoring maize production, and now because of government inertia in making technology available and stimulating improvements in the marketing structure.

8.3. Conclusions: implications for research methods

8.3.1. Overview

Results of the Zambia study suggest several areas where improvements in impact assessment methods are needed. These include accounting for complementary policies and investments, the effect of sunk costs on returns to current projects, how increasing returns to existing organizations may affect program implementation, distributional objectives, the political issues involved in selection of economic prices, and the importance of linkages and multiplier effects for long-run growth.

8.3.2. ROR methods: issues for Zambia and for future research

8.3.2.1. Accounting for complementary policies and investments

Investments in agricultural technology are part of a larger panorama: of investments in complementary policies/organizations that determine the success or failure of technology development and adoption, and, stepping back even farther, of the political motivations -- the result of conflicts between interest groups-- guiding investment, policy and organizational decisions. This macro-environment conditions the impact that technologies will have, and who will benefit from them.

Conventional methods of assessing research impact truncate the larger picture, which portrays how technology research fits into the agricultural and economic development of a country. The standard method of impact assessment for technology investments, calculation of a rate of return using the benefits of increased production and income from technology adoption against the costs of research and sometimes extension, fails to account for the interdependencies of the focus project with complementary investments that lead to its success or failure.

The sustained adoption of improved maize technology by Zambian smallholders, particularly those in remote areas, depended on concurrent investments in the seed industry, extension service, and price/marketing policies and organizations. In the counterfactual case, if smallholder-oriented marketing policies/organizations had not been in place, successful diffusion of improved maize technology to line-of-rail farmers would still have relied on concurrent or past investments in a reliable seed industry, transportation infrastructure and a marketing organization, whether public or private. The mixed reputation of the rate of return method is mostly due to its abuse by analysts who highlight a single investment (maize technology, the seed industry, a credit program) as alleviating a key development constraint, without detailing the nature and costs of the complementary investments that were essential to the success of the focus investment.

The marginal rate of return (MRR) method addresses the complementarity issue to a certain extent, through estimating an aggregate production function that includes research and complementary investments as separate variables. The results of the MRR analysis indicate the effect that individual investment components have on increasing the supply of agricultural products. However, if the complementarity and coordination between program components are critical to widespread adoption of the new maize varieties, measurement of the contributions of individual programs is not valid. For example, if an MRR in Zambia shows higher marginal returns to research than seed and marketing investments, and this results in increased funding for research while the other projects lose funding or drop out, research investments may not have the anticipated impact. This implies that closely related investments should be evaluated as a package, if assessing components individually carries the risk that essential complementary investments may not be made.

If the success of, and distribution of benefits from, one program depends on so many other complementary investments, and in turn affects other investments, analysts may wonder whether they have any choice but to evaluate every potential investment in a general equilibrium framework. This study suggests the possibility of a middle ground, expanding the partial equilibrium ROR approach to incorporate consideration of key complements to the focus program; their costs, and what difference it will make to the extent and pattern of adoption of technology if key complementary investments are not made.

In the Zambia study, a concerted effort was made, working closely with farmers, maize researchers, past and current agricultural sector policymakers, and donor agencies, to identify the key policies and organizations that contributed to farmer adoption of improved maize varieties in the 1980s. Government and donor program reviews and evaluations were used to compile lists of programs and projects beginning in the late 1970s that were likely to have had an impact on maize adoption, including establishment of the seed industry, farming systems teams, integrated rural development projects, cooperative development and marketing and price policy implementation.

Costs of these complementary investments were estimated and included in the rate of return analysis. This was a difficult task, because the Ministry of Finance usually had only very partial records of their own expenditures, and especially those made through donor projects. Records of individual donor agencies had to be examined, and were not always available. Also, in many cases projects and programs such as integrated rural development projects had certain components such as strengthening primary cooperative societies, extension or building storage sheds, all with implications for maize technology adoption. However, the portion of the total budget for that component that could be attributed specifically to maize was not explicit in the budget, and had to be estimated based on discussions with personnel actually involved in the project. Given these constraints, the documentation of costs and contributions to maize technology development/adoption made by complementary policies/organizations was as complete as possible.

After compiling these costs, the study calculated a ROR to the bundle of investments in maize technology, then, using sensitivity analysis, found that the inclusion of the cost of maize marketing related programs and subsidies had by far the greatest impact on ROR. Focusing on the marketing policy/organization investment, a numerical simulation was carried out to estimate what the extent and pattern of adoption of maize technology would have been in the absence of these marketing investments. This information was used to recalculate the ARR and the distribution of benefits between different groups of producers, and between producers and consumers, in the with and without policy cases.

This "expanded ROR" approach, supplemented by qualitative analysis, conveys an idea of the network and sequence of investments necessary to facilitate technology development and adoption by the target group of beneficiaries, and their costs. In the Zambia case, extended analysis of one set of complementary investments, marketing policies/organizations, highlighted its pivotal role in shifting the distribution of benefits between different producer groups, and from producers to consumers. It is not an easy approach in terms of data requirements, but is far less cumbersome than general equilibrium analysis, and feasible if the researcher can obtain qualitative information to limit the analysis to the most important complementary investments.

8.3.2.2. Accounting for sunk or fixed costs

Because it views past investments--in research, extension, infrastructure --as sunk costs that are not included in the ROR calculation, the ROR is biased toward projects and programs that represent incremental changes to the existing structure of policies and organizations, which reflect a particular configuration of property rights. In Zambia, this meant that once the railway linking the Copperbelt to Lusaka and Zimbabwe was built, for the primary purpose of hauling copper ore from the Copperbelt, the relative advantage it conferred on farmers living nearby, through lower transport costs, was not measured against the cost of railway construction. In subsequent projects, transport of commodities from the line-of-rail area will always be relatively more attractive than that from more remote areas that did not benefit from a windfall railroad. Efforts to realign the rights structure after independence by extending commercial maize production to remote small farmers did not benefit from this base of sunk costs. All costs for establishment and maintenance of the marketing system were current, and counted, and later evaluated as uneconomic compared to the benefits realized.

Early investments in infrastructure fundamentally changed transformation and transaction costs for farmers along the line-of-rail: they were granted a permanent reduction in transportation costs for inputs and their marketed commodities, but paid none of the fixed cost of these investments themselves. If additional mines had been discovered in Eastern Province, those farmers might also have reaped a windfall cost reduction paid for by the mining industry. In contrast, the government of Zambia's attempt beginning in the 1970s to reduce transformation/transaction costs for small farmers through subsidization of marketing channels and prices almost bankrupted the government, and never resulted in a permanent cost reduction for the farmers.

Does it make sense to try and attribute some portion of the costs of long-ago infrastructure development to today's projects in the ROR framework? Probably not, especially since the discounted value of costs incurred so long ago would make them appear relatively insignificant anyway. The important point is to recognize, when programs are planned, the impact that past investments have had on the country's development path and the fact that, as a result of these past investments, future programs that perpetuate the same development path will probably appear more attractive than alternatives that require greater outlays to build a foundation. However, the country's leadership may feel that the future pay-off to broadening the development base, e.g., through drawing more small farmers into commercial agriculture, may be increased social stability, the value of which is, to say the least, difficult to quantify.

In this study, the historical look at the nature and politico-economic motivations behind colonial and post-independence maize policies provided an alternative to the view that post-independence maize programs were simply a manifestation of economic ineptitude. Instead, the analysis showed that the programs played an important role in solidifying political support for Kaunda's UNIP party, and were an attempt to extend development opportunities to a segment of the Zambian population that benefitted little from colonial mining-centered development.

8.3.2.3. Increasing returns and organization stakeholders

Post-Independence coordination of maize marketing was hampered by two phenomena. First, the characteristic of increasing returns motivated the post-Independence government to maintain the same organizational structure for maize marketing as before Independence, although the underlying institutional bases, i.e., the objectives of the maize program and the beneficiaries, had changed dramatically. This was one "disconnection" that may have led to inefficiency in the maize system. Second, the providers and beneficiaries of maize marketing services regarded the services as political largesse, and had few incentives to promote an evolution of the organizational structure of maize marketing that would provide inputs and marketing services on time in a more cost-effective way.

The "bad fit" of policies to implementing organizations, and lack of incentives within organizations to improve services and keep costs low, increase the cost of service provision. These are important factors that deserve greater attention in program planning and evaluation. The additional costs due to marketing organization failure were included in the Zambia ARR calculation, and the institutional analysis detailed why policies and organizations were mismatched as well as reasons behind the alienation of key stakeholders in the maize marketing system.

8.3.2.4. Distributional objectives

To incorporate policy objectives like development of disadvantaged areas directly into the ROR calculation, an alternative to factoring in the fixed costs of past investments is to attach greater weight to projected benefits by these groups. In effect this can be seen as a counterweight to the benefits that favored groups garnered from past investment programs. Weighting of benefits is not a new technique, and has been well-explored by Little and Mirrlees (1974), but is seldom utilized because it is analytically cumbersome, and because it has been difficult to get policymakers to clearly state that one group's benefits are more important than others, and by how much.

An alternative to weighting benefits in a formal ROR framework, once policy objectives, target populations and essential complements are defined, is to choose specific investments based on an evaluation of the cost-effectiveness of different policy/organization combinations. In Zambia, with an established goal of increasing the welfare of remote farmers and urban consumers, this process might have identified a less expensive, more sustainable alternative to using the existing maize marketing structure.

8.3.2.5. Determination of economic prices: a property rights issue

Shadow prices or opportunity costs are substituted for the market prices of commodities, goods and services in the ROR calculation when it is felt that their market prices do not accurately represent their economic value, usually because of the effect of government policies, e.g., taxes, subsidies or regulation of the foreign exchange rate. For this study, opportunity cost adjustments were made for internationally traded commodities, goods and services (maize, fertilizer, seed, project goods/services purchased with foreign exchange), and for labor. For traded items, the border price (C.I.F., since goods were either imported or the alternative to domestic production was importation) was estimated and adjusted by the shadow exchange rate, the estimated world market value of Zambian kwacha. The opportunity cost of household farm labor was assumed to be the average wage rate for casual labor, under the assumption that labor is generally scarce in rural areas because of the existence of employment opportunities in the copper mining sector that draw many male workers away from the farm. These types of opportunity cost adjustments, for traded goods and labor, are common and reflect standard "rules of thumb" used by analysts.

There are multiple opportunity costs, and the choice of one over others is a policy decision that perhaps should be made more transparent, not left to the analyst. In the case of labor, the opportunity cost of labor for farmers in poorer, remote regions may be lower than the average casual wage rate, if casual labor opportunities are not readily available. On the other hand, it may be higher for farmers who live close to copper mining areas, since their "foregone opportunity" may be employment in the mines. Project analysis that uses the higher labor opportunity cost discourages employment; a lower opportunity cost encourages more labor intensity. Thus, it matters whose opportunity cost is chosen.

Adjustment of internationally traded items by a shadow exchange rate that represents the world market value of the domestic currency assumes that the "correct" policy for the government is not to interfere with the flow of foreign exchange into the country. In fact, exchange rate policies often serve a redistributive purpose, a partial substitution for effective tax systems that are so difficult to implement in developing countries. An overvalued currency (as was the case in Zambia) reduces the price farmers get for agricultural exports, discouraging exports and keeping the supply within the country, while lower prices for food benefits urban consumers. Overvaluation is also an import subsidy, which facilitates the acquisition of capital goods important for industrial growth and imported consumer goods. Choosing a shadow exchange rate as the "correct" value for foreign currency negates the importance of these policies, which may have valuable, intended implications for industrial growth and social stability.

The main point of this section is that selection of an opportunity cost is not a technical issue to be decided solely by the analyst, but a matter of policy, based on reflections on past policies and their justification as well as consideration of where the government thinks the country to go in the future. The Zambia study analyzed the effects and justification behind past maize policies through simulation of the without-policy situation, and through qualitative analysis. An alternative would have been to construct alternative opportunity cost measures that would have reflected the impact of these policies, or future policies, in the ROR calculation itself.

8.3.2.6. Long-run dynamic growth considerations

In Zambia, the estimation of benefits from the set of maize investments was calculated in the static sense of income received, without indicating how the programs might affect growth linkages with other agricultural sub-sectors or sectors, e.g., off-farm employment, and thus contribute to more dynamic, sustained income growth for the target population, or affect long-run efficiency for the country as a whole. This is obviously important when we seek to compare, as in Zambia, the relative long-run efficiency implications of an investment program that focuses on stimulating production from a narrow base, by large and small/medium line-of-rail farmers, vs. one aimed more broadly, including small/medium remote farmers. The Zambia study did not capture the multiplier effects of the maize program beyond the agricultural sector. Input-output analysis or other modeling techniques could be used to do so.

8.4. Policy implications for NARS

8.4.1. What influences technology adoption? Who are the clients of research?

In Zambia, the successful adoption of new maize technology by target smallholder groups was dependent on concurrent investments in complementary organizations that promoted marketing of inputs and maize to smallholders, even in remote areas. This implies that researchers and policy-makers, in setting priorities for technology research and evaluating the probability of a technology's success, need to recognize the systemic nature of constraints to adoption. Failure to adopt may not simply indicate a technical problem on the farmer's field, but could be linked to unavailability of credit, inputs, markets, or incompatibility of the commodity with the preferences of consumers or industrial users. In the past, planning for technology development has tended to isolate technology issues from the broader agricultural sector. However, the ability to target the most important constraint areas where new technology is needed, recognize the non-research barriers to technology adoption, and assess whether or not these are binding, requires a deep understanding of how technology is utilized throughout the sector. This implies recognition of a broader set of research clients than farmers -- including consumers, and small- and large-scale industrial users -- and more effective participation by these clients in setting research priorities and monitoring research products.

8.4.2. Effective participation by clients in research planning and monitoring

The Zambia case illustrated how the success of research depends on fostering links that promote tight cooperation and coordination between developers and users of agricultural technology. In Zambia, these links owed much to SIDA's funding of two important components of technology development and dissemination within one project structure, and to the professional motivations of the two expatriate maize breeders and seed industry leaders.

This experience implies that a key way to promote coordination is to give clients effective participation in the research process through formal or informal controls over research and extension programs. Farmer and seed industry input was important in the development of the improved Zambian hybrids. In Taiwan, farmer associations hire and fire their own extension agents, with agent salaries partially a function of the association's profits, giving the agent an incentive to seek out pertinent research results. Extension-research connections are informal but active, with many research experiments based in part on ideas provided by extension personnel or farmers. In Zambia, a proposal was recently approved to place one of the major research stations, Golden Valley, under the jurisdiction of a Research Trust, governed by a Board of Directors including MAFF, ZNFU, ZSPA, UNZA and others. This may increase farmer and other research client participation in setting research agendas, oversight and facilitate contract funding of research.

8.4.3. Donor assistance and the confusion of research-client links

This study told the story of three different international agencies funding maize breeding research in Zambia. Initially there was very successful cooperation, but later conflict and disintegration ensued. This is a microcosm of other parts of the research organization and agricultural sector: there are over 200 internationally funded projects in Zambia's agriculture sector today; an estimated 80 percent of the total cost of research and extension in Zambia is funded externally.

Significant technology advances have been achieved because of donor projects, but perhaps the price of assistance has been an unintentionally introduced confusion over who the real clients of the research system are. The agriculture sector has always been a low-priority item in the national budget; MAFF has had little incentive to say no to any donor projects that bring capital and operational funds to the ministry, and hesitates to offend donors by rejecting a pet project. Thus research and extension priorities have been skewed according to the amount of resources allocated to particular research teams by donors, not necessarily the needs of the country. Maize itself has been the primary beneficiary of this process.

But donor agencies have a different set of clients than national research systems; they have an incentive to create and implement separate projects to which they can show a passable return on the organization's particular investment. This has sometimes resulted, as in the conflict between FAO and SIDA in Zambia, in a competition among donors for control of a program, or in duplication of services by different donors. Heavy reliance on outside funding sends confusing signals to researchers and partially blocks an avenue through which Zambian research clients -- farmers, consumers and industry -- can exert influence over research priority-setting and implementation.

8.4.4. The role of economic analysis in research planning

Zambia is now going through a period of radical economic and agricultural adjustment. The parastatal maize marketing system has been abolished, and with it smallholder access to the commercial market in many areas. Diversification of smallholder farming systems away from maize is hampered by the lack of technology for alternative cereals and other crops, and the absence of local markets where farmers can obtain seeds and fertilizer and sell their commodities.

In this new environment targeting scarce technology development resources to alleviate the most important constraints in the commodity subsector requires an understanding of the dynamic relationship between technology adoption and commodity demand throughout the subsector, and of the institutional/organizational factors that influence demand. This implies a need for the research planning process to be better informed by economic analysis.

A portfolio of economic tools can be used in research planning. They include subsector, domestic resource cost, and rate of return analyses, but these cannot be used in "cookbook" fashion. Meaningful application of these tools requires a careful, situation-specific review of the environment, policies and organizations that influence production and utilization of a given commodity. The Zambia maize study linked technology adoption by target farmers with non-research complementary organizations and policies. The main results of the study were that inclusion of the costs of these complementary investments in the calculation of the ARR made a radical difference in the ARR outcome, and that the implementation of these complementary policies and organizations defined who benefitted from the technology.

8.5. Solving the coordination problem: lessons from Zambia's maize breeder-farmer-seed industry-extension synergy

Although maize market coordination was poor during the 1980s, coordination between maize research, the seed industry and extension was in contrast quite good and contributed to the rapid development of varieties, availability of seed and extension of technology to smallholder farmers in the mid-1980s. What are the lessons? Hybrid maize dissemination in Zambia was helped by the strong four-way relationship between Ristanovic's maize breeding team, farmers (all sizes), the extension service/Adaptive Research Planning Team (ARPT), and Zamseed. Ristanovic later described himself as an "entrepreneur" in his dealings with Zamseed, selling and shaping a product for a market. Similarly, another breeder, Dr. Gibson, was an "entrepreneur" among farmers, promoting and soliciting reactions about hybrid and open-pollinated technology. As a result, the characteristics of the new maize varieties met key problems for smallholders: season length and disease resistance. A strong sense that professional success (in the case of Ristanovic and Gibson) and financial success (in the case of Zamseed and farmers) depended on cooperation bound these actors together.

The fact that the Swedish International Development Authority (SIDA) funded both maize breeding and the establishment of the seed industry under one project also created interdependence and motivated coordination between the maize breeders and Zamseed. One result was the close relationship between the different hybrids, i.e., a core of parent varieties was combined and recombined in different arrangements, as single, double and three-way crosses, simplifying and making seed production more economical. Another was the rapid availability of the new hybrids through Zamseed following their release from the breeding program. A key challenge for the National Agricultural Research System (NARS), and the agricultural sector in general, is to replicate and expand these linkages in maize and other crop and livestock subsectors.

8.6. Postscript: policy implications for agricultural and economic development

Examination of the motivations and implementation of post-Independence Zambian maize policies revealed that remote farmers and urban consumers, both groups supporters of UNIP both, were the targeted beneficiaries. Perhaps the presence of increasing returns led to the use of existing maize marketing organizations to meet new institutional goals. The lesson from the Zambia case is not that it was bad for the economy to target these groups; that is a political decision. However, a better process was needed to match policy to implementing organization once target groups were identified. In this case, what were the reduced cost alternatives to using the existing maize marketing system to increase the welfare of remote farmers and urban consumers? Perhaps it would have been extension of rail or road infrastructure to remote areas, promotion of private sector marketing or high value cash crops, or, for urban consumers, permitting the proliferation of low-cost hammermills.

The alienation of key economic groups-- industrialists, businessmen and large farmers-- from the Zambian political process after Independence removed a check on the governing UNIP party that might otherwise have effectively signalled, and perhaps prevented, the disastrous economic consequences to come from UNIP's mismatched policy objectives and organizational tools. Encouraging a freer political process is a critical complement to economic reform; legitimizing and encouraging the formation of diverse political groups, and strengthening local governments, will provide fora for ensuring the continuing evolution of the politico-economic system, allowing many interest groups to exert pressure on the most powerful and feel that they are stakeholders in the system even if they do not dominate them. Opening the political process will facilitate movement toward an economically dynamic **and** politically sustainable development path.

THE ECONOMIC IMPACT OF IMPROVED MAIZE VARIETIES IN ZAMBIA
VOLUME II

By

Julie Ann Howard

A DISSERTATION

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

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1994

APPENDICES

APPENDIX 1

APPENDIX 1

ESSENTIALS OF A MAIZE BREEDING PROGRAM[1]

While individual techniques for the development of varieties and hybrids differ, there are five essential steps at the core of most breeding programs.

Germplasm collection

A successful breeding program depends on the availability of plant materials, or germplasm, exhibiting wide genetic diversity. The first step in assembling genetically variable material is to identify geographic areas where collections can be made. These are usually areas where a particular plant originated (centers of diversity) or developed into different forms (areas of domestication), or any other area storing or banking such plant materials. Germplasm collected from these areas is desirable because it has a large genetic base and exhibits a wide range of characteristics. The major objective in this phase is to assemble a wide range of genetically variable material; scientists are not yet searching for specific traits. Collected germplasm is then inspected for diseases and pests before it is distributed for further work. After screening, the material is advanced and multiplied (Allard, 1960).

Development of a genetically diverse population

The development of a genetically diverse population flows naturally from the process of collecting germplasm. A population can be either a collection of individuals from the same source in time, or a community of individuals resulting from the free intercrossing of individuals within a common gene pool.

The process of developing a genetically diverse population often includes the creation of a new breeding population. This is achieved by inter-mating several populations to obtain a wider genetic base than the source material. Breeders carry out systematic evaluations of the yield potential of newly collected germplasm, and of newly crossed populations. The compatibility of these crosses is also evaluated to determine their future usefulness for the maize breeding program.

Promising populations are identified by characteristics such as yield potential, time to maturity, insect and disease resistance and general compatibility. These populations are then crossed with an assortment of other materials and inbred lines and subjected to further evaluation.

---

[1] From Howard, Kalonge and Chitalu (1994).

Improvement of breeding populations

Population improvement is the process of increasing the frequency of desirable characteristics in a given population through breeding. Increasing the mean yield of the population is especially emphasized. It is during this step in maize breeding that highly adapted populations are often released as open pollinated varieties. During this stage, the individual populations of interest are isolated and allowed to pollinate naturally. Selection of plants with desired characteristics can continue up to time of harvest.

Development and improvement of inbred lines

An inbred line is a material resulting from several years of self-fertilization (selfing). Individuals with superior characteristics are identified visually, then self-fertilization is accomplished by pollinating the female flower of a plant with pollen from the male flower of the same plant. The cob shoots of the plants to be selfed are covered with paper bags called isolators and fastened before the silks appear. This prevents foreign pollen from reaching the silks and cross-pollinating the plant. The silks are allowed to reach two to five centimeters in length before the tassel of the same plant is bagged for pollen collection. The paper isolator is then removed, and pollen in the tassel bag is dusted onto the silks for self-fertilization.

Inbred lines selected from improved populations are developed by selfing individual plants for several cycles. Selections are based on vigor, standing ability, freedom from disease and other desirable characteristics. Seed from cobs of the selected plants are planted in separate rows (ear-to-row method). Visual observation and selection of the progeny continues, and undesirable plants are eliminated. When the ear-to-row method is used, the best rows and best plants in each row are selected for planting ear-to-row in the following season. Genetic uniformity in the inbred lines is achieved after five to six cycles of selfing. Uniform plants in a line look very similar in terms of height, color and many other characteristics, and look very different from individuals of different lines.

Inbred lines can be further improved by out-crossing the already established lines with other materials which have desirable characteristics. Promising plants from such crosses are then harvested from the desired lines and planted ear-to-row for further selection.

Hybrid development

Hybrid development and testing is the last step in maize breeding. First, breeders multiply the developed inbreds, planting seeds from the inbred lines in isolation from any other maize field and allowing them to pollinate freely (open pollination). At this stage, the breeders also make inter-matings between different lines, to identify the best combinations for hybrids. The superior combinations are then planted in multiple locations, to test the consistency of performance across locations and time. The most stable combinations are subjected to a further round of testing on farmers' fields.

Hybrids can alternatively be formed by crossing two inbred lines (single cross), by crossing two single cross hybrids (double cross), or by crossing single cross hybrids and inbred lines in a 1:1 ratio (three-way cross). The combinations of inbred lines or other hybrids that give rise to a new hybrid are called parents.

Seed production

In Zambia, after a period of testing, the breeder submits the new hybrid or open-pollinated variety to the Variety Release Committee for official clearance and naming. This committee is responsible for the release of all new cultivars proposed for distribution in Zambia. It is composed of representatives from different institutions such as Zamseed, SCCI, Zambia Seed Producers' Association (ZSPA), Ministry of Agriculture, Food and Fisheries (MAFF), University of Zambia School of Agricultural Sciences, and other agencies related to farming and seed utilization. The committee is headed by the Director of Agriculture, MAFF. Before a nominated cultivar is released, the committee reviews data about its yield, disease resistance, and field performance. The committee can also phase out obsolete varieties (Wellving, 1984).

Seed production in Zambia can be divided into four stages.
Breeder seed remains under the breeder's control within MAFF. Inbred lines are maintained true-to-type using the ear-to-row method, and are bulked by hand pollination. Breeder seed for the open pollinated varieties is maintained under strict standards regarding purity and trueness to type. Very small amounts of breeder seed are produced.

Production of **pre-basic seed**, the bulking of inbred lines using natural isolation, as opposed to the ear-to-row method, is the responsibility of Zamseed, with the work carried out by ZSPA members on contract to Zamseed, under the supervision of breeders and SCCI. Only small amounts of pre-basic seed are produced.

Basic seed is the progeny of pre-basic seed, and is grown by ZSPA members under contract to Zamseed and inspected by SCCI. A high standard of management is required. Inbred lines and open pollinated varieties must be isolated from others by distances of 800 and 400 meters, respectively. Irrigation is also required.

The final step is the production of **certified seed**, which will be sold commercially to maize growers. Certified seeds include single crosses (SC), three-way crosses (TC), double crosses (DC) and open pollinated varieties.

To produce these, Zambian basic seed is given to ZSPA members for either direct multiplication (in open pollinated varieties) or to make the preset combinations for hybrids. A ZSPA farmer producing MM752, for example, is given its inbred line parents MML3233 and MML5522. The female line (MML3233) is planted in six rows interplanted with two rows of the male line (MML5522). The lines are clearly marked. Once tasseling begins, the six female lines are detasseled to ensure that they are pollinated only by the male line, not self-pollinated. The seed harvested from the female lines is the desired hybrid seed for commercial maize production. Seed from the male line is discarded or sold as a commercial crop. Again, high standards of management are required, with minimum isolation distances of 400 and 200 meters for hybrids and open pollinated varieties, respectively.

Each year, Zamseed, in collaboration with MAFF officers, estimates the country's seed requirements and requests ZSPA to allocate specific hectarages among their members. Growers who are allocated seed are registered by SCCI and their seed crop is provided an official certificate number. Seed production officers from Zamseed monitor the development of the crop in the field and all the way through its processing and storage. Government seed inspectors from SCCI also carry out field inspections and are authorized to reject seed crops if violations are discovered (Thole, 1989).

APPENDIX 2

APPENDIX 2

GRZ AND DONOR EXPENDITURES ON MAIZE RESEARCH AND THE SEED INDUSTRY

Table 33: Estimated GRZ expenditures on maize-related research, 1978-91 (financial values)[a]

ml. ZK

ITEM	1978[a]	1979	1980	1981	1982	1983
PERSONAL EMOLUMENTS[b]						
Salaries		.1722	.1757	.2106	.2674	.2971
RECURRENT DEPARTMENTAL CHARGES[c]						
General Expenses		.0439	.0521	.0684	.0992	.0937
Traveling on Duty		.015	.0168	.023	.0353	.035
Field Services (General)		.0868	.0987	.1261	.1445	.1614
Seed Production/ Seed Control Services		.0321	.0939[e]	.0311	.0259	.0437
Cereal Research Team						.0144
CAPITAL EXPENDITURES[d]						
Mt. Makulu Research Station		.0118	.0185	—	.0212	.0118
Cereals Research Team		.007	.0371	—		
Seed Production Project[e]		.1409	.1216	.0563[e]	.1045	.0304
Mouldy Maize Project		.0194	.032	.035	.028	
Research Training and Extension[f]				(.2)	(.3089)	(.0293)
Adaptive Research Planning Team[g]					.0158	.0389
TOTAL EXPENDITURES	.4337	.5291	.6464	.5505	.7418	.7264

[a] Based on actual expenditures reported in GRZ Financial Reports, 1979-91

[b] Maize-related amount estimated as 25 percent of total Agricultural Research Branch salaries. Based on per cent of scientists engaged full-time or part-time in maize research (Kean and Singogo, 1989)

[c] Maize-related amount estimated as 25 percent of expenditures by the Agricultural Research Branch

[d] Maize-related amount estimated as 25 per cent of expenditures, except for Mouldy Maize Research (100% of expenses attributed to maize research)

[e] Partially funded by Belgium

[f] Fully funded by SIDA; to avoid double-counting, not included in this total

[g] Partially funded by USAID; maize-related amount estimated as 25 per cent of expenditures

Table 33: Estimated GRZ expenditures on maize-related research, 1978-91[a] (financial values) (con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988	1989	1990	1991[m]
PERSONAL EMOLUMENTS[b]								
Salaries	.644	.7277	1.113	1.124	1.698	2.936	2.5	4.825
RECURRENT DEPARTMENTAL CHARGES[c]								
Allowances	.0091	.0293	.0478	.0636	.0986	.1177	.8537	.1568
Purchase of Goods	.0529	.1376	.1975	.1950	.5107	.5888	1.935	1.236
Purchase of Services	.0153	--	.2883	.0376	.7168	.1221	3.173	1.722
CAPITAL EXPENDITURES[d]								
Mt. Makulu Research Station[e]	.0048	.011	.00078	.0055	.0028	.0046	.0386	.4000
Seed Production Project/Seed Control Institute[f]	(.1092)	(.1201)		--	(.5570)	(.1265)	(.1072)	(.75)
Research Training and Extension[g]	.3212	.1964	.1064	.1273	.0778	--		
Adaptive Research Planning Team[h]	.032	.0451	.1392	.9181	1.009	.8515	2.525	16.730
Buildings, Housing, Civil Works[i]		.0223	.0156	.0097	.2247	.1787	.7656	.1675
Agricultural Research Project (ZAREP)[j]				.0182	.1704	.3626	2.286	86.863
Crop Research[k]				(.3276)	(.5568)	(1.227)	(.2297)	(2.078)
Maize Research Extension[l]							(.756)	(.200)
TOTAL EXPENDITURES	1.079	1.160	1.909	2.499	4.508	5.162	14.076	112.10

h Partially funded by CIMMYT, Netherlands,SIDA,NORAD,IFAD; maize-related amounted estimated as 25 percent of expenditures

i Partially funded by NORAD, SIDA; maize-related amount estimated as 25 percent of expenditures

j Funded by NORAD, African Development Bank and World Bank; maize-related amount estimated as 25 percent of expenditures

k Funded by SIDA; maize-related amount estimated as 25 percent of total expenditures. To avoid double-counting, not included in this total

l Funded by FAO/UNDP; 100 percent of expenditures attributed to maize research. To avoid double-counting, not included in this total

m 1991 data are total provisions for each category; actual expenditure data not available

n Estimated; expenditure data not available for 1978

Table 34: Estimated GRZ expenditures on maize-related research, 1978-91 (economic values)

ml. ZK

ITEM	1978[d]	1979	1980	1981	1982	1983
PERSONAL EMOLUMENTS[a]						
Salaries		.1722	.1757	.2106	.2674	.2971
RECURRENT DEPARTMENTAL CHARGES[b]						
General Expenses		.1401	.1674	.2246	.3416	.244
Traveling on Duty		.015	.0168	.023	.035	.035
Field Services (General)		.277	.3171	.4141	.4976	.4203
Seed Production/ Seed Control Services		.1025	.3017	.1021	.8919	.1138
Cereal Research Team						.0375
CAPITAL EXPENDITURES[c]						
Mt. Makulu Research Station		.0411	.0649	---	.0799	.0333
Cereals Research Team		.0239	.1301	---		
Seed Production Project		.4910	.4265	.202	.3939	.0857
Mouldy Maize Project		.0676	.1126	.1256	.1055	
Research Training and Extension				(.200)	(.3089)	(.0293)
Adaptive Research Planning Team					.0596	.1096
TOTAL EXPENDITURES	1.091	1.331	1.712	1.302	1.870	1.376

[a] There are no tradeable goods in this category

[b] The content of tradeable goods in this category is estimated at 75 percent, except for traveling on duty and allowances, which have no tradeable goods

[c] Tradeable goods content in this category is estimated at 85 percent

[d] Estimated; actual expenditure data were unavailable

[e] Estimated; actual expenditure data were unavailable

Table 34: Estimated GRZ expenditures on maize-related research, 1978-91 (economic values) (con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988	1989	1990	1991[e]
PERSONAL EMOLUMENTS[a]								
Salaries	.644	.7277	1.113	1.124	1.698	2.936	2.5	4.825
RECURRENT DEPARTMENTAL CHARGES[b]								
Allowances	.0091	.0293	.0478	.0636	.0986	.1177	.8537	.1568
Purchase of Goods	.1178	.1581	.1554	.248	.7911	.8283	3.712	2.142
Purchase of Services	.0341	--	.2269	.0478	1.110	.1718	6.086	2.984
CAPITAL EXPENDITURES[c]								
Mt. Makulu Research Station	.0115	.0013	.00059	.00719	.00454	.00672	.0788	.7322
Seed Production Project/Seed Control Institute	(.1092)	(.1201)		--	(.557)	(.1265)	(.1072)	(.750)
Research Training and Extension	.768	.2295	.0807	.1665	.1262	–		
Adaptive Research Planning Team	.0765	.0527	.1056	1.201	1.636	1.244	5.153	30.625
Buildings, Housing, Civil Works		.0261	.0118	.0127	.3645	.2611	1.562	.3066
Agricultural Research Project (ZAREP)				.0238	.2764	.5297	4.664	159.00
Crop Research				(.3276)	(.5568)	(1.227)	(.2297)	(2.078)
Maize Research Extension							(.756)	(.200)
TOTAL EXPENDITURES	1.661	1.225	1.742	2.894	6.105	6.095	24.610	200.77

[a] There are no tradeable goods in this category

[b] The content of tradeable goods in this category is estimated at 75 percent, except for traveling on duty and allowances, which have no tradeable goods

[c] Tradeable goods content in this category is estimated at 85 percent

[d] Estimated; actual expenditure data were unavailable

[e] Estimated; actual expenditure data were unavailable

Table 35: USAID expenditures on Zambia Agricultural Development, Research and Extension (ZAMARE) 1983-88[a]

ml. USD

ITEM	1983-4	1984-5	1985-6	1986-7	1987-8[b]	TOTAL
Salaries, Travel, Allowances for Field and Home Office Staff	.603	.700	.8266	.8748		3.004
Other Direct Costs	.295	.3127	.2311	.1921		1.031
Participant Training	.8201	.8138	.9206	.844		3.399
Other[c]	1.016	1.016	1.016	1.016	1.016	5.081
TOTAL EXP.	2.734	2.843	2.995	2.927	1.016	12.515
EST. MAIZE-RELATED EXP.[d]	.6836	.7107	.7486	.7318	.2541	3.129
ZK equivalent at OER[e] (mln ZK)	.8333	1.566	4.26	9.327	2.031	
ZK equivalent --economic value[f] (mln ZK)	2.909	3.738	4.986	7.056	2.659	

[a] Source: USAID (1988), USAID (1991)

[b] Breakdown of expenditures not available for 1987-8

[c] Difference between expenditures reported under contract AFR-0201-C-00-1097 and total life-of-project expenditures for 611-0201

[d] 25 percent of total project costs are attributed to maize research and extension. This represents a weighted average of person-years of technical assistance directly related to maize research, proportion of students trained in maize-related areas, and commodities/housing and operational recurrent costs attributed to maize research and extension

[e] For the financial analysis, USD maize-related expenditures are converted to ZK using the nominal ZK/SDR and SDR/USD rates

[f] For the economic analysis, 85 percent of maize-related USD costs are converted to ZK using the SER

Table 36: SIDA expenditures on research and seed, 1979-92[a]

ml. ZK

ITEM	1979	1980	1981	1982	1983	1984	1985
RESEARCH AND SEED PROGRAMME	.485[b]						
Basic/Breeder seed production		.08			.042	.122	.355[c]
Seed Control/Testing/ SCCI		.1	.15	.17	.15	.554	.322
Seed Company		.15					2.08
Seed Training		.025	.05	.075	.050	.063	.139
Personnel/ Consultancy		.195					
Management Agreement			1	1.055	1.092	1.443	2.140
Housing, Zamseed				.200	.200		
Operation Costs, Research/Mt. Makulu					.074		
ARPT-Luapula Province						.305	.411
TOTAL EXPENDITURES	.485	.550	1.2	1.5	1.608	2.182	5.447
ESTIMATED MAIZE RESEARCH EXPENDITURES[d]	.0606	.0688	.025	.2638	.302	.4675	.7265
ZK equiv. at OER[e]	.0606	.0688	.25	.2638	.302	.4675	.7265
ZK equiv.--economic value[f]	.2113	.2411	.8972	.9942	.8511	1.118	.8489
ESTIMATED MAIZE SEED EXPENDITURES[g]	.1649	.188	.48	.6	.5968	.824	1.872
ZK equiv. at OER	.1649	.188	.480	.600	.5968	.824	1.872
ZK equiv.--economic value	.5746	.6594	1.723	2.262	1.682	1.970	2.188

[a] Source: SIDA Joint GRZ/SIDA Agricultural Sector Support Programme Budget and Annual Review, 1979-91. Amounts are budgeted amounts, not actual expenditures. Actual expenditure information was not available.

[b] Breakdown of budget not available. Proportions to maize research and maize seed expenditures based on 1980 proportions.

[c] Includes research budget

[d] Maize research expenditures are estimated as follows: 25 percent of general research-related expenditure categories, i.e. basic/breeder seed production, ARPT, research operation costs, based on percent of scientists engaged full or part-time in maize research (Kean and Singogo, 1989); 25 percent of management agreement and personnel/consultancy categories; 100 percent of maize research expenditures.

Table 36: SIDA expenditures on research and seed, 1979-92[a] (con't)

ml. Swedish kroner

ITEM	1986	1987	1988	1989	1990	1991
RESEARCH AND SEED PROGRAMME						
Agricultural Research and Breeder Seed Production	1.442					
Seed Control/Testing/ SCCI	1.398	1.675	1.5	1.175	1	.840
Seed Company	6.139	2.145	.3	.556		
Seed Training	.735	1.009	1.280	1.729	2.327	3.020
Personnel/ Consultancy						
Management Agreement	10.577	12.074	12.376	13.283	13.106	12.173
Housing, Zamseed						
Maize research		1.466	1.635	1.890	2.703	2.507
ARPT	3.8	3.908	4.410	4.082	4.132	3.614
TOTAL EXPENDITURES	24.091	22.277	21.510	22.715	23.268	22.154
ESTIMATED MAIZE RESEARCH EXPENDITURES[d]	3.955	5.462	5.832	6.231	7.013	6.454
ZK equiv. at OER[e] ('000 ZK)	7.373	7.472	9.473	21.275	52.752	103.277
ZK equiv.--economic value [f] ('000 ZK)	5.593	9.774	15.368	31.081	107.65	189.05
ESTIMATED MAIZE SEED[g] EXPENDITURES	7.54	6.761	8.03	6.697	6.573	6.413
ZK equiv. at OER ('000 ZK)	14.056	9.25	13.045	22.867	49.447	102.633
ZK equiv.--economic value ('000 ZK)	10.663	12.1	21.163	33.406	100.91	187.86

[e] 1979-85 SIDA investments were reported in ZK. It is assumed that these were converted from SEK at the official exchange rate. 1986-91 investments were reported in SEK. These costs were converted to ZK using the ZK/SDR and SEK/SDR rates (Tables 93, 94)

[f] For the economic analysis, 85 percent of maize-related costs are converted to ZK using the SER.

[g] Maize seed expenditures: 40 percent of seed-related expenditures (seed control/testing, seed company, seed training, personnel/consultancy, management agreement, housing-Zamseed) are attributed to maize, since maize sales represent approximately 40 percent of the total value of seeds sold by Zamseed (maize sales represented 47.8 percent of the total value of seeds sold in 1985-86, and 34.7 percent of total value of seeds sold in 1990-91 (Zamseed records).

[h] For the economic analysis, 85 percent of maize-related costs are converted to ZK using the SER.

Table 37: FAO/UNDP expenditures on maize research, 1978-87, and maize/legume research, 1987-92[a]

ml. USD

ITEM	1978	1979	1980	1981	1982	1983	1984	1985
TOTAL EXPENDITURES	.1733	.1733	.1733	.1733	.1733	.1733	.1733	.1733
ESTIMATED MAIZE-RELATED EXPENDITURES	.1733	.1733	.1733	.1733	.1733	.1733	.1733	.1733
ZK equiv. at OER[c] ('000 ZK)	.1357	.1342	.1386	.1519	.1602	.2119	.3819	.9877
ZK equiv.-- economic value[d] ('000 ZK)	.4685	.4676	.4861	.545	.604	.597	.9131	1.154

ITEM	1986	1987[b]	1988	1989	1990	1991	1992	TOTAL
TOTAL EXPENDITURES	.1733	.1733	.1733	.1733	.1733	.1733	.1733	2.6
ESTIMATED MAIZE-RELATED EXPENDITURES	.1733	.0867	.0867	.0867	.0867	.0867	.0867	2.079
ZK equiv. at OER[c] ('000 ZK)	2.203	.6936	.8672	1.843	3.716	7.674	14.1	33.4
ZK equiv.-- economic value[d] ('000 ZK)	1.671	.907	1.407	2.693	7.584	14.048	27.960	61.506

[a] Annual expenditure data was not available. Estimated based on FAO (1990) and personal communications with maize team members.

[b] Beginning in 1987, the FAO/UNDP-funded project expanded to include legume research. Maize-related expenditures are estimated at 50 percent of the total.

[c] For the financial analysis, USD maize-related expenditures are converted to ZK using the nominal ZK/SDR and SDR/USD rates.

[d] For the economic analysis, 85 percent of maize-related USD costs are converted to ZK using the SER.

Table 38: CIMMYT expenditures on Zambia maize research 1980-92[a]

ml. USD

Year/Item	1980	1981	1982	1983	1984	1985	1986
BREEDING PROGRAM							
CIMMYT Team Member Visits to Zambia	.01	.01	.01	.01	.01	.01	.01
In-country training						.05	.05
Training at CIMMYT/Mexico		.0014	.0014	.0014	.0014	.0014	.0014
Visiting scientists sent to CIMMYT/ Mexico				.0073	.0073	.0073	.0073
Zambian participation in regional maize workshops						.007	
Zambian maize team training in Harare (@$500)	.002	.002	.002	.002	.002	.002	.002
Subtotal, Breeding Program	.012	.0134	.0134	.0207	.0207	.0777	.0707
MAIZE AGRONOMY AND MAIZE-RELATED ON-FARM RESEARCH							
ARPT planning studies		.0025	.0025				
OFR in-country training					.0075	.0075	
Cooperative research, UNZA							
OFR research, training, Southern Province							
OFR research, training, Lusaka and Central Provinces							.0011
OFR regional training workshops, U.Zimb.				.0034	.0034	.0034	.0034
OFR trial data analysis workshop, Harare							
Maize agronomy courses, CIMMYT/Mexico							
Regional OFR and Maize conferences						.0027	
Subtotal, Maize Agronomy and OFR	0.0	.0025	.0025	.0034	.0109	.0136	.0045
TOTAL CIMMYT EXPENDITURES	.012	.0159	.0159	.0241	.0316	.0913	.0752
ZK equiv. at OER[b] ('mln ZK)	.0096	.01398	.01474	.02938	.06965	.5196	.95849
ZK equiv.--economic value[c] ('mln ZK)	.0337	.05021	.05573	.10151	.16624	.60798	.72545

Table 38: CIMMYT expenditures on Zambia maize research 1980-92 (con't)

ml. USD

Year/Item	1987	1988	1989	1990	1991	1992
BREEDING PROGRAM						
CIMMYT Team Member Visits to Zambia	.01	.01	.01	.01	.01	.01
In-country training	.05	.05	.05	.05	.05	.05
Training at CIMMYT/Mexico	.0014	.0014	.0014	.0014		
Visiting scientists sent to CIMMYT/ Mexico	.0073	.0073	.0073			
Zambian participation in regional maize workshops	.007		.007			
Zambian maize team training in Harare (@$500)	.002	.002	.002	.002	.002	.002
Subtotal, Breeding Program	.0777	.0707	.0777	.0634	.062	.062
MAIZE AGRONOMY AND MAIZE-RELATED ON-FARM RESEARCH						
ARPT planning studies						
OFR in-country training						
Cooperative research, UNZA	.005	.005	.005			
OFR research, training, Southern Province	.009	.009				
OFR research, training, Lusaka and Central Provinces	.0011	.0011	.0011	.0011	.0011	.0011
OFR regional training workshops, U.Zimb.	.0034	.0034	.0034	.0034	.0034	.0034
OFR trial data analysis workshop, Harare	.0015	.0015	.0015	.0015	.0015	.0015
Maize agronomy courses, CIMMYT/Mexico	.0168	.0168	.0168	.0168	.0168	.0168
Regional OFR and Maize conferences	.0027		.0054			.0027
Subtotal, Maize Agronomy and OFR	.0395	.0368	.0332	.0228	.0228	.0255
TOTAL CIMMYT EXPENDITURES	.1172	.1075	.1109	.0862	.0848	.0875
ZK equiv. at OER[b] ('mln ZK)	.93678	1.0718	2.3653	3.7017	7.5063	14.23
ZK equiv.--economic value[c] ('mln ZK)	1.2264	1.7434	3.5023	7.5196	13.85	28.004

[a] Estimates (personal communications: Gelaw, 1991; Waddington, 1993; Low, 1993)
[b] For the financial analysis, USD expenditures are converted to ZK using the nominal ZK/SDR and SDR/USD rates.
[c] For the economic analysis, 85 percent of USD costs are converted to ZK using the SER.

Table 39: Zamseed investments 1981-2000[a]

ml. ZK

	1981	1982-3	1983-4	1984-5	1985-6	1986-7	1987-8	1988-9	1989-90	1990-91	1991-2	1992-3	1993-2000
Land					2								
Industrial Buildings		.1	.8	.5	.2	1.1	.146		1.797		1.628		
Staff Houses			.4	.4	.2	.3	.146			1.176			
Motor Vehicles	.2		.1		.2	1.2		.1731		.7843		20.938	
Furniture, equipment		.3	.4		1.5	2.9		.3462		1.569			
TOTAL	1	.4	2.6	.9	4.1	5.5	.292	.5194	1.797	3.529	1.628	20.938	20.938
Less SIDA investments[b]		.2	.2		2.08	1.879	.720	.133	.521	0	0	0	0
TOTAL	1	.2	2.4	.9	2.02	3.621	0	.3864	1.276	3.529	1.628	20.938	20.938
Estimated maize seed-related expenditures[c]	.4	.08	.96	.36	.808	1.448	0	.1545	.510	1.412	.651	8.375	8.375
Economic values[d]	1.435	.3016	2.705	.8607	.9442	1.099	0	.2507	.7455	2.881	1.192	16.608	16.608

[a] Source: Norrby, 1986 and Zamseed reports

[b] See Table 32. Includes SIDA expenditures for seed company and housing, Zamseed

[c] 40 percent of seed-related expenditures are attributed to maize, since maize sales represent approximately 40 percent of the total value of seeds sold by Zamseed (maize sales represented 47.8 percent of the total value of seeds sold in 1985/6, and 34.7 percent of total value of seeds sold in 1990/91 (Zamseed records).

[d] For the economic analysis, 85 percent of maize seed-related costs are estimated to be tradeable goods.

APPENDIX 3

APPENDIX 3

SMALL-AND MEDIUM-SCALE FARMER MAIZE ADOPTION SURVEY QUESTIONNAIRE

ZAMBIA MAIZE RESEARCH IMPACT STUDY
QUESTIONNAIRE -- PRODUCER MAIZE ADOPTION SURVEY

CSA-SEA # ________________________________

Household No. ________________________________

Village ________________________________

Enumerator ________________________________

Date of Interview ________________________________

Name of Farmer ________________________________

Note: The questionnaire should be discussed with the head of the household (who may be either male or female), and, if possible, with **both** the leading male and female decision-makers.

Introduce yourself politely to the farmer and explain that you are working with the University of Zambia. Explain to the farmer that this survey is being conducted to determine how maize varieties developed by Zambian researchers have been adopted by farmers, and to understand the factors which have influenced farmer decisions about whether to use the new varieties or not. The information will assist national policymakers to design future maize research, extension and marketing systems that better meet the needs of the farmers. Finally, ask if the farmer has any questions.

PART A: BASIC INFORMATION ABOUT THE HOUSEHOLD

1. What is the SEX of the HOUSEHOLD HEAD? (Check one)
   ( ) 1 Female
   ( ) 2 Male
   ( ) 3 Both present

2. What GRADE in SCHOOL did you COMPLETE? (Enter grade completed)_____

3. Have you GROWN MAIZE AT SOME TIME during the period 1983-91? (Check one)
   ( ) 1 Yes
   ( ) 2 No

If "yes," proceed to question 4. If "no," SKIP TO Q29.

4. What is the TOTAL NUMBER OF PERSONS living in this household today? (Include adults, children and other dependents WHO EAT FROM THE SAME POT.) ______

5. Of the TOTAL NUMBER OF PERSONS above, how many are LESS THAN 15 YEARS OF AGE? ______

PART B: FARM SIZE 1983/84-1991/92

(Note to enumerators: in this section and the ones that follow, the numbers assigned to the fields MUST BE CONSISTENT, i.e. field #1 in question 7 is the same as field #1 in questions 8, 13, 14, and so on.

Now I would like to discuss the SIZE OF YOUR FARM and HOW IT HAS CHANGED DURING THE PAST FEW YEARS.

6. How many fields do you have at the PRESENT time? ______

7. What is the SIZE of field 1 (in hectares, acres, limas or paces--whatever unit the farmer is most comfortable with)? ______

   Unit of measure ______

   (continue for each field up to the total number of fields in Q6)

   What is the SIZE of field 2? ______

   What is the SIZE of field 3? ______

   What is the SIZE of field 4? ______

   What is the SIZE of field 5? ______

   What is the SIZE of field 6? ______

   TOTAL SIZE ______

HH# _____

8. How did you PREPARE YOUR LAND FOR PLANTING this year? (make sure total number of fields is the same as farmer reported for Q6).

Field Number	Method of Preparation

PREPARATION METHOD CODES

1-Hand hoe	5-Hand hoe and tractor
2-Oxen	6-Hand hoe, oxen and tractor
3-Tractor	7-Oxen and tractor
4-Hand hoe and oxen	8-Other (specify)

9. Have you ever planted IMPROVED MAIZE? By IMPROVED MAIZE, I mean MAIZE SEED THAT HAS BEEN DEVELOPED BY RESEARCHERS AT MT. MAKULU RESEARCH STATION. THIS SEED CAN BE PURCHASED AT THE COOP DEPOT, ZAMSEED RETAIL STORE OR OTHER STOCKISTS. The names of improved maize varieties are MM-752, MM-604, MMV600, etc.

( ) 1 Yes
( ) 2 No

If the answer is YES, PROCEED to question 10.

If the answer is NO, SKIP TO Q29.

10. IN WHAT YEAR did you begin PLANTING IMPROVED MAIZE FROM MT. MAKULU (should be 1984-5 or later; be sure to give the answer in terms of the **season**, e.g. 1985-6; 1988-9)?

_____

11. Now I would like to discuss how the TOTAL NUMBER OF YOUR FIELDS AND THE SIZE OF EACH FIELD have changed beginning THE YEAR BEFORE YOU STARTED PLANTING IMPROVED MAIZE. HOW MANY FIELDS did you have in 19__(year before year stated in Q10)?

_____

12. Has the NUMBER OF FIELDS or the SIZE of any of the fields changed between 198_ (the year before the farmer began planting improved maize) and the present time?

( ) 1 Yes
( ) 2 No

HH#_______

If NO, SKIP to Q14. If YES, PROCEED to Q13.

13. Please describe the CHANGES in the SIZE AND/OR THE TOTAL NUMBER of FIELDS since you began planting improved maize.

Yr.	Field No.	Type of Change	Amount of Change	Unit

TYPE OF CHANGE CODES

1-Addition of new field
2-Loss of field
3-Expansion of existing field
4-Contraction of existing field

PART C: CROPPING PATTERNS 1983/84-1991/92

14. Now I would like to discuss the AREA you have planted to different crops SINCE THE YEAR BEFORE YOU BEGAN PLANTING IMPROVED MAIZE (SEE Q10) THROUGH THIS CROPPING SEASON. (Note to enumerator: refer to Q13 for the number of fields you should ask about in each year. Introduce the wooden model to the farmer and explain that the model is intended to represent EACH FIELD the farmer has planted in EACH YEAR since the YEAR BEFORE THE FARMER STARTED PLANTING IMPROVED MAIZE FROM MT. MAKULU. If IMPROVED MAIZE AREA or VARIETY changes between years, note this and the reasons for the changes in the last two columns of the table.)

Year	Field No.	Crop	Variety Type MAIZE ONLY	Intercrop 0-None 1-22-see crop codes	Area (# of wooden pieces)	Improved maize area/variety change	Reason for improved maize area/variety change (specify)

CROP CODES		**VARIETY CODES**			**AREA/VARIETY CHANGE CODES**
1-Maize	12-Pumpkin	1-752	9-600	19-local-Senga	1-no change
2-Sorghum	13-Tobacco	2-604	10-612	20-local-Mumba	2-improved maize area increase
3-Cassava	14-Cotton	3-603	11-SR52	21-popcorn	3-change to different imp.mz
4-Millet	15-Other(spec)	4-601	12-R201	22-local-Gankata	
5-Soybean	16-Not cropped	5-501	13-R215	23-local-Siluutuba	4-improved maize area decrease
6-Rice	17-Can't recall	6-502	14-ZS206	24-ZH-1	5-change from local to improved maize variety
7-Bean	18-Watermelon	7-504	15-other	25-yellow maize(spec.)	6-change from
8-Grdnut	19-Okra	8-400	16-can't recall (local)		7-other (specify)
9-Sw.pot.	20-Squash		17-can't recall(improved)		8-imp.maize area increase + change of variety
10-Ir.pot.	21-Cucumber		18-local-Mulenga		9-change from Zimb/Rhod.var to Zamb imp var.
11-Sunflr	22-Yam				10-imp maize area decrease and change of variety
					11-change from Zambian to Zimb/Rhod. variety

HH#___

15. How did you FIND OUT ABOUT IMPROVED MAIZE from Mt. Makulu?

____

____

16. In general, what are the THREE MOST IMPORTANT REASONS WHY YOU STARTED TO GROW IMPROVED MAIZE? Please rank your responses IN ORDER OF IMPORTANCE.

1. ____
2. ____
3. ____

PART D: COMPLEMENTARY INSTITUTIONS

EXTENSION Next I would like to ask you about your EXPERIENCE WITH THE AGRICULTURAL EXTENSION SERVICE.

17. Have you EVER BEEN VISITED by an EXTENSION AGENT?

( ) 1 Yes
( ) 2 No

If no, SKIP to Q19. If yes, PROCEED to Q18.

18. What was the PURPOSE(S) of the visit?

____
____
____

19. Have you ever ADOPTED RECOMMENDATIONS concerning improved maize production?

( ) 1 Yes
( ) 2 No

If no, SKIP to Q21. If yes, PROCEED to Q20.

HH#___

20. Please SPECIFY the recommendations you ADOPTED in order of importance. By important, I mean in terms of INCREASING YOUR YIELD. Also, please tell me where or from whom you learned about these recommendations (Note to enumerator: proper names are not needed here, but institutional affiliation, e.g. extension agent, primary society officer, etc. is important.)

MAIZE RECOMMENDATIONS ADOPTED IN ORDER OF IMPORTANCE	SOURCE OF RECOMMENDATION

<u>CREDIT</u>. Now I would like to ask about CREDIT you have RECEIVED in the past for MAIZE-RELATED ACTIVITIES.

21. Have you ever RECEIVED CREDIT for INPUTS USED ON MAIZE, SUCH AS FERTILIZER, SEEDS, OR BAGS, or for OXEN OR OXEN-RELATED IMPLEMENTS, or TRACTOR HIRE for the purpose of PREPARING LAND to be PLANTED to MAIZE?

( ) 1 Yes
( ) 2 No

If no, SKIP to Q23. If yes, PROCEED to Q22.

HH#__

22. In WHAT YEARS did you RECEIVE CREDIT for INPUTS USED ON MAIZE, or for OXEN OR OXEN-RELATED IMPLEMENTS, or TRACTOR HIRE for preparing land to be planted to maize? (Note to enumerator: for each year that farmer received credit for maize, oxen/oxen-implements, or tractor hire, ask about the source of credit, type of credit and amount of credit received.)

Year	Type of Credit	Credit Source	Amount	Type	Unit

CREDIT TYPE CODES	CREDIT SOURCE CODES		TYPE CODES	UNIT CODES
1-Maize	1-Lima Bank	8-Church org.	1-Seeds	1-50 kg
2-Oxen/implements	2-Primary Society	9-ZCF	2-Fertilizer	2-90 kg
3-Tractor hire	3-CUSA	10-Private seller	3-Bags	3-10 kg
4-Other (specify)	4-AFC		4-Oxen	4-Kwacha
	5-Commercial Bank	11-DCU	5-Implements	5-Other (specify)
	6-Other (specify)	12-PCU	6-Cash	
	7-Other farmer		7-Other (specify)	

HH#__

23. For YEARS when you DID NOT RECEIVE CREDIT FOR MAIZE, why not?

Year	Reason

FERTILIZER. Now I would like to discuss FERTILIZER USE ON IMPROVED MAIZE.

24. Have you EVER APPLIED CHEMICAL FERTILIZER to IMPROVED MAIZE?
( ) 1 Yes
( ) 2 No

If no, skip to Q26. If yes, proceed to Q25.

25. In WHAT YEARS did you USE CHEMICAL FERTILIZER on IMPROVED MAIZE? (Note to enumerator: for each year that the farmer used fertilizer on maize, ask the type, the type desired [if different from the type received], the source, amount and time of fertilizer delivery. Use a separate line for each type of fertilizer received in each year.)

Year	Fertilizer type received	Fertilizer type desired	Source	Amount	Unit	Time of delivery

FERTILIZER CODES		SOURCE CODES	UNIT CODES	DELIVERY TIME CODES
Basal		1-Primary society	1-50 kg	1-Before planting
1-X	5-V	2-NCZ	2-90 kg	2-Just after planting
2-D	6-R	3-Namboard	3-10 kg	3-Germination to 1 mo.after
3-A	7-L	4-Other (specify)	4-Other (spec.)	
4-C	8-Other	5-DCU		4-More than 1 month after germination
Top		6-PCU		
9-Urea		7-Private seller		
10-Ammonium nitrate		8-Private voluntary organization		
11-Other top		9-CUSA		

HH#__

26. SEED AVAILABILITY. Next I would like to discuss the AVAILABILITY OF IMPROVED MAIZE SEED. (Note to enumerator: look back at Q14. Determine from the table the years when improved maize seed was used, and what type was used. Enter these in the table below. For each year and type of improved maize seed used by the farmer, ask if the type of improved maize used was the type desired. If not, record the type desired. Also ask the source of each type of improved seed, and ask what month the maize seed was available at the source.)

Year	Type of Improved Maize Used	Type of Maize Desired	Source of Improved Maize Seed	When was Maize Seed Delivered?

VARIETY CODES
1-752
2-604
3-603
4-601
5-501
6-502
7-504
8-400
9- 600
10-612
11-R201
12-R215
13-ZS206
14-Other
15-can't recall, but improved

SOURCE CODES
1-Primary society
2-Zamseed Depot
3-Retail shop
4-Replanted
5-Other(specify)
6-DCU
7-PCU
8-Private seller
9-NAMBOARD

DELIVERY TIME CODES
1-Sept. or earlier
2-October
3-November
4-December
5-January
6-Can't recall

MAIZE MARKETING. Finally, I would like to discuss MARKETING of IMPROVED MAIZE.

HH#______

27. Have you EVER SOLD IMPROVED MAIZE?

( )1 Yes
( )2 No

If no, TERMINATE the INTERVIEW. Thank the farmer politely for his/her cooperation. If yes, PROCEED to Q28.

28. During WHAT YEARS did you SELL IMPROVED MAIZE? (Note to enumerator: for each year mentioned by the farmer, ask about AMOUNT of improved maize SOLD, AMOUNT RETAINED, WHERE SOLD, TIME OF COLLECTION/ DELIVERY and TIME of PAYMENT.)

Year	Amt. of improved maize SOLD (No. of 90 kg bags)	Amt. of improved maize RETAINED (No. of 90 kg bags)	Where sold	Collection/ Delivery	Time of Collection/ Delivery	Time of Payment

LOCATION CODES	COLL./DEL. CODES	TIME OF COLL./DEL./PAYMENT CODES	
1-Primary society	1-Collected	1-May	4-Aug.
2-Private buyer	2-Delivered	2-June	5-Sept.
3-Other (specify)		3-July	6-Oct.or later
4-DCU			
5-PCU			
6-Namboard			

CONCLUDE the interview and THANK the farmer. Ask if he/she has any questions or comments he/she would like to add.

29. ADDITIONAL COMMENTS

APPENDIX 4

APPENDIX 4

LARGE FARMER MAIZE ADOPTION SURVEY QUESTIONNAIRE

QU

Note:
15 or

1. Di

2. Ar

3. Wh

4. Wh

5. Hov

6. Hav
vari
Stati

HH#______

ZAMBIA MAIZE RESEARCH IMPACT STUDY
QUESTIONNAIRE -- COMMERCIAL FARMER MAIZE ADOPTION SURVEY

Note: please complete this questionnaire only if you own or manage a farm on which 15 or more hectares of maize are usually planted each year.

1. District and province where farm is located________________________________

2. Are you the farm's (check all applicable)..................   owner______

   manager_____

   other(specify)

   ____

3. What is your sex?..

   male_______

   female______

4. What is your age?..   ____________

5. How many years of formal education did you complete?......   ____________

6. Have you ever planted any of the following maize hybrids/ varieties which were developed at Mt. Makulu Research Station?

MM-752	MM-501	MMV-400
MM-604	MM-502	MMV-600
MM-603	MM-504	
MM-601	MM-612	

   yes_______

   no________

no________

If you answered "no" to question 6, please skip to question 9.
If you answered "yes" to question 6, please proceed to question 7.

7. In what season did you begin planting an improved maize hybrid/variety from Mt. Makulu (e.g. 1984-5, 1985-6, etc.)? ____________

8. Please use the following table to describe the cropping/livestock pattern of your farm beginning the season BEFORE you began using an improved maize hybrid/variety from Mt. Makulu, and continuing through the 1992-93 (plans) season.

a. Describe the crop/livestock pattern for every season since you began using improved maize from Mt. Makulu, although you may not have planted maize each year.

b. For each season, please ensure that the sum of the reported hectarages given for crops, livestock and fallow land, equals the correct area of the farm in that year.

c. For seasons in which you changed maize varieties/hybrids, or your hectarage of Mt. Makulu maize changed (increased or decreased) by more than 10 percent, briefly explain the reason why in the last column.

EXAMPLE. Farmer Z. began growing MM752 in the 1984-5 season. Prior to 1984-85, he grew SR52, then switched to MM752 because he expected higher yields. He continued to grow about the same hectarage of Mt. Makulu improved maize between 1984-88, along with other crops--soybean, tobacco, local maize intercropped with watermelon and pumpkin for the workers--and cattle. In the 1986-7 season, Z. experimented with MM-603 and R215, then switched back to MM-752 the following year because of its superior yield under good management. He decreased his maize area beginning in the 1988-89 season because of unfavorable product and input prices, and because he wanted to increase his cattle herd and his tobacco hectarage (to take advantage of the export retention scheme). In 1991-92, however, Z. increased the maize hectarage again because he anticipated higher producer prices.

(EXAMPLE)

Year	Crop or livestock type	Variety type (MAIZE ONLY)	Intercrop	Area-- specify # and unit (acre,ha or lima) or # of animals	Reason for improved maize area/variety change (specify)
83-4	MAIZE	SR-52	-	20 HA	
83-4	MAIZE	LOCAL	PUMPKIN, WATERMELON	5 HA	
83-4	SOYA	-	-	30 HA	
83-4	BEEF CATTLE	-	-	40 HEAD	
83-4	PASTURE/ FALLOW	-	-	10 HA	
			TOTAL	65 HA	
84-5	MAIZE	MM752	-	20 HA	EXPECTED HIGHER YIELDS WITH MM752
84-5	MAIZE	LOCAL	PUMPKIN, WATERMELON	5 HA	
84-5	SOYA	-	-	20 HA	
84-5	BEEF CATTLE	-	-	50 HEAD	
84-5	PASTURE/ FALLOW	-	-	20 HA	
			TOTAL	65 HA	

(CONTINUES THROUGH 91-2 SEASON) END OF EXAMPLE

HH#________

Year	Crop or livestock type	Variety type (MAIZE ONLY)	Intercrop	Area--specify # and unit (acre,ha or lima) or # of animals	Reason for improved maize area/variety change (specify)

9. Please comment on your experience with Mt. Makulu improved maize hybrids/varieties, or, if you have never used Mt. Makulu varieties/hybrids or have discontinued using them, please explain why.

____

____

____

____

____

____

____

____

10. What crop problems (including all crops, not just maize) would you like the Research Branch to work on? Please rank these in order of their importance to you.

1.____

____

2.____

____

3.____

____

4.____

____

5.____

____

11. Additional comments____

THANK YOU VERY MUCH FOR YOUR ASSISTANCE.

APPENDIX 5

APPENDIX 5

MSU/MAFF/RDSB MAIZE ADOPTION SURVEY RESULTS

Table 40: Means of cultivation, medium farmers

(percent of all farmers)

Method of cultivation[a]	Region I	Region II	Region III	Imp.maize adopters	Non-adopters
Hand hoe only	22.2	3.6	87.5	17.8	62.5
Oxen only	77.8	87.5	6.3	75.3	25.0
Tractor only, or combination of tractor and oxen or hand hoe		5.4		4.1	
Hand hoe and oxen		3.6	6.3	2.7	12.5
Total	100.0	100.1	100.1	99.9	100.1
n	9	56	16	73	8

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992

[a] Regional differences are significant at $p < .001$.

Table 41: Maize as a proportion of total farm area, before and after adoption[a]

Year	Mean proportion of total farm area planted in maize (improved and unimproved)[b] (percent)	n
1983 (pre-adoption)	65	27
1984	68	33
1985	70	32
1986	67	33
1987	65	32
1988	64	32
1989	62	32
1990	64	33
1991	57	30

Source: MSU/MAFF/RDSB Maize Adoption Survey, 1992

[a] By farmers adopting improved maize in 1984
[b] Differences in yearly proportions were not significant at $p < .05$.

Table 42: Year of improved maize adoption

(percent of farmers)

Season	Small[a]	Small cumulative	Medium	Medium cumulative
84/5	12.2	12.2	17.8	17.8
85/6	5.5	17.7	19.2	37.0
86/7	5.5	23.2	17.8	54.8
87/8	8.5	31.7	13.7	68.5
88/9	12.8	44.5	5.5	74.0
89/90	22.6	67.1	13.7	87.7
90/1	16.5	83.6	8.2	95.9
91/2	16.5	100.0	4.1	100.0
Total	100.0	100.0	100.0	100.0
n	164		73	

[a] Differences between small and medium farmers were significant at $p < .001$.

Table 43: Mean cropped area (ha), before adoption of improved maize and 1991-92

	year before adoption	91/92	percent change
84/85 ADOPTERS[a]			
Small (20)	2.01	2.61	29.8
Medium (13)	7.61	8.64	13.4
85/86 ADOPTERS			
Small (9)	1.31	1.72	31.2
Medium (13)	9.17	10.95	19.4
86/87 ADOPTERS			
Small (8)	1.55	1.87	21.0
Medium (12)	11.04	10.32	-6.5
87/88 ADOPTERS			
Small (14)	1.81	1.93	6.5
Medium (10)	10.37	10.29	-.7
88/89 ADOPTERS			
Small (21)	1.94	2.38	22.8
Medium (4)	7.02	6.73	-4.2
89/90 ADOPTERS			
Small (37)	2.07	1.87	-9.6
Medium (10)	5.77	7.63	32.2
90/91 ADOPTERS			
Small (22)	1.99	2.05	2.6
Medium (6)	7.55	6.69	-11.3
91/92 ADOPTERS			
Small (27)	1.10	1.29	17.8
Medium (3)	11.17	10.17	-9.0
MEAN CHANGE			
Small			15.3
Medium			4.2

[a] n in parentheses

Table 44: Cropping pattern, pooled for all adopters, year before adoption

(percent of total cropped area)

	All	Region I, small (n=27)	Region I, medium (n=8)	Region II, small (n=89)	Region II, medium (n=53)	Region III, small (n=48)	Region III, medium (n=12)
Cassava	1.9[a]	0	0	0	0	25.8[iii]	3.3[uuu]
Local maize	42.2[b]	46.2[r]	26.0[bb]	52.8[kk]	43.3[yy]	41.2[kkk]	23.2[vvv]
SR52[3]	16.2[c]	2.2[s]	26.3[cc]	10.0[ll]	20.7[zz]	0	12.8[www]
Zimb. hybrids	1.1[d]	0	0	1.6[mm]	1.1[aaa]	1.2[lll]	2.3[xxx]
Sorghum	1.2[e]	4.6[t]	7.3[dd]	.1[nn]	.2[bbb]	.8[mmm]	1.6[yyy]
Soybean	2.3[f]	0	0	4.2[oo]	2.2[ccc]	1.2[nnn]	3.1[zzz]
Bean	3.6[g]	0	0	1.3[pp]	1.3[ddd]	7.3[ooo]	28.7[aaaa]
Groundnut	9.1[h]	16.5[u]	6.9[ee]	8.8[qq]	10.0[eee]	3.2	6.2[bbbb]
Sweet potato	.3[i]	.7[v]	0	.5[rr]	.2	.5[qqq]	0
Sunflower	7.5[j]	6.1[w]	13.1[ff]	5.5[ss]	9.5[fff]	.5[rrr]	0
Cotton	5.3[k]	4.4[x]	10.9[gg]	5.6[tt]	5.9[ggg]	0	0
Fallow	4.4	7.8	0	7.0	3.9	2.4	5.1
Millet	2.9[l]	4.4[y]	3.6[hh]	1.0[uu]	.4[hhh]	15.0[sss]	12.4[cccc]
Tobacco	.06[m]	0	0	.3[vv]	0	0	0
Pea	.5[n]	0	0	0	.9[iii]	0	0
Pumpkin	0.6[o]	1.3[z]	4.4[ii]	.8[ww]	0	0	0
Rice	.4[p]	5.7[aa]	1.5[jj]	0	0	0	0
Other	.5[q]	0	0	.4[xx]	.3[jjj]	1.0[ttt]	2.9

[a] 39.2 percent of cassava area was sole cropped, 60.8 percent intercropped. Common intercrops were groundnut, bean, other vegetables.
[b] Of which 22.6 percent was sole cropped, 77.4 percent intercropped. Pumpkin (alone) or pumpkin combined with watermelon, bean, groundnut, other vegetables, sorghum or millet were the most common intercrops.
[c] 44.1 percent of SR52 area was sole cropped, 55.9 percent was intercropped (pumpkin, groundnut and other vegetables were common intercrops.)
[d] 43.2 percent of Zimbabwean hybrid maize area was sole cropped, 56.8 percent was intercropped (pumpkin, watermelon, sorghum were common intercrops.)
[e] 54 percent of area was sole cropped, 45.9 percent intercropped (pumpkin, groundnut, other vegetables)
[f] 9.1 percent of area was sole cropped, 6.9 percent intercropped (watermelon, pumpkin)
[g] 99.2 percent of area was sole cropped, .8 percent intercropped
[h] 49.1 percent was sole cropped, 50.9 percent intercropped (pumpkin, watermelon, bean, sweet potato).
[i] All was sole cropped.

[j] 76.6 percent of area was sole cropped, 23.4 percent intercropped (pumpkin, watermelon, millet)
[k] 76.9 percent of area was sole cropped, 23.0 percent intercropped (pumpkin, watermelon, vegetables).
[l] 50.4 percent of area was sole cropped, 49.6 percent intercropped (pumpkin, vegetable)
[m] All sole cropped.
[n] All sole cropped.
[o] All sole cropped.
[p] All sole cropped.
[q] Includes sole and intercropped okra, bambara nuts, watermelon, and other vegetables.
[r] Of which 46.4 percent was sole cropped, 53.6 percent intercropped.
[s] All sole cropped.
[t] 82.8 percent sole cropped, 17.2 percent intercropped.
[u] 90 percent sole cropped, 10 percent intercropped
[v] All sole cropped.
[w] 55.6 percent sole cropped, 44.4 percent intercropped.
[x] All sole cropped.
[y] All sole cropped.
[z] All sole cropped.
[aa] All sole cropped.
[bb] 74.8 percent sole cropped, 25.2 percent intercropped.
[cc] 50 percent sole cropped, 50 percent intercropped.
[dd] 50.1 percent sole cropped, 49.9 percent intercropped
[ee] All sole cropped.
[ff] All sole cropped.
[gg] All sole cropped.
[hh] All intercropped.
[ii] All sole cropped.
[jj] All sole cropped.
[kk] 24.6 percent sole cropped, 75.4 percent intercropped.
[ll] 67.2 percent sole cropped, 32.8 percent intercropped.
[mm] All sole cropped.
[nn] All intercropped.
[oo] 88.1 percent sole cropped, 11.9 percent intercropped.
[pp] All sole cropped.
[qq] 53.6 percent sole cropped, 46.4 percent intercropped.
[rr] All sole cropped.
[ss] 89.8 percent sole cropped, 10.2 percent intercropped.
[tt] 77.4 percent sole cropped, 22.6 percent intercropped.
[uu] 90.0 percent sole cropped, 10 percent intercropped.
[vv] All sole cropped.
[ww] All sole cropped.
[xx] includes bambara nuts, watermelon.
[yy] 14.5 percent sole cropped, 85.5 percent intercropped.
[zz] 37.6 percent sole cropped, 62.4 percent intercropped.
[aaa] All intercropped.
[bbb] All intercropped.
[ccc] 94.8 percent sole cropped, 5.2 percent intercropped.
[ddd] All sole cropped.
[eee] 37.9 percent sole cropped, 62.1 percent intercropped.
[fff] 69.9 percent sole cropped, 30 percent intercropped.
[ggg] 68.3 percent sole cropped, 31.7 percent intercropped.
[hhh] All sole cropped.
iii All sole cropped.
[jjj] 29.9 percent sole cropped, 70.1 percent intercropped.
[kkk] 34.8 percent sole cropped, 65.11 percent intercropped.
[lll] All intercropped.

[mmm] All intercropped.
[nnn] All sole cropped.
[ooo] 93.6 percent sole cropped, 6.4 percent intercropped.
[ppp] 41.3 percent sole cropped, 58.7 percent intercropped.
[qqq] All sole cropped.
[rrr] All sole cropped.
[sss] 81.1 percent sole cropped, 18.9 percent intercropped.
[ttt] Includes okra, watermelon.
[uuu] All sole cropped.
[vvv] All intercropped.
[www] 51.5 percent sole cropped, 48.5 percent intercropped.
[xxx] All sole cropped.
[yyy] All sole cropped.
[zzz] All sole cropped.
[aaaa] All sole cropped.
[bbbb] 25 percent sole cropped, 75 percent intercropped.
[cccc] 3.1 percent sole cropped, 96.9 percent intercropped.

Table 45: Cropping pattern, improved maize adopters, 1991-92

(percent of total cropped area)

	All	Region I, small (n=27)	Region I, medium (n=8)	Region II, small (n=89)	Region II, medium (n=53)	Region III, small (n=48)	Region III, medium (n=12)
Cassava	2.1[a]	0	0	.4[jj]	0	16.0[jjj]	7.5[ttt]
Local maize	8.1[b]	24.6[s]	8.5[aa]	11.2[kk]	4.4[yy]	11.0[kkk]	10.0[uuu]
Improved maize	47.7[c]	41.3[t]	29.0[bb]	51.9[ll]	56.5[zz]	35.6[lll]	16.6[vvv]
Zimb. hybrids	2.4[d]	0	13.7[cc]	1.4[mm]	2.5[aaa]	0	0
Sorghum	2.0[e]	11.2[u]	18.6[dd]	.8[nn]	0	.8[mmm]	.5[www]
Soybean	1.0[f]	0	0	1.3[oo]	1.4[bbb]	.7[nnn]	
Bean	2.8[g]	0	0	1.2[pp]	.8[ccc]	12.5[ooo]	12.2[xxx]
Groundnut	9.7[h]	10.1[v]	7.5[ee]	10.4[qq]	11.2[ddd]	3.8[ppp]	6.8[yyy]
Sweet potato	.8[i]		0	.5[rr]	.6[eee]	2.2[qqq]	2.5[zzz]
Sunflower	3.4[j]	.9[w]	12.2[ff]	3.2[ss]	3.9[fff]	0	
Cotton	6.4[k]	3.1[x]	1.6[gg]	6.9[tt]	9.2[ggg]	0	
Fallow	8.4	6.5	5.4	8.4	7.5	9.5	15.0
Millet	3.4[l]	1.9[y]	3.4[hh]	0	0	7.8[rrr]	26.8[aaaa]
Tobacco	.5[m]	0	0	.5[uu]	.7		
Irish potato	.3[n]	0	0	0	0		2.0[bbbb]
Pumpkin	.3[o]	0	0	1.6[vv]	0		
Bambara nut	.05[p]	0	0	.2[ww]	0	.2[sss]	
Watermel.	.5	0	0	.1[xx]	1.0[iii]		
Rice	.04[r]	.4[z]	.3[ii]	0	0		
Other	.2	0	0	0	.2[jjj]		

[a] 73.3 percent sole cropped, 26.6 percent intercropped.
[b] 31.8 percent sole cropped, 68.2 percent intercropped.
[c] 45.8 percent sole cropped, 54.2 percent intercropped.
[d] 49.3 percent sole cropped, 50.7 percent intercropped.
[e] 53.9 percent sole cropped, 46.1 percent intercropped.
[f] 96.9 percent sole cropped, 30.9 percent intercropped.
[g] 82.9 percent sole cropped, 17.1 percent intercropped.
[h] 59.8 percent sole cropped, 40.2 percent intercropped.
[i] All sole cropped.

All
49.
All
All
38
56
68
90
All
All
All
All
65
54
All
39.
73.
All
All
94.
All
All
27
40
All
All
87.
34.
[illegible]
All
93.
81.9
All
All
27
All
17.8
44.5
70.
All
All
51.
All
All
12.9
All
All
63.3
82.9
52.5

[j] 98.9 percent sole cropped, .01 percent intercropped.
[k] 86.6 percent sole cropped, 13.4 percent intercropped.
[l] 74.7 percent sole cropped, 25.3 percent intercropped.
[m] All sole cropped.
[n] All sole cropped.
[o] All sole cropped.
[p] 49.8 percent sole cropped, 50.2 percent intercropped.
[q] All sole cropped.
[r] All sole cropped
[s] 38.7 percent sole cropped, 61.3 percent intercropped.
[t] 56 percent sole cropped, 44 percent intercropped.
[u] 68.6 percent sole cropped, 31.4 percent intercropped.
[v] 90.4 percent sole cropped, 9.6 percent intercropped.
[w] All sole cropped.
[x] All sole cropped.
[y] All sole cropped.
[z] All sole cropped.
[aa] 65.4 percent sole cropped, 34.6 percent intercropped.
[bb] 54.1 percent sole cropped, 45.9 percent intercropped.
[cc] All intercropped.
[dd] 39.3 percent sole cropped, 60.1 percent intercropped.
[ee] 73.9 percent sole cropped, 26.1 percent intercropped.
[ff] All sole cropped.
[gg] All sole cropped.
[hh] 94.2 percent sole cropped, 5.8 percent intercropped.
[ii] All sole cropped.
[jj] All sole cropped.
[kk] 27.1 percent sole cropped, 72.9 percent intercropped.
[ll] 40 percent sole cropped, 60 percent intercropped.
[mm] All sole cropped.
[nn] All sole cropped.
[oo] 87.4 percent sole cropped, 12.6 percent intercropped.
[pp] 34.2 percent sole cropped, 65.7 percent intercropped.
[qq] 77.7 percent sole cropped, 22.3 percent intercropped.
[rr] All sole cropped.
[ss] 93.6 percent sole cropped, 6.4 percent intercropped.
[tt] 81.9 percent sole cropped, 18.1 percent intercropped.
[uu] All sole cropped.
[vv] All sole cropped.
[ww] 27.3 percent sole cropped, 72.7 percent intercropped.
[xx] All sole cropped.
[yy] 17.8 percent sole cropped, 82.2 percent intercropped.
[zz] 44.5 percent sole cropped, 55.5 percent intercropped.
[aaa] 70.6 percent sole cropped, 29.4 percent intercropped.
[bbb] All sole cropped.
[ccc] All sole cropped.
[ddd] 51.4 percent sole cropped, 48.6 percent intercropped.
[eee] All sole cropped.
[fff] All sole cropped.
[ggg] 12.9 percent sole cropped, 87.1 percent intercropped.
[hhh] All sole cropped.
iii All sole cropped.
[jjj] 63.3 percent sole cropped, 36.7 percent intercropped
[kkk] 82.9 percent sole cropped, 17.1 percent intercropped
[lll] 52.5 percent sole cropped, 47.5 percent intercropped

[mmm] 28.8 percent sole cropped, 71.2 percent intercropped
[nnn] All cropped.
[ooo] 67.5 percent sole cropped, 32.5 percent intercropped.
[ppp] 79.7 percent sole cropped, 20.3 percent intercropped.
[qqq] All sole cropped.
[rrr] 88.8 percent sole cropped, 11.2 percent intercropped.
[sss] All sole cropped.
[ttt] All sole cropped.
[uuu] All intercropped.
[vvv] 69.5 percent sole cropped, 30.5 percent intercropped.
[www] All sole cropped.
[xxx] All sole cropped.
[yyy] 34.9 percent sole cropped, 65.1 percent intercropped.
[zzz] All sole cropped.
[aaaa] 68.5 percent sole cropped, 31.5 percent intercropped.
[bbbb] All sole cropped.

Table 46: Proportion of maize area planted to different variety categories, 1983-92

(percent of total large, small/medium maize area)

	83-4	84-5	85-6	86-7	87-8	88-9	89-90	90-1	91-2
Large Farmers									
SR52	87.0	87.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zimb. hybrids[a]	13.0	6.5	21.0	8.0	11.6	17.0	43.6	37.7	25.1
Zambian improved	0.0	6.5	78.9	91.7	88.4	83.0	56.4	62.3	74.9
Total	100.0	100.0	99.9	99.7	100.0	100.0	100.0	100.0	100.0
Small/ Med. Farmers									
Local	65.5	62.3	48.1	41.1	37.2	33.4	29.6	28.2	26.0
SR52	24.3	31.3	24.3	20.7	18.7	0.0	0.0	0.0	0.0
Zimb. hybrids	10.2	5.5	4.2	3.6	3.2	19.7	17.5	16.7	15.4
Zambian improved	0.0	.8	23.4	34.6	40.7	47.0	53.0	55.1	58.6
Total	100.0	99.9	100.0	100.0	99.8	100.1	100.1	100.0	100.0

Sources: Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6) and MSU/MAFF/RDSB Large Farmer Maize Adoption Survey results. Allocation of maize area for small/medium farmers is based on results from the MSU/MAFF/RDSB Small/Medium Farmer Maize Adoption Survey.

[a] Zimbabwean hybrids refer to CG4141, PNR473, R201, R215, ZS206, and ZS225.

Table 47: Why small/medium farmers adopted improved maize

(percent of farmers)

	Good yields	Early maturing	Source of cash	Food source	Drought tolerant	Cob or seed charac-teristic[a]	Other	n
Region I	31.4	25.7	17.1	8.6	8.6	0.0	8.6	35
Region II	40.4	21.3	11.3	2.8	5.6	4.9	13.7	141
Region III	45.0	20.0	6.7	6.7	0.0	1.7	19.9	60
All Regions	40.3	21.6	11.0	4.6	4.6	3.4	14.5	236

Source: MSU/MAFF/RDSB Maize Adoption Survey
[a] Desirable characteristics included heavy seeds, small seeds, large cobs, multiple cobs

Table 48: Sources of information about improved maize

(percent of farmers)

	Extension worker	Other farmers	Primary coop society	Radio	Other	n
All	27.8	33.8	17.7	8.9	11.8	237
Region I	42.9	37.1	5.7	5.7	8.7	35
Region II	19.7	34.5	21.1	12.7	11.9	142
Region III	38.3	30.0	16.7	--	15.0	60
Small	23.8	40.2	18.3	4.3	13.4	164
Medium	37.0	19.2	16.4	19.2	8.2	73
Close[a]	21.1	38.2	14.5	13.2	13.0	152
Remote	40.0	25.9	23.5	1.2	9.4	85

Source: MSU/MAFF/RDSB Maize Adoption Survey
[a] Close/remote differences were significant at $p < .05$.

Table 49: Fertilizer use, per farmer, 1985-91

kg product/farmer; n in parentheses

	85	86	87	88	89	90	91
All	1044.7 (47)	963.9 (61)	1047.4 (78)	1111.9 (101)	934.7 (135)	938.8 (145)	902.8 (123)
Small	560.9** (23)	656.9* (29)	608.1*** (37)	740.4*** (57)	633.7*** (84)	648*** (90)	616.1** (84)
Medium	1508.3** (24)	1242.2* (32)	1443.9*** (41)	1593.2*** (44)	1430.4*** (51)	1414.5*** (55)	1520.5** (39)
Close	1035.2 (27)	1053.8 (39)	1117.9 (53)	1220.9 (67)	1033.67 (90)	1058.3* (96)	896.2 (93)
Remote	1057.5 (20)	804.5 (22)	898 (25)	897.1 (34)	736.7 (45)	704.5* (49)	862.9 (30)
Region I	475 (4)	850 (6)	720 (5)	638.2 (7)	883.3* (12)	622.9* (14)	341.7** (6)
Region II	1225 (34)	1174.4 (41)	1167.9 (56)	1247.9 (75)	1108* (88)	1104* (99)	1121.3** (82)
Region III	616.7 (9)	396.4 (14)	1047.4 (16)	647.4 (19)	516.6* (35)	565.6* (32)	487.1** (35)

* $p < .05$
** $p < .01$
*** $p < .001$

Table 50: Proportion of improved maize adopters using fertilizer, 1985-91

percent of improved maize adopters[a]

	85[b]	86[c]	87[d]	88[e]	89[f]	90[g]	91[h]
All	86.5	82.2	77.8	83.2	81.1	76.6	58.6
Small	84.0	84.8	78.3	86.2	82.0	73.6	59.6
Medium	88.9	80.0	82.0	79.6	79.7	82.1	56.5

[a] pool of improved maize adopters, i.e., 85 includes farmers first adopting improved varieties in 84 or 85; 86 includes those adopting in 84, 85, 86, etc.
[b] n=52; small=21; medium=27
[c] n=73; small=33; medium=40
[d] n=99; small=46, medium=50
[e] n=119; small=65; medium=54
[f] n=164; small=100; medium=64
[g] n=188; small=121; medium=67
[h] n=210; small=141;medium=69

Table 51: Time of fertilizer delivery

percent of farmers reporting; n in parentheses

	1984	1985	1986	1987	1988	1989	1990	1991
ALL	(30)	(47)	(64)	(80)	(102)	(133)	(149)	(126)
before planting	36.7	38.3	40.6	36.3	49.0	31.6	31.5	34.9
just after planting	13.3	21.3	20.3	21.3	10.8	15.0	18.8	10.3
germ.-1 month	33.3	25.5	29.7	33.8	31.4	42.1	34.9	36.5
over 1 month	16.7	14.9	9.4	8.8	8.8	11.3	14.8	18.3
SMALL	(19)	(44)	(55)**	(75)	(111)	(157)	(176)	(162)**
before planting	31.6	22.7	27.3	24.0	38.7	27.4	27.3	26.5
just after planting	10.5	22.7	25.5	33.3	16.2	17.8	23.3	14.2
germ.-1 month	31.6	34.1	32.7	32.0	32.4	41.4	33.0	35.8
over 1 month	26.3	20.5	14.5	10..7	12.6	13.4	16.5	23.5
MED.	(11)	(48)	(65)**	(83)	(88)	(103)	(109)	(73)**
before planting	45.5	54.2	49.2	44.6	54.5	35.0	39.4	52.1
just after planting	18.2	20.8	18.5	12.0	8.0	13.6	10.1	6.8
germ.-1 month	36.4	16.7	29.2	33.7	30.7	40.8	34.9	24.7
over 1 month	--	8.3	3.1	9.6	6.8	10.7	15.6	16.4
CLOSE	(17)	(54)	(75)	(105)	(133)	(175)	(184)	(116)**
before planting	47.1	51.9	41.3	39.0	48.9	32.0	34.2	39.8
just after planting	5.9	7.4	17.3	16.2	9.8	16.6	16.3	11.9
germ.-1 month	35.3	29.6	33.3	33.3	28.6	38.9	31.0	27.8
over 1 month	11.8	11.1	8.0	11.4	12.8	12.6	18.5	20.5
REMOTE	(13)	(38)	(45)	(53)	(66)	(85)	(101)	(59)**
before planting	23.1	21.1	35,6	26.4	39.4	27.1	27.7	18.6
just after planting	23.1	42.1	28.9	34.0	18.2	15.3	21.8	11.9
germ.-1 month	30.8	18.4	26.7	32.1	37.9	45.9	38.6	45.8
over 1 month	23.1	18.4	8.9	7.5	4.5	11.8	11.9	23.7
REGION I	(2)	(6)***	(12)**	(10)*	(14)*	(24)**	(25)	(11)
before planting		33.3	50.0	20.0	21.4	25.0	36.0	9.1
just after planting				40.0	21.4	25.0	12.0	27.3
germ.-1 month	50.0	33.3	16.7	--	42.9	16.7	28.0	27.3
over 1 month	50.0	33.3	33.3	40.0	14.3	33.3	24.0	36.4
REGION II	(21)	(70)***	(83)**	(116)*	(149)*	(168)**	(197)	(156)
before planting	47.6	48.6	45.8	40.5	51.0	35.7	36.0	36.5
just after planting	9.5	22.9	21.7	18.1	10.7	15.5	15.7	7.7
germ.-1 month	38.1	24.3	30.1	36.2	31.5	41.7	35.5	38.5
over 1 month	4.8	4.3	2.4	5.2	6.7	7.1	12.7	17.3
REGION III	(7)	(16)***	(25)**	(32)*	(36)*	(68)**	(63)	(68)
before planting	14.3	--	12.0	18.8	33.3	19.1	17.5	33.8
just after planting	28.6	25.0	32.0	31.3	16.7	14.7	28.6	19.1
germ.-1 month	14.3	25.0	40.0	31.3	27.8	48.5	30.2	19.1
over 1 month	42.9	50.0	16.0	18.8	22.2	17.6	23.8	27.9

* $p < .05$
** $p < .01$
*** $p < .001$

Table 52: Farmers unable to obtain preferred maize seed variety

(percent; n in parentheses)

	85	86	87	88	89	90	91	Avg.
Region I	0	13	0	17	20	22	23	14
	(5)	(8)	(7)	(12)	(15)	(23)	(26)	
Region II	24	15	17	14	18	14	22	18
	(46)	(59)	(69)	(90)	(108)	(126)	(129)	
Region III	20	40	40	43	38	29	31	34
	(10)	(15)	(20)	(23)	(34)	(35)	(39)	

APPENDIX 6

APPENDIX 6

ZAMSEED MAIZE SEED SALES BY PROVINCE AND VARIETY, 1981-91

Table 53: Zamseed maize sales by province and variety, 1981-82[a]

(50 KG BAGS) (% OF SALES IN PARENTHESES)

PROVINCE	SR52	ZH1	GRAND TOTAL
SOUTHERN	39338 (95.0)	2276 (5.0)	41614 24.0
EASTERN	7159 (42.0)	10013 (58.0)	17172 (10.0)
LUSAKA	40970 (87.0)	6130 (13.0)	47100 (27.0)
NORTHERN	8300 (100.0)		8300 (5.0)
LUAPULA	2330 (100.0)		2330 (1.0)
COPPERBELT	3884 (100.0)		3884 (2.0)
WESTERN	1897 (87.0)	278 (13.0)	2175 (1.0)
CENTRAL	36426 (80.0)	9195 (20.0)	45621 (26.0)
NORTHWEST	4911 (100.0)		4911 (3.0)
GRAND TOTAL	145215 (0.84)	27892 (16.0)	173107

[a] Source: Zambia Seed Company, Ltd.

Table 54: Zamseed maize sales by province and variety, 1982-83[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	SR52	ZH1	R215	GRAND TOTAL
SOUTHERN	41725 (87.0)	895 (2.0)	5300 (11.0)	47920 (31.0)
EASTERN	28188 (85.0)	955 (3.0)	4000 (12.0)	33143 (22.0)
LUSAKA	5249 (66.0)	739 (9.0)	1968 (25.0)	7956 (5.0)
NORTHERN	19960 (100.0)			19960 (13.0)
LUAPULA	1690 (100.0)			1690 (1.0)
COPPERBELT	3822 (85.0)	700 (15.0)		4522 (3.0)
WESTERN	2208 (82.0)		500 (18.0)	2708 (2.0)
CENTRAL	25281 (84.0)	3076 (10.0)	1800 (6.0)	30156 (20.0)
NORTHWEST	2636 (93.0)	200 (7.0)		2836 (2.0)
GRAND TOTAL	132720 (87.0)	6564 (4.0)	13568 (9.0)	152852
FINAL SALES TOTAL				167008

[a] Source: Zambia Seed Company, Ltd.

Table 55: Zamseed maize sales by province and variety, 1984-85[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	SR52	ZH1	MM752	CG4141	PNR473	OTHER	GRAND TOTAL
SOUTHERN	13980 (40.0)		801 (2.0)	15096 (43.0)	5119 (15.0)	1 (0.0)	34997 (21.0)
EASTERN	52429 (95.0)		1290 (2.0)		1390 (3.0)		55109 (33.0)
LUSAKA	10377 (62.0)	192 (1.0)	958 (6.0)	2406 (14.0)	2529 (15.0)	341 (2.0)	16803 (10.0)
NORTHERN	16200 (98.0)		350 (2.0)				16550 (10.0)
LUAPULA	2180 (99.0)		30 (1.0)				2210 (1.0)
COPPERBELT			154 (100)				154 (0.0)
WESTERN	1940 (68.0)		30 (1.0)	500 (17.0)	400 (14.0)		2870 (2.0)
CENTRAL	24651 (83.0)	772 (3.0)	2047 (7.0)	2298 (8.0)			29768 (18.0)
NORTHWEST	3256 (94.0)		110 (3.0)		115 (3.0)		3481 (2.0)
STOCKISTS	2303 (73.0)		154 (5.0)	358 (11.0)	341 (11.0)		3156 (2.0)
GRAND TOTAL	127316 (77.0)	965 (1.0)	5924 (4.0)	20657 (13.0)	9893 (6.0)	342 (0.0)	165097
FINAL SALES TOTAL							137793

[a] Source: Zambia Seed Company, Ltd. Detailed sales information was not available for 1982-83.

Note: MM752 was released in 1983 and sold through Zamseed beginning in the 1984-85 season. However, no sales data for MM752 is available in the records. Data for SR52 and MM752 sales may have been mixed for this season.

Table 56: Zamseed maize sales by province and variety, 1985-86[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	SR52	ZH1	CG4141	OTHER	MM752	MM501	MM502
SOUTHERN	235 (1.0)		20 (0.0)	70 (0.0)	14780 (56.0)	53 (0.0)	20 (0.0)
EASTERN	7011 (21.0)				22446 (66.0)		
LUSAKA	3550 (17.0)	391 (2.0)	87 (0.0)	357 (2.0)	10637 (51.0)	8 (0.0)	139 (1.0)
NORTHERN	490 (2.0)				13284 (63.0)		
LUAPULA							
COPPERBELT	793 (17.0)	1 (0.0)			3971 (83.0)		
WESTERN				110 (2.0)	1101 (23.0)	115 (2.0)	99 (2.0)
CENTRAL	234 (1.0)	20 (0.0)		523 (2.0)	25257 (79.0)		
NORTHWEST	970 (52.0)				92 (5.0)		
GRAND TOTAL	13283 (9.0)	412 (0.0)	107 (0.0)	1060 (1.0)	91568 (62.0)	176 (0.0)	258 (0.0)

Table 56: Zamseed maize sales by province and variety, 1985-86[a] (con't)

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM504	MM601	MM603	MM604	MMV400	MMV600	GRAND TOTAL
SOUTHERN	444 (2.0)	1397 (5.0)	5667 (21.0)	3303 (12.0)	507 (2.0)		26496 (18.0)
EASTERN	4 (0.0)	40 (0.0)	2268 (7.0)	2123 (6.0)			33892 (23.0)
LUSAKA	771 (4.0)	3069 (15.0)	1661 (8.0)	110 (1.0)	69 (0.0)	14 (0.0)	20863 (14.0)
NORTHERN				7292 (35.0)			21066 (14.0)
LUAPULA			46 (4.0)	660 (62.0)		365 (34.0)	1071 (1.0)
COPPERBELT	10 (0.0)		10 (0.0)				4785 (3.0)
WESTERN	630 (13.0)		2255 (47.0)	500 (10.0)			4810 (3.0)
CENTRAL	370 (1.0)	144 (0.0)	1634 (5.0)	3757 (12.0)			31939 (22.0)
NORTHWEST			2 (0.0)		1 (0.0)	800 (43.0)	1865 (1.0)
GRAND TOTAL	2229 (2.0)	4650 (3.0)	13543 (9.0)	17745 (12.0)	577 (0.0)	1179 (1.0)	146787
FINAL SALES TOTAL							146091

[a] Source: Zambia Seed Company, Ltd.

Table 57: Zamseed maize sales by province and variety, 1986-87[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	SR52	ZH1	CG4141	OTHER	MM752	MM501	MM502
SOUTHERN	30 (0.0)				4035 (9.0)	1 (0.0)	1548 (4.0)
EASTERN	163.2 (1.0)				462 (2.0)		
LUSAKA	1843 (6.0)	194 (1.0)	12 (0.0)		6434 (22.0)	10 (0.0)	209 (1.0)
NORTHERN					4553 (31.0)		
LUAPULA	4 (0.0)				44 (1.0)		
COPPERBELT	3 (0.0)				2488 (29.0)		
WESTERN					200 (3.0)		
CENTRAL					8181 (21.0)		70 (0.0)
NORTHWEST					317 (13.0)		
OTHER	1231 (2.0)				2337 (37.0)		
SERIOES					2170 (51.0)		5 (0.0)
GRAND TOTAL	3275 (2.0)	194 (0.0)	12 (0.0)		31221 (18.0)	11 (0.0)	1832 (1.0)

Table 57: Zamseed maize sales by province and variety, 1986-87[a] (con't)

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM504	MM601	MM603	MM604	MMV400	MMV600	GRAND TOTAL
SOUTHERN	9146 (21.0)	2278 (6.0)	14120 (33.0)	9693 (23.0)	1913 (4.0)	307 (1.0)	43071 (24.0)
EASTERN			6727 (31.0)	14286 (66.0)		59 (0.0)	21697 (12.0)
LUSAKA	2157 (8.0)	2046 (7.0)	9268 (32.0)	2894 (10.0)	495 (2.0)	3078 (11.0)	28640 (16.0)
NORTHERN			110 (1.0)	6450 (44.0)		3602 (24.0)	14715 (8.0)
LUAPULA		10 (0.0)	1685 (57.0)	8 (0.0)		1222 (41.0)	2973 (2.0)
COPPERBELT	310 (4.0)	485 (6.0)	3107 (36.0)	1838 (21.0)	15 (0.0)	394 (5.0)	8641 (5.0)
WESTERN	1822 (3.0)		3013 (50.0)	100 (2.0)	872 (15.0)		6006 (3.0)
CENTRAL	8111.2 (21.0)	881 (2.0)	5609 (14.0)	13484 (34.0)		2822 (7.0)	39157 (22.0)
NORTHWEST			316 (13.0)	80 (3.0)		1644 (70.0)	2357 (1.0)
OTHER			579 (9.0)	1926 (31.0)			6254 (4.0)
SERIOES		601 (14.0)	890 (21.0)	600 (14.0)		180 (3.0)	4266 (2.0)
GRAND TOTAL	21546 (12.0)	6301 (4.0)	45424 (26.0)	51358 (29.0)	3295 (2.0)	13309 (7.0)	177779
FINAL SALES TOTAL							177386

[a] Source: Zambia Seed Company, Ltd.

Table 58: Zamseed maize sales by province and variety, 1987-88[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM752	MM601	MM603	MM604	MM502	MM504	R215	R201	ZS225	GRAND TOTAL
SOUTHERN	2015 (5.0)	431 (1.0)	2241 (5.0)		272 (1.0)	33 (0.0)	21479 (48.0)	17272 (39.0)	880 (2.0)	44623 (24.0)
EASTERN	4022 (13.0)		1 (0.0)	18403 (59.0)	400 (1.0)		3949 (13.0)		4600 (15.0)	31375 (17.0)
LUSAKA	375 (3.0)	125 (1.0)	2883 (22.0)	214 (2.0)	60 (0.0)		4607 (35.0)	1976 (15.0)	2790 (21.0)	13030 (7.0)
NORTHERN	4952 (22.0)	2 (0.0)	11277 (49.0)	1407 (6.0)			5256 (23.0)		14 (0.0)	22908 (12.0)
LUAPULA	450 (10.0)	25 (1.0)	2400 (54.0)				1600 (36.0)			4475 (2.0)
COPPERBELT	2378 (24.0)	1263 (13.0)	770 (8.0)	4 (0.0)			5118 (51.0)	1 (0.0)	443 (4.0)	9977 (5.0)
WESTERN	500 (5.0)		5868 (58.0)				1900 (19.0)	1900 (19.0)		10168 (5.0)
CENTRAL	7481 (19.0)	240 (1.0)	5016 (12.0)	184 (0.0)		5 (0.0)	15041 (37.0)	7073 (18.0)	5141 (13.0)	40181 (21.0)
NORTHWEST	1076 (35.0)		181 (6.0)				1740 (57.0)	60 (0.02)		3057 (2.0)
RETAIL	1788 (19.0)	912 (10.0)	925 (10.0)	132 (1.0)	276 (3.0)		3176 (34.0)	1378 (15.0)	658 (7.0)	9245 (5.0)
GRAND TOTAL	25037 (13.0)	2998 (2.0)	31562 (17.0)	20344 (11.0)	1008 (1.0)	38 (0.0)	63866 (34.0)	29660 (16.0)	14526 (8.0)	189039
FINAL SALES TOTAL										208088

[a] Source: Zambia Seed Company, Ltd.

Table 59: Zamseed maize sales by province and variety, 1988-89[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM752 MM612	MM601 MM502 MM501	MM603 MM604	R201 R215	MMV400	MMV600	MM504	ZS206	GRAND TOTAL
SOUTHERN	2508 (6.0)	611 (1.0)	13697 (32.0)	19631 (46.0)	3666 (8.0)	3222 (7.0)			43335 (16.0)
EASTERN	8912 (24.0)		27947 (75.0)		400 (1.0)				37259 (14.0)
LUSAKA	1199 (9.0)		8479 (61.0)	3101 (22.0)	1000 (7.0)	200 (1.0)			13979 (5.0)
NORTHERN	6638 (21.0)		25287 (79.0)						31925 (12.0)
LUAPULA	516 (7.0)	57 (1.0)	4572 (64.0)			2020 (28.0)			7165 (3.0)
COPPERBELT	1042 (6.0)	3731 (22.0)	12439 (72.0)						17212 (6.0)
WESTERN			5530 (68.0)		1440 (18.0)		1200 (15.0)		8170 (3.0)
CENTRAL	16634 (29.0)	5030 (9.0)	10323 (18.0)	21127 (37.0)		2228 (4.0)	1785 (3.0)	298 (1.0)	57425 (21.0)
NORTHWEST	2363 (32.0)		1400 (19.0)			3593 (49.0)			7356 (3.0)
OTHER									31264 (12.0)
RETAIL									15765 (6.0)
GRAND TOTAL	39812 (15.0)	9429 (4.0)	109674 (41.0)	43859 (16.0)	6106 (2.0)	11663 (4.0)	2985 (1.0)	298 (0.0)	270854
FINAL SALES TOTAL									272093

[a] Source: Zambia Seed Company, Ltd.

Table 60: Zamseed maize sales by province and variety, 1989-90[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM752	MM601	MM603	MM604	MM612	MM502	MM504
SOUTHERN	1320 (3.0)		16558 (38.0)				
EASTERN	4451 (13.0)		2310 (7.0)	23691 (67.0)			
LUSAKA	2320 (12.0)		3060 (16.0)	1820 (9.0)			1000 (5.0)
NORTHERN	3610 (11.0)		11504 (34.0)	12023 (36.0)	6511 (19.0)		
LUAPULA	700 (8.0)		6690 (73.0)	600 (7.0)			
COPPERBELT	3403 (37.0)	800 (9.0)	1989 (21.0)	3106 (33.0)			
WESTERN			5209 (37.0)	3451 (24.0)			600 (4.0)
CENTRAL	16406 (26.0)		9136 (14.0)	20291 (32.0)	2250 (4.0)	200 (0.0)	2972 (5.0)
NORTHWEST	3384 (41.0)		299 (4.0)		1700 (20.0)		
OTHER	1835 (7.0)	731 (3.0)	6974 (27.0)	2846 (11.0)	8 (0.0)	457 (2.0)	128 (1.0)
GRAND TOTAL	37429 (14.0)	1531 (1.0)	63729 (24.0)	67828 (26.0)	10469 (4.0)	657 (0.0)	4700 (2.0)

Table 60: Zamseed maize sales by province and variety, 1989-90[a] (con't)

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MMV400	MMV600	ZS206	R215	R201	GRAND TOTAL
SOUTHERN	2100 (5.0)			8208 (19.0)	15080 (35.0)	43266 (17.0)
EASTERN		810 (2.0)		2505 (7.0)	1470 (4.0)	35237 (13.0)
LUSAKA	400 (2.0)	600 (3.0)		8550 (43.0)	1950 (10.0)	19700 (8.0)
NORTHERN						33648 (13.0)
LUAPULA		1160 (13.0)				9150 (3.0)
COPPERBELT						9298 (4.0)
WESTERN				4840 (34.0)		14100 (5.0)
CENTRAL				10510 (17.0)	1540 (2.0)	63305 (24.0)
NORTHWEST	1 (0.0)	2910 (35.0)				8294 (3.0)
OTHER	96 (0.0)	1580 (6.0)	4189 (16.0)	6433 (25.0)	195 (1.0)	25472 (10.0)
GRAND TOTAL	2597 (1.0)	7060 (3.0)	4189 (2.0)	41046 (16.0)	20235 (8.0)	261470
FINAL SALES TOTAL						300000

[a] Source: Zambia Seed Company, Ltd. Detailed data for 1988 were not available.

Table 61: Zamseed maize sales by province and variety, 1990-91[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM752	MM601	MM603	MM604	MM612	MM502	MM504
SOUTHERN	1514 (3.0)	1257 (3.0)	16475 (38.0)	23082 (53.0)		177 (0.0)	22 (0.0)
EASTERN	15260 (38.0)		973 (2.0)	23755 (59.0)	1 (0.0)		
LUSAKA	2196 (9.0)	888 (4.0)	5644 (24.0)	4280 (18.0)	8 (0.0)	1013 (4.0)	8 (0.0)
NORTHERN			92 (15.0)	100 (17.0)	403 (68.0)		
LUAPULA	444 (9.0)		3200 (65.0)	496, (10.0)	700 (14.0)		
COPPERBELT	143 (4.0)	56 (1.0)	2173 (57.0)	1046 (27.0)			
WESTERN			5901 (88.0)	220 (3.0)			
CENTRAL	14884 (46.0)	175 (1.0)	2118 (7.0)	13634 (42.0)	245 (1.0)	10 (0.0)	
NORTHWEST	1 (2.0)		2 (4.0)	52 (85.0)	6 (9.0)		
GRAND TOTAL	34442 (22.0)	2377 (2.0)	36580 (23.0)	66665 (43.0)	1363 (1.0)	1200 (1.0)	30 (0.0)

Table 61: Zamseed maize sales by province and variety, 1990-91[a] (con't)

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MMV400	MMV600	ZS206	R215	R201	ZS225	GRAND TOTAL
SOUTHERN	386 (1.0)	13 (0.0)	379 (1.0)	383 (1.0)	158 (0.0)		43847 (28.0)
EASTERN	0.8 (0.0)	41.8 (0.0)		40 (0.0)			40072 (26.0)
LUSAKA	326 (1.0)	5614 (24.0)	2635 (11.0)	643 (3.0)	24 (0.0)	121 (1.0)	23401 (15.0)
NORTHERN							595 (0.0)
LUAPULA			100 (2.0)				4940 (3.0)
COPPERBELT	5 (0.0)		420 (11.0)		5 (0.0)		3845 (2.0)
WESTERN	560 (8.0)						6681 (4.0)
CENTRAL			1100 (3.0)	56 (0.0)			32221 (21.0)
NORTHWEST							61.2 (0.0)
GRAND TOTAL	1274 (1.0)	5669 (4.0)	4634 (3.0)	1123 (1.0)	187 (0.0)	121 (0.0)	155662
FINAL SALES TOTAL							143633

[a] Source: Zambia Seed Company, Ltd.

Table 62: Zamseed maize sales by province and variety, 1991-92[a]

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MM752	MM601	MM603	MM604	MM612	MM501	MM502	MM504
SOUTHERN	987 (2.0)	1407 (3.0)	12076 (26.0)	26805 (58.0)		20 (0.0)	69 (0.0)	610 (1.0)
EASTERN	1198 (4.0)	4600 (14.0)	14000 (43.0)	9000 (27.0)			2800 (9.0)	
LUSAKA	692 (5.0)	174 (1.0)	6804 (54.0)	2641 (21.0)				20 (0.0)
NORTHERN	2139 (20.0)		1806 (17.0)	1608 (15.0)	4890 (47.0)			
LUAPULA	7 (0.0)		1114 (52.0)	4 (0.0)	1000 (47.0)			
COPPERBELT	1515 (21.0)	208 (3.0)	3167 (43.0)	2001 (27.0)	4 (0.0)			
WESTERN		4 (0.0)	1965 (73.0)	530 (20.0)				
CENTRAL	949 (4.0)	408 (2.0)	8032 (32.0)	10103 (40.0)	3816 (15.0)			
NORTHWEST	150 (8.0)		700 (37.0)	250 (13.0)	200 (11.0)			
RETAIL	202 (4.0)	80 (2.0)	1867 (38.0)	2051 (42.0)	680 (14.0)			
GRAND TOTAL	7839 (5.0)	6881 (5.0)	51531 (35.0)	54993 (38.0)	10590 (7.0)	20 (0.0)	2869 (2.0)	630 (0.0)

[a] Source: Zambia Seed Company, Ltd.

Table 62: Zamseed maize sales by province and variety, 1991-92[a] (con't)

(50 KG BAGS)(% OF SALES IN PARENTHESES)

PROVINCE	MMV400	MMV600	ZS206	R215	R201	ZS225	BULK	GRAND TOTAL
SOUTHERN	1695 (4.0)		391 (1.0)	1787 (4.0)	289 (1.0)			46136 (32.0)
EASTERN	11 (0.0)	11 (0.0)					1148 (4.0)	32768 (22.0)
LUSAKA	379 (3.0)	366 (3.0)	1125 (9.0)	373 (3.0)	54 (0.0)			12628 (9.0)
NORTHERN								10443 (7.0)
LUAPULA								2125 (1.0)
COPPERBELT		13 (0.0)	377 (5.0)					7285 (5.0)
WESTERN	204 (8.0)							2703 (2.0)
CENTRAL	19 (0.0)		1965 (8.0)	57 (0.0)				25350 (17.0)
NORTHWEST		584 (31.0)						1884 (1.0)
RETAIL								4879 (3.0)
GRAND TOTAL	2308 (2.0)	974 (1.0)	3858 (3.0)	2217 (2.0)	343 (0.0)		1148 (1.0)	146200
FINAL SALES TOTAL								199864

[a] Source: Zambia Seed Company, Ltd.

APPENDIX 7

APPENDIX 7

PRODUCTION COSTS

Table 63: Production costs per hectare (financial), small/medium farmer, local varieties, no oxen, without fertilizer[a,b]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield,tons[c]	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	.64	1.36	1.22	1.02	1.20	0.20	1.12	1.12
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal Fertilizer (Compound D), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top Dressing (Am. Nitrate), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor,78 person-days[d]	45.2	45.2	45.2	45.2	45.2	56.1	95.16	276.12	685.62	499.98	780.00	1170.0	1560.0	5578.38	11700.0	11700.0
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[e]	3.02	2.04	3.64	3.2	4.51	4.7	11.02	38.86	44.94	70.06	71.25	192.01	159.70	112.91	1243.29	1243.29
Total Variable Cost	48.2	47.2	48.8	48.4	49.7	60.8	106.18	314.98	730.56	570.04	851.25	1362.01	1719.70	5691.29	12943.2	12943.2
Maize price, ZK/ton	100	130	150	177	203	272	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000.0
Value of production	65.4	57.3	118.	123.	198.	220.	354.6	837.9	553.2	1211.8	1696.4	3210.0	6654.2	6566.0	44758.4	44758.4
Net margin	17.1	10.0	69.3	74.3	148.	160.	248.4	522.9	-177.4	641.7	845.1	1847.9	4934.5	874.7	31815.1	31815.1
Break-even yield (tons)	.48	.36	.33	.27	.24	.22	.34	.52	.84	.64	.61	.43	.31	.17	.32	.32
NM return on var.cost (%)	35.5	21.3	141	154	299	263	233.9	166.0	-24.28	112.58	99.28	135.7	286.9	15.37	245.8	245.8
NM return to labor, ZK/day	.80	.71	1.47	1.54	2.49	2.77	4.40	10.24	6.52	14.64	20.84	38.69	83.26	82.73	557.89	557.89

[a] Based on estimates of variable costs/ha for emergent (<10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.
[b] Assumes that no fertilizer or pesticides are used on local varieties.
[c] See Table 98.

[d] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (see Table 94) for each year. The labor requirement for non-oxen users is estimated at 89 days (ARPT, undated); adjusted downwards since farmers do no apply fertilizer.

[e] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 64: Production costs per hectare (economic), small/medium farmer, local varieties, no oxen, without fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22	1.02	1.20	0.20	1.12	1.12
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top Dressing (Am. Nitrate), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 78 person-days	45.24	45.24	45.24	45.24	45.24	56.16	95.16	276.12	685.62	499.98	780.00	1170.00	1560.00	5578.38	11700	11700
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[a]	9.56	6.51	11.69	10.52	15.54	12.25	24.55	44.21	35.25	89.10	110.36	270.10	306.36	195.64	2321.68	2321.6
Total Variable Cost	54.80	51.75	56.93	55.76	60.78	68.41	119.71	320.33	720.87	589.08	890.36	1440.10	1866.36	5774.02	14021.6	14021

[a] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 65: Production costs per hectare (financial), small/medium farmer, local varieties, no oxen, with fertilizer[a,b]

YEAR	78/9	79/ 80	80/ 81	81/ 82	82/ 83	83/ 84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield,tons[c]	1.01	.68	1.21	1.07	1.5	1.25	1.73	2.11	.98	2.10	1.88	1.56	1.84	.30	1.72	1.72
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal Fertilizer (Compound D), 100 kg	23.5	23.5	23.5	23.5	29.9	48.2	53.50	53.50	160.00	160.00	196.54	792.00	1134.00	1600.00	2939.61	2939.6
Top Dressing (Am. Nitrate), 100 kg	20.2	20.2	20.2	20.2	28.2	46.4	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.00	2939.61	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor,89 person-days[d]	51.6	51.6	51.6	51.6	51.6	64.1	108.58	315.06	782.31	570.49	890.00	1335.00	1780.00	6365.08	13350.0	13350.
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[e]	4.65	3.13	5.6	4.93	6.94	7.23	16.95	59.77	69.12	107.75	109.59	295.32	245.63	173.66	1912.27	1912.27
Total Variable Cost	99.9	98.4	101	100	117	165.	230.73	480.03	1123.43	950.24	1324.13	3188.32	4027.63	9738.73	21141.4	21141.4
Maize price, ZK/ton	100	130	150	178	203	272	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000.0
Value of production	101	88.2	182	190	306	339	545.4	1288.8	850.8	1863.8	2609.2	4937.1	10234.7	10099.0	68841.6	68841.6
Net margin	.67	-10.2	80.9	89.4	180	173.	314.6	808.7	-272.6	913.6	1285.0	1748.8	6207.0	320.3	47700.1	47700.1
Break-even yield (tons)	1.0	.76	.67	.56	.57	.61	.73	.79	1.3	1.07	.95	1.01	.72	.29	.53	.53
NM return on var.cost (%)	.67	-10.3	80.2	89.2	162	104.	136.4	168.5	-24.3	96.14	97.1	54.9	154.1	3.7	225.6	225.6
NM return to labor, ZK/day	.59	.47	1.5	1.6	2.7	2.7	4.8	12.6	5.7	16.7	24.4	34.7	89.7	75.6	686.0	686.0

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.
[b] Assumes that no fertilizer or pesticides are used on local varieties.
[c] See Table 98.

[d] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (see Table 94) for each year. The labor requirement for non-oxen users is estimated at 89 days (ARPT, undated).

[e] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 66: Production costs per hectare (economic), small/medium farmer, local varieties, no oxen, with fertilizer

YEAR	78/ 79	79/ 80	80/ 81	81/ 82	82/ 83	83/ 84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons	1.01	0.68	1.21	1.07	1.50	1.25	1.73	2.11	0.98	2.10	1.88	1.56	1.84	0.30	1.72	1.72
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	23.5	23.5	23.5	23.5	29.9	48.2	53.50	53.50	160.00	160.00	196.54	792.00	1134.00	1600.00	2939.61	2939.6
Top Dressing (Am. Nitrate), 100 kg	20.1	20.1	20.1	20.1	28.1	46.4	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.00	2939.61	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days	51.6	51.6	51.6	51.6	51.6	64.0	108.58	315.06	782.31	570.49	890.00	1335.00	1780.00	6365.08	13350.0	13350
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[a]	14.7	10.0	17.9	16.1	23.9	18.8	37.75	68.0	54.22	137.05	169.75	415.43	471.20	300.91	3570.90	3570.90
Total Variable Cost	182	177	188	200	221	250	353.26	637.36	1157.83	1117.69	1732.63	3164.08	6150.32	13520.9	30438.6	30438.6

[a] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 67: Production costs per hectare (financial), small/medium farmer, local varieties, oxen, no fertilizer[a,b]

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons[c]	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22	1.02	1.20	0.20	1.12	1.12
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top Dressing (Am. Nitrate), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 52 person-days[d]	30.2	30.2	30.2	30.2	30.2	37.4	63.44	184.08	457.08	333.32	520.00	780.00	1040.00	3718.92	7800.00	7800.00
Oxen hire/ha	10.7	10.7	10.7	10.7	10.7	13.4	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[e]	3.02	2.04	3.64	3.20	4.51	4.70	11.02	38.86	44.94	70.06	71.25	192.01	159.70	112.91	1243.29	1243.29
Total Variable Cost	43.8	42.9	44.5	44.0	45.3	55.5	97.03	288.36	664.52	521.98	791.25	1422.01	1836.94	4381.83	10543.3	10543.3
Maize price, ZK/ton	100	130	150	178	203	272	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000.0
Value of production	65.4	57.4	118	123	199	221	354.6	837.9	553.2	1211.8	1696.4	3210.0	6654.23	6566.0	44758.4	44758.4
Net margin	21.6	14.5	73.7	79.3	153	165	257.6	549.6	-111.3	689.8	905.1	1787.9	4817.3	2184.2	34215.1	34215.1
Break-even yield (tons)	.44	.33	.30	.25	.22	.20	.31	.47	.77	.59	.57	.45	.33	.13	.26	.26
NM return on var.cost (%)	49.2	33.9	166	180	338	297	265.4	190.6	-16.8	132.2	114.4	125.7	262.2	49.9	324.5	324.5
NM return to labor, ZK/day	.99	.86	2.0	2.1	3.53	3.9	6.17	14.11	6.65	19.68	27.41	49.38	112.64	113.52	807.98	807.98

[a] Based on estimates of variable costs/ha for emergent (<10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] Assumes that no fertilizer, pesticides are used on local varieties.

[c] See Table 98.

[d] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for oxen/fertilizer users is estimated at 61 person-days(ARPT,undated);adjusted downwards since farmers do not apply fertilizer.

[e] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season.

Table 68: Production costs per hectare (economic), small/medium farmer, local varieties, oxen, no fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22	1.02	1.20	0.20	1.12	1.12
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top Dressing (Am. Nitrate), 100 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 52 person-days	30.2	30.2	30.2	30.2	30.2	37.4	63.44	184.08	457.08	333.32	520.00	780.00	1040.00	3718.92	7800.00	7800.00
Oxen hire/ha	10.7	10.7	10.7	10.7	10.7	13.4	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[a]	9.56	6.51	11.7	10.5	15.5	12.3	24.55	44.21	35.25	89.10	110.36	270.10	306.36	195.64	2321.68	2321.68
Total Variable Cost	50.4	47.3	52.5	51.3	56.4	63.1	110.56	293.71	654.83	541.03	830.36	1500.10	1983.61	4464.56	11621.7	11621.7

[a] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 69: Production costs per hectare (financial), small/medium farmer, local varieties, oxen, with fertilizer[a,b]

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons[c]	1.01	.68	1.21	1.07	1.5	1.25	1.73	2.11	.98	2.10	1.88	1.56	1.84	.30	1.72	1.72
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	23.5	23.5	23.5	23.5	29.9	48.2	53.50	53.50	160.00	160.00	196.54	792.00	1134.00	1600.00	2939.61	2939.6
Top Dressing (Am. Nitrate), 100 kg	20.2	20.2	20.2	20.2	28.2	46.4	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.00	2939.61	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days[d]	35.4	35.4	35.4	35.4	35.4	43.9	74.42	215.94	536.19	391.01	610.00	915.00	1220.00	4362.58	9150.00	9150.00
Oxen hire/ha	10.7	10.7	10.7	10.7	10.7	13.4	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[e]	4.65	3.13	5.6	4.93	6.94	7.23	16.95	59.77	69.12	107.75	109.59	295.32	245.63	173.66	19112.3	1912.27
Total Variable Cost	94.3	92.8	95.3	94.6	111	159	219.14	446.33	1039.81	889.37	1244.13	3218.32	4104.87	8286.24	18441.5	18441.5
Maize price, ZK/ton	100	130	150	178	203	272	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000.0
Value of production	101	88.2	182	190	306	340	545.4	1288.8	850.8	1863.8	2609.2	4937.1	10234.7	10099.0	68841.6	68841.6
Net margin	6.25	-4.6	86.5	95	194	181	326.53	842.43	-189.0	974.4	1365.0	1718.8	6129.8	1812.8	50400.1	50400.1
Break-even yield (tons)	.94	.71	.64	.53	.55	.58	.70	.73	1.20	1.00	.90	1.02	.74	.25	.46	.46
NM return on var.cost (%)	6.63	-4.96	90.8	100	175	114	148.9	188.7	-18.2	109.56	109.72	53.41	149.33	21.88	273.3	273.3
NM return to labor, ZK/day	.68	.50	2.0	2.14	3.77	3.68	6.57	17.35	5.69	22.38	32.38	43.18	120.49	101.23	976.23	976.23

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] Assumes that no fertilizer, pesticides are used on local varieties.

[c] See Table 98.

[d] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for oxen users is estimated at 61 person-days(ARPT,undated).

[e] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season.

Table 70: Production costs per hectare (economic), small/medium farmer, local varieties, oxen, with fertilizer

YEAR	78/ 79	79/ 80	80/ 81	81/ 82	82/ 83	83/ 84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94- 2001
Estimated yield, tons	1.01	.68	1.21	1.07	1.5	1.25	1.73	2.11	.98	2.10	1.88	1.56	1.84	.30	1.72	1.72
VARIABLE COSTS																
Seed, 17 kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basal fertilizer (Compound D), 100 kg	23.5	23.5	23.5	23.5	29.9	48.2	53.50	53.50	160.00	160.00	196.54	792.00	1134.00	1600.00	2939.61	2939.6
Top Dressing (Am. Nitrate), 100 kg	20.2	20.2	20.2	20.2	28.2	46.4	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.00	2939.61	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days	35.4	35.4	35.4	35.4	35.4	43.9	74.42	215.94	536.19	391.01	610.00	915.00	1220.00	4362.58	9150.00	9150.00
Oxen hire/ha	10.7	10.7	10.7	10.7	10.7	13.4	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing [a]	14.7	10.0	18	16.2	23.9	18.8	37.75	68.0	54.22	137.05	169.75	415.43	471.20	300.91	3570.90	3570.90
Total Variable Cost	177	172	183	194	216	243	341.67	603.65	1074.21	1056.82	1652.63	3194.08	6227.56	12068.4	27738.6	27738.6

[a] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 71: Production costs per hectare (financial), small/medium farmer, SR52 or non-Zambian hybrids, no oxen, with fertilizer[a]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, non-Zambian hybrids[b]	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
Estimated yield, tons, SR-52[b]	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13	1.77	2.08	0.34	1.94	1.94
VARIABLE COSTS																
Seed, 17 kg[c]	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.5	2015.5
Basal fertilizer (Compound D), 100 kg[d]	23.50	23.50	23.50	23.50	29.90	48.20	53.50	53.50	160.00	160.00	196.54	792.00	1134.0	1600.0	2939.6	2939.6
Top Dressing (Am. Nitrate), 100 kg[d]	20.16	20.16	20.16	20.16	28.16	46.40	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.0	2939.6	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days[e]	51.62	51.62	51.62	51.62	51.62	64.08	108.58	315.06	782.31	570.49	890.00	1335.0	1780.0	6365.1	13350.	13350.
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[f]	5.75	3.86	6.95	6.10	8.64	8.98	21.08	74.40	85.90	133.61	136.50	367.39	304.67	214.92	2366.6	2366.7
Total Variable Cost	111.61	109.71	112.81	111.95	128.89	180.94	260.70	522.54	1183.0	1038.3	1459.1	3462.0	4464.0	10526.	23611.	23611.
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.	40000.	40000
Value of production	124.5	108.6	225.8	234.7	380.2	421.9	678.1	1604.2	1057.3	2311.1	3250.0	6141.9	12694.	12498.	85200.	85200
Net margin	12.89	-1.16	112.94	122.72	251.33	241.00	417.42	1081.6	-125.71	1272.8	1790.8	2679.9	8230.4	1972.1	61588.	61588
Break-even yield (tons)	1.12	.84	.75	.63	.63	.66	.83	.86	1.37	1.17	1.05	1.10	.80	.32	.59	.59
NM return on var.cost (%)	11.55	-1.06	100.12	109.61	194.99	133.20	160.12	206.99	-10.63	122.58	122.73	77.41	184.37	18.73	260.84	260.84
NM return to labor, ZK/day	.72	.57	1.85	1.96	3.40	3.43	5.91	15.69	7.38	20.71	30.12	45.11	112.48	93.68	842.01	842.01

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.
[b] See Table 98.
[c] Assumes that the cost of SR-52 and non-Zambian hybrid seed is approximately equivalent to the cost of MM752
[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated

[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for hybrid/non-oxenusers is estimated at 89 days/ha (ARPT,undated).

[f] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 72: Production costs per hectare (economic), small/medium farmer, SR52, no oxen, with fertilizer

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, SR-52	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13	1.77	2.08	0.34	1.94	1.94
VARIABLE COSTS																
Seed, 17 kg	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.5	2015.52
Basal fertilizer (Compound D), 100 kg[a]	65.18	65.10	66.89	74.54	82.18	94.87	117.19	143.30	182.18	230.86	377.42	785.82	2174.4	3845.1	7581.7	7581.69
Top Dressing (Am. Nitrate), 100 kg[a]	50.649	50.618	51.94	57.69	63.45	72.44	89.74	110.99	139.12	179.29	295.47	627.83	1724.7	3009.8	5936	5935.97
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days	51.62	51.62	51.62	51.62	51.62	64.08	108.58	315.06	782.31	570.49	890.00	1335.0	1780.0	6365.1	13350	13350.0
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[b]	16.51	11.20	20.33	18.20	27.04	21.28	42.69	77.07	61.31	154.91	192.46	470.31	532.02	337.65	4025.2	4025.21
Total Variable Cost	194.54	189.12	201.35	212.62	234.86	265.94	384.04	674.30	1207.8	1197.8	1863.5	3420.6	6588.5	14304	32908	32908.4

[a] See Table 96 for calculation of economic import parity price for fertilizer.
[b] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 73: Production costs per hectare (economic), small/medium farmer, non-Zambian hybrids, no oxen, with fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, non-Zambian hybrids	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed, 17 kg[a]	31.50	31.40	32.43	36.53	40.62	48.70	59.66	70.88	95.48	112.90	168.26	358.90	1122.6	1870.80	3683.12	3683.12
Basal fertilizer (Compound D), 100 kg[b]	65.18	65.10	66.89	74.54	82.18	94.87	117.19	143.30	182.18	230.86	377.42	785.82	2174.4	3845.09	7581.69	7581.69
Top Dressing (Am. Nitrate), 100 kg[b]	50.649	50.618	51.94	57.69	63.45	72.44	89.74	110.99	139.12	179.29	295.47	627.83	1724.7	3009.84	5935.97	5935.97
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days	51.62	51.62	51.62	51.62	51.62	64.08	108.58	315.06	782.31	570.49	890.00	1335.0	1780.0	6365.08	13350.00	13350.0
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[c]	19.88	13.42	24.33	21.84	32.44	25.51	51.19	92.22	73.46	184.97	230.41	563.30	636.88	407.17	4813.66	4813.66
Total Variable Cost	218.82	212.15	227.20	242.21	270.31	305.60	426.36	732.46	1272.5	1278.5	1961.6	3670.9	7438.6	15497.98	35364.43	35364.4

[a] See Table 97 for calculation of economic import parity price for imported seed.
[b] See Table 96 for calculation of economic import parity price for fertilizer.
[c] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 74: Production costs per hectare (financial), small/medium farmer, SR52 or non-Zambian varieties, oxen, with fertilizer[a]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94 -2001
Estimated yield, tons, non-Zambian hybrids[b]	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
Estimated yield, tons, SR-52[b]	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13	1.77	2.08	0.34	1.94	1.94
VARIABLE COSTS																
Seed, 17 kg[c]	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.52	2015.52
Basal fertilizer (Compound D), 100 kg[d]	23.50	23.50	23.50	23.50	29.90	48.20	53.50	53.50	160.00	160.00	196.54	792.00	1134.0	1600.00	2939.61	2939.61
Top Dressing (Am. Nitrate), 100 kg[d]	20.16	20.16	20.16	20.16	28.16	46.40	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.00	2939.61	2939.61
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days[e]	35.38	35.38	35.38	35.38	35.38	43.92	74.42	215.94	536.19	391.01	610.00	915.00	1220.0	4362.58	9150.00	9150.00
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[f]	5.75	3.86	6.95	6.10	8.64	8.98	21.08	74.40	85.90	133.61	136.50	367.39	304.67	214.92	2366.67	2366.67
Total Variable Cost	106.03	104.13	107.23	106.37	123.31	174.15	249.11	488.84	1099.4	977.45	1379.2	3492.0	4541.3	9074.14	20911.4	20911.4
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000
Value of production	124.5	108.6	225.8	234.7	380.2	421.9	678.1	1604.2	1057.3	2311.1	3250.0	6141.9	12695.	12498.8	85200.0	85200
Net margin	18.47	4.42	118.52	128.30	256.91	247.79	429.01	1115.3	-42.09	1333.7	1870.8	2649.9	8153.2	3424.6	64288.6	64288.6
Break-even yield (tons)	1.06	.80	.71	.60	.61	.64	.79	.80	1.27	1.10	.99	1.11	.82	.27	.52	.52
NM return on var.cost (%)	17.42	4.24	110.53	120.61	208.34	142.28	172.22	228.16	-3.83	136.44	135.65	75.88	179.53	37.74	307.43	307.43
NM return to labor, ZK/day	.88	.65	2.52	2.68	4.79	4.78	8.25	21.82	8.10	28.27	40.67	58.44	153.66	127.66	1203.91	1203.91

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] See Table 98.
[c] Assumes that the cost of SR-52 and non-Zambian hybrid seed is approximately equivalent to the cost of MM752
[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated
[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for hybrid/oxenusers is estimated at 61 person-days/ha.
[f] Based on per-bag costs reported for 1988, 1989, 1990, 1992 [g] estimated yield for that season

Table 75: Production costs per hectare (economic), small/medium farmer, SR52, oxen, with fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, SR-52	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13	1.77	2.08	0.34	1.94	1.94
VARIABLE COSTS																
Seed, 17 kg	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.52	2015.52
Basal fertilizer (Compound D), 100 kg[a]	65.18	65.10	66.89	74.54	82.18	94.87	117.19	143.30	182.18	230.86	377.42	785.82	2174.4	3845.09	7581.69	7581.69
Top Dressing (Am. Nitrate), 100 kg[a]	50.649	50.618	51.94	57.69	63.45	72.44	89.74	110.99	139.12	179.29	295.47	627.83	1724.7	3009.84	5935.97	5935.97
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days	35.38	35.38	35.38	35.38	35.38	43.92	74.42	215.94	536.19	391.01	610.00	91 5.00	1220.0	4362.58	9150.00	9150.0
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[b]	16.51	11.20	20.33	18.20	27.04	21.28	42.69	77.07	61.31	154.91	192.46	470.31	532.02	337.65	4025.21	4025.21
Total Variable Cost	188.96	183.54	195.77	207.04	229.28	259.16	372.45	640.60	1124.1	1136.9	1783.5	3450.6	6665.8	12851.8	30208.4	30208.4

[a] See Table 96 for calculation of economic import parity price for fertilizer.

[b] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 76: Production costs per hectare (financial), small/medium farmer, SR52 or non-Zambian varieties, oxen, no fertilizer[a]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94 -2001
Estimated yield, tons, non-Zambian hybrids[b]	.78	.52	.94	.82	1.16	.96	1.34	1.63	.76	1.62	1.46	1.21	1.42	.38	1.32	1.32
Estimated yield, tons, SR-52[b]	.71	.48	.86	.75	1.06	.88	1.23	1.49	.69	1.48	1.33	1.11	1.30	.34	1.21	1.21
VARIABLE COSTS																
Seed, 17 kg[c]	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.52	2015.52
Basal fertilizer (Compound D), 100 kg[d]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Top Dressing (Am. Nitrate), 100 kg[d]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 52 person-days[e]	30.16	30.16	30.16	30.16	30.16	37.44	63.44	184.08	457.08	333.32	520.00	780.00	1040.0	3718.92	7800.00	7800.00
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[f]	3.44	2.31	4.16	3.63	5.13	5.33	12.57	44.22	51.05	79.65	81.38	219.11	181.33	206.33	1405.56	1405.56
Total Variable Cost	54.84	53.71	55.55	55.02	56.52	69.42	124.42	321.59	713.46	593.8	909.5	1650.7	2236	5221.89	12721.1	12721.1
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000
Value of production	74.5	65.0	135.0	139.6	225.7	250.4	404.3	953.3	628.3	1377.8	1937.5	3663.0	7555.6	11998.8	50600.0	50600.0
Net margin	19.66	11.29	79.45	84.54	169.17	181.02	279.93	631.74	-85.13	783.98	1028.0	2012.3	5319.6	6776.9	37878.9	37878.9
Break-even yield (tons)	.55	.41	.37	.31	.28	.26	.40	.53	.82	.67	.65	.52	.40	.16	.32	.32
NM return on var.cost (%)	35.86	21.03	143.01	153.64	299.3	260.76	225.0	196.44	-11.93	132.03	113.03	121.9	237.91	129.78	297.77	297.77
NM return to labor, ZK/day	.96	.80	2.11	2.21	3.83	4.20	6.60	15.69	7.15	21.49	29.77	53.70	122.30	201.84	878.44	878.44

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] See Table 98.

[c] Assumes that the cost of SR-52 and non-Zambian hybrid seed is approximately equivalent to the cost of MM752

[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated

[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for hybrid/oxenusers is estimated at 61 person-days/ha; adjusted downwards because farmers are not applying fertilizer.

[f] Based on per-bag costs reported for 1988, 1989, 1990, 1992 [g] estimated yield for that season

Table 77: Production costs per hectare (economic), small/medium farmer, non-Zambian hybrids, oxen, fertilizer,

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94 -2001
Estimated yield, tons, non-Zambian hybrids	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed, 17 kg[a]	31.50	31.40	32.43	36.53	40.62	48.70	59.66	70.88	95.48	112.90	168.26	358.90	1122.6	1870.8	3683.1	3683.1
Basal fertilizer (Compound D), 100 kg[b]	65.18	65.10	66.89	74.54	82.18	94.87	117.2	143.3	182.18	230.86	377.42	785.82	2174.4	3845.1	7581.7	7581.7
Top Dressing (Am. Nitrate), 100 kg[b]	50.65	50.62	51.94	57.69	63.45	72.44	89.74	110.9	139.12	179.29	295.47	627.83	1724.7	3009.8	5936	5936
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days	35.38	35.38	35.38	35.38	35.38	43.92	74.42	215.94	536.19	391.01	610.00	91 5.00	1220.0	4362.6	9150.0	9150.0
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.0	1500.0
Transport and Packing[c]	19.88	13.42	24.33	21.84	32.44	25.51	51.19	92.22	73.46	184.97	230.41	563.30	636.88	407.17	4813.7	4813.7
Total Variable Cost	213.24	206.57	221.62	236.63	264.73	298.81	414.77	698.76	1188.9	1217.7	1881.6	3700.9	7515.8	14046	32664	32664

[a] See Table 97 for calculation of economic import parity price for imported seed.
[b] See Table 96 for calculation of economic import parity price for fertilizer.
[c] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 78: Production costs per hectare (economic), small/medium farmer, SR52, oxen, no fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, SR-52	.71	.48	.86	.75	1.06	.88	1.23	1.49	.69	1.48	1.33	1.11	1.30	.34	1.21	1.21
VARIABLE COSTS																
Seed, 17 kg	10.58	10.58	10.58	10.58	10.58	13.27	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	2015.52	2015.52
Basal fertilizer (Compound D), 100 kg[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Top Dressing (Am. Nitrate), 100 kg[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 52 person-days	30.16	30.16	30.16	30.16	30.16	37.44	63.44	184.08	457.08	333.32	520.00	780.00	1040.0	3718.92	7800.00	7800.0
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[b]	10.38	7.08	12.76	11.38	16.86	13.28	26.79	48.05	38.11	96.74	120.18	294.94	332.51	337.65	2510.57	2510.57
Total Variable Cost	61.77	58.47	64.16	62.77	68.25	77.37	138.64	325.42	700.53	610.88	948.3	1726.6	2387.2	5353.22	13826.1	13826.1

[a] See Table 96 for calculation of economic import parity price for fertilizer.

[b] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 79: Production costs per hectare (economic), small/medium farmer, non-Zambian hybrids, oxen, no fertilizer

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94 -2001
Estimated yield, tons, non-Zambian hybrids	.78	.52	.94	.82	1.16	.96	1.34	1.63	.76	1.62	1.46	1.21	1.42	.38	1.32	1.32
VARIABLE COSTS																
Seed, 17 kg[a]	31.50	31.40	32.43	36.53	40.62	48.70	59.66	70.88	95.48	112.90	168.26	358.90	1122.6	1870.8	3683.1	3683.1
Basal fertilizer (Compound D), 100 kg[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Top Dressing (Am. Nitrate), 100 kg[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 52 person-days	30.16	30.16	30.16	30.16	30.16	37.44	63.44	184.08	457.08	333.32	520.00	780.0	1040.0	3718.9	7800.0	7800.0
Oxen hire/ha	10.66	10.66	10.66	10.66	10.66	13.38	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.0	1500.0
Transport and Packing[c]	11.40	7.67	13.95	12.44	18.45	14.49	29.19	52.56	41.98	105.89	131.92	321.51	363.20	377.38	2738.8	2738.8
Total Variable Cost	83.72	79.88	87.19	89.78	99.89	114.01	174.86	372.94	757.03	670.72	1020.2	1910.4	3163.0	6517.1	15722	15722

[a] See Table 97 for calculation of economic import parity price for imported seed.
[b] See Table 96 for calculation of economic import parity price for fertilizer.
[c] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 80: Production costs per hectare (financial), small/medium farmer, Zambian improved varieties, no oxen, fertilizer[a]

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, Zambian improved[b]	0.00	0.00	0.00	0.00	0.00	0.00	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed (MM603/604/612/504),17 kg[c]	0.00	0.00	0.00	0.00	0.00	0.00	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	561.0	561.0
Basal fertilizer (Compound D) 100 kg[d]	0.00	0.00	0.00	0.00	0.00	0.00	53.50	53.50	160.00	160.00	196.54	792.00	1134.0	1600.0	2939.6	2939.6
Top Dressing (Am. Nitrate) 100 kg[d]	0.00	0.00	0.00	0.00	0.00	0.00	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.0	2939.6	2939.6
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days[e]	0.00	0.00	0.00	0.00	0.00	0.00	108.58	315.06	782.31	570.49	890.00	1335.0	1780.0	6365.1	13350	13350
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[f]	0.00	0.00	0.00	0.00	0.00	0.00	22.98	81.06	93.64	145.43	148.75	400.44	332.00	234.98	2577.8	2577.8
Total Variable Cost	0.00	0.00	0.00	0.00	0.00	0.00	262.60	529.20	1190.8	1050.1	1471.4	3495.1	4491.4	10547	22368	22368
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333	40000	40000
Value of production	0.0	0.0	0.0	0.0	0.0	0.0	739.47	1747.8	1152.7	2515.6	3541.7	6694.5	13833	13665	92800	92800
Net margin							476.87	1218.6	-38.12	1465.4	2070.3	3199.4	9342	3118.6	70432	70432
Break-even yield (tons)							.83	.87	1.37	1.18	1.06	1.11	.81	.32	.56	.56
NM return on var.cost (%)							181.59	230.27	-3.2	139.54	140.70	91.54	208.0	29.57	314.88	314.88
NM return to labor, ZK/day							6.58	17.23	8.36	22.88	33.26	50.95	124.97	106.56	941.37	941.37

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] See Table 98.

[c] Source: Zambia Seed Company. MM603/604/612/504are the varieties most commonly adopted by small and medium-scale farmers.

[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated

[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94)for each year. The labor requirement for hybrid/non-oxenusers is estimated at 89 days/ha (ARPT, undated).

[f] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 81: Production costs per hectare (economic), small/medium farmer, Zambian improved varieties, no oxen

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94 -2001
Estimated yield, tons, Zambian improved	0	0	0	0	0	0	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed (MM603/604/ 612/504),17kg	0.00	0.00	0.00	0.00	0.00	0.00	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	561.00	561.00
Basal fertilizer (Compound D), 100 kg[a]	0.00	0.00	0.00	0.00	0.00	0.00	117.19	143.30	182.18	230.86	377.42	785.82	2174.4	3845.1	7581.7	7581.7
Top Dressing (Am. Nitrate), 100 kg[a]	0.00	0.00	0.00	0.00	0.00	0.00	89.74	110.99	139.12	179.29	295.47	627.83	1724.7	3009.8	5936	5936
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 89 person-days	0.00	0.00	0.00	0.00	0.00	0.00	108.58	315.06	782.31	570.49	890.00	1335.0	1780.0	6365.1	13350	13350
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport and Packing[b]	0.00	0.00	0.00	0.00	0.00	0.00	51.19	92.22	73.46	184.97	230.41	563.30	636.88	407.17	4813.7	4813.7
Total Variable Cost	0.00	0.00	0.00	0.00	0.00	0.00	392.54	689.46	1219.9	1227.8	1901.4	3513.6	6693.4	14374	32242	32242

[a] See Table 96 for calculation of economic import parity price for fertilizer.
[b] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 82: Production costs per hectare (financial), small/medium farmer, Zambian improved varieties, oxen[a]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, Zambian improved[b]	0	0	0	0	0	0	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed (MM603/604/612/504),17kg[c]	0.00	0.00	0.00	0.00	0.00	0.00	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	561.00	561.00
Basal fertilizer (Compound D), 100 kg[d]	0.00	0.00	0.00	0.00	0.00	0.00	53.50	53.50	160.00	160.00	196.54	792.00	1134.0	600.00	2939.61	2939.61
Top Dressing (Am. Nitrate), 100 kg[d]	0.00	0.00	0.00	0.00	0.00	0.00	51.70	51.70	112.00	112.00	128.00	766.00	868.00	1600.0	2939.61	2939.61
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days[e]	0.00	0.00	0.00	0.00	0.00	0.00	74.42	215.94	536.19	391.01	610.00	915.00	1220.0	4362.6	9150.00	9150.00
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.00
Transport and Packing[f]	0.00	0.00	0.00	0.00	0.00	0.00	22.98	81.08	93.64	145.43	148.75	400.44	332.00	234.98	2577.78	2577.78
Total Variable Cost	0.00	0.00	0.00	0.00	0.00	0.00	251.02	495.50	1107.2	989.27	1391.4	3525.1	4568.6	9094.2	19668.0	19668.0
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.	40000.0	40000
Value of production	0.0	0.0	0.0	0.0	0.0	0.0	739.47	1747.8	1152.7	2515.6	3541.7	6694.5	13833	13665	92800	92800
Net margin							488.46	1252.3	45.50	1526.3	2150.3	3169.4	9264.7	4571.1	73132.0	73132.0
Break-even yield (tons)							.80	.811	1.28	1.11	1.0	1.12	0.82	0.27	0.49	0.49
NM return on var.cost (%)							194.59	252.73	4.11	154.28	154.54	89.91	202.79	50.26	371.83	371.83
NM return to labor, ZK/day							9.23	24.07	9.54	31.43	45.25	66.96	171.88	146.45	1348.89	1348.89

[a] Based on estimates of variable costs/ha for emergent (< 10 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.

[b] See Table 98.

[c] Source: Zambia Seed Company. MM603/604/612/504are the varieties most commonly adopted by small and medium-scale farmers

[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated

[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for hybrid/oxenusers is estimated at 61 person-days/ha (ARPT,undated).

[f] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season.

Table 83: Production costs per hectare (economic), small/medium farmer, Zambian improved varieties, oxen

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, Zambian improved	0	0	0	0	0	0	2.35	2.86	1.33	2.83	2.55	2.12	2.49	0.41	2.32	2.32
VARIABLE COSTS																
Seed (MM603/604/612/504),17kg	0.00	0.00	0.00	0.00	0.00	0.00	25.84	27.88	42.84	62.22	108.12	201.62	377.40	746.64	561.00	561.00
Basal fertilizer (Compound D), 100 kg [a]	0.00	0.00	0.00	0.00	0.00	0.00	117.19	143.30	182.18	230.86	377.42	785.82	2174.4	3845.09	7581.69	7581.7
Top Dressing (Am. Nitrate),100 kg [a]	0.00	0.00	0.00	0.00	0.00	0.00	89.74	110.99	139.12	179.29	295.47	627.83	1724.7	3009.84	5935.97	5936
Pesticide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor, 61 person-days	0.00	0.00	0.00	0.00	0.00	0.00	74.42	215.94	536.19	391.01	610.00	915.00	1220.0	4362.58	9150.00	9150.0
Oxen hire/ha	0.00	0.00	0.00	0.00	0.00	0.00	22.57	65.42	162.50	118.61	200.00	450.00	637.24	550.00	1500.00	1500.0
Transport and Packing [b]	0.00	0.00	0.00	0.00	0.00	0.00	51.19	92.22	73.46	184.97	230.41	563.30	636.88	407.17	4813.66	4813.7
Total Variable Cost	0.00	0.00	0.00	0.00	0.00	0.00	380.95	655.75	1136.3	1167	1821.4	3543.6	6770.6	12921.3	29542.3	29542

[a] See Table 96 for calculation of economic import parity price for fertilizer

[b] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 84: Production costs per hectare (financial), large farmer, SR52 or non-Zambian hybrids[a]

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, non-Zambian hybrids[b]	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.86	5.86	5.85	5.85	5.85
Estimated yield, tons, SR-52[b]	5.43	5.43	5.43	5.43	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45
VARIABLE COSTS																
Seed, 25 kg[c]	15.56	15.56	15.56	15.56	15.56	19.52	38.00	41.00	63.00	91.50	159.00	296.50	555.00	1098.00	2964.00	2964.0
Basal fertilizer (Compound D), 400 kg[d]	94.00	94.00	94.00	94.00	119.60	192.80	214.00	214.00	640.00	640.00	786.16	3168.00	4536.00	6400.00	11758.4	11758
Top Dressing (Am. Nitrate), 300 kg[d]	60.48	60.48	60.48	60.48	84.48	139.20	155.10	155.10	336.00	336.00	384.00	2298.00	2604.00	4800.00	8818.83	8818.8
Herbicide	24.60	24.60	24.60	24.60	24.60	30.87	52.10	150.99	375.07	273.76	440.00	805.80	804.00	3053.11	6632.00	6632.0
Pesticide	6.56	6.56	6.56	6.56	6.56	8.23	13.89	40.25	99.97	72.97	207.00	225.00	39.99	813.78	378.00	378.00
Labor, 20 person-days[e]	11.60	11.60	11.60	11.60	11.60	14.40	24.40	70.80	175.80	128.20	200.00	300.00	400.00	1430.35	3000.00	3000.0
Insurance[f]	44.65	44.65	44.65	44.65	49.77	70.25	99.40	208.79	520.72	411.90	471.04	1631.67	2153.12	4634.22	7717.69	7717.7
Tractor hire[g]	171.07	171.07	171.07	171.07	171.07	214.68	362.28	1049.9	2608.1	1903.6	1750.0	7000.0	9800.0	21230.0	30100.0	30100
Combine hire	23.60	23.60	23.60	23.60	23.60	29.62	49.98	144.86	359.83	262.64	317.50	680.00	1411.08	2929.06	5000.00	5000.0
Transport and packing[h]	26.02	26.02	26.02	26.02	26.09	32.74	55.26	160.14	397.80	290.36	329.58	1068.17	754.00	3238.16	6277.78	6277.8
Total Variable Cost (excl. insurance)	433.5	433.5	433.5	433.5	483.2	682.1	965.0	2027.1	5055.5	3999.0	4573.2	15841.5	20904.1	44992.5	74929.1	74929.
TVC plus insurance	478.15	478.15	478.15	478.15	532.93	752.32	1064.4	2235.9	5576.2	4410.9	5044.3	17473.1	23057.2	49626.7	82646.7	82646
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000
Value of production	563.5	732.6	845.3	1001.8	1148.8	1538.0	1777.9	3452.8	4896.7	5022.2	7847.2	17857.3	31416.7	188315	226000	226000
Net margin	130.0	299.05	411.75	568.3	665.65	855.97	812.89	1425.71	-158.82	1023.18	3723.99	2015.78	10512.6	143322	151071	151071
Break-even yield (tons)	4.33	3.33	2.89	2.44	2.38	2.51	3.07	3.32	5.83	4.50	3.29	5.02	3.76	1.35	1.87	1.87
NM return on var.cost (%)	24.99	68.99	94.98	131.10	137.77	125.5	84.24	70.33	-3.14	25.59	71.59	12.72	50.29	318.55	201.62	201.62
NM return to labor, ZK/day	130.58	299.63	412.33	568.87	666.23	856.69	814.11	1429.25	-150.03	1029.59	3283.99	2030.78	10532.6	143394	151221	151221

[a] Based on estimates of variable costs/ha for small commercial (10-50 ha), and large commercial (>50 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.
[b] See Table 98.
[c] Source: Zambia Seed Company.
[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated
[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for large farmers is estimated at 20 person-days (Farm Management Section, GRZ).
[f] 10.3 % of variable cost (Farm Management Section, GRZ)
[g] Tractor use by large farmers is estimated at 14 hours/ha (Farm Management Section, GRZ)
[h] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 85: Production costs per hectare (economic), large farmer, SR52

Table 85: Production costs per hectare (economic), large farmer, SR52

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, SR-52	5.43	5.43	5.43	5.43	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45
VARIABLE COSTS																
Seed, 25 kg	15.56	15.56	15.56	15.56	15.56	19.52	38.00	41.00	63.00	91.50	159.00	296.50	555.00	1098.00	2964.00	2964.00
Basal fertilizer (Compound D), 400 kg[a]	260.70	260.38	267.55	298.14	328.73	379.47	468.74	573.20	728.71	923.45	1509.7	3143.3	8697.7	15380.4	30326.8	30326.8
Top Dressing (Am. Nitrate), 300 kg[a]	151.94	151.85	155.79	173.07	190.34	217.20	269.23	110.99	417.36	537.86	886.40	1883.5	5174.1	9029.51	17808	17807.9
Herbicide[b]/	77.86	78.54	79.04	80.80	84.72	84.72	116.04	173.44	295.17	348.19	681.56	1133.5	1542.3	5290.37	12384.4	12384.4
Pesticide[c]/	20.76	20.94	21.07	21.54	22.59	21.43	30.94	46.23	78.67	92.81	320.64	316.51	76.71	1410.10	705.86	705.86
Labor, 20 person-days	11.60	11.60	11.60	11.60	11.60	14.40	24.40	70.80	175.80	128.20	200.00	300.00	400.00	1430.35	3000.00	3000.00
Insurance	127.09	127.76	129.43	136.21	145.29	149.89	204.38	264.08	452.72	539.05	767.59	1990.5	5471.6	8334.09	14836.3	14836.3
Tractor hire[d]	541.37	546.12	549.58	561.82	589.10	559.10	806.89	1206.0	2052.5	2421.2	2710.8	9846.9	32576	36786.9	56207.7	56207.7
Combine hire[e]	74.69	75.35	75.82	77.51	81.28	77.14	111.32	166.39	283.18	334.04	491.81	956.55	2706.9	5075.42	9336.83	9336.83
Transport and Packing[f]	79.36	80.06	80.56	82.36	86.67	82.26	118.72	175.74	301.01	356.22	492.45	1448.1	1394	5412.41	11307.9	11307.9
Total Variable Cost (excl. insurance)	1233.8	1240.4	1256.6	1322.4	1410.6	1455.2	1984.3	2563.8	4395.4	5233.4	7452.3	19325	53122	80913.5	144041	144041
TVC plus insurance	1360.9	1368.2	1385.9	1458.6	1555.9	1605.1	2188.6	2827.9	4848.1	5772.5	8219.9	21315	58594	89247.5	158878	158878

[a] See Table 96 for calculation of economic import parity price for fertilizer
[b] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).
[c] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).
[d] 75% of tractor hire costs are assumed to be imported goods and are valued at the SER.
[e] 75% of combine hire costs are assumed to be imported goods and are valued at the SER.

[f] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (see Table 94).

Table 86: Production costs per hectare (economic), large farmer, non-Zambian hybrids

YEAR	78/9	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, non-Zambian hybrids	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.86	5.86	5.85	5.85	5.85
VARIABLE COSTS																
Seed, 25 kg[a]	46.33	46.18	47.69	53.72	59.74	71.62	87.74	104.24	140.41	166.04	247.44	527.80	1650.8	2751.2	5416.36	5416.36
Basal fertilizer (Compound D),400 kg[b]	260.70	260.38	267.55	298.14	328.73	379.47	468.74	573.20	728.71	923.45	1509.7	3143.3	8697.7	15380	30326.8	30326.8
Top Dressing (Am. Nitrate), 300 kg[b]	151.95	151.85	155.79	173.07	190.34	217.20	269.23	110.99	417.36	537.86	886.40	1883.5	5174.1	9029.5	17807.9	17807.9
Herbicide[c]	77.86	78.54	79.04	80.80	84.72	84.72	116.04	173.44	295.17	348.19	681.56	1133.5	1542.3	5290.4	12384.4	12384.4
Pesticide[d]	20.76	20.94	21.07	21.54	22.59	21.43	30.94	46.23	78.67	92.81	320.64	316.51	76.71	1410.1	705.86	705.86
Labor, 20 person-days	11.60	11.60	11.60	11.60	11.60	14.40	24.40	70.80	175.80	128.20	200.00	300.00	400.00	1430.4	3000.00	3000.00
Insurance	130.87	131.54	133.36	140.78	150.50	155.88	210.40	271.92	462.97	549.42	780.42	2025.5	5595.3	8545.3	15174.3	15174.3
Tractor hire[e]	541.37	546.12	549.58	561.82	589.10	559.10	806.89	1206.0	2052.5	2421.2	2710.8	9846.9	32576	36787	56207.7	56207.7
Combine hire[f]	74.69	75.35	75.82	77.51	81.28	77.14	111.32	166.39	283.18	334.04	491.81	956.55	2706.9	5075.4	9336.83	9336.83
Transport and Packing[g]	85.35	86.10	86.64	88.58	93.04	88.30	127.43	188.64	323.10	382.37	528.60	1557.1	1498.9	5809.7	12137.9	12137.9
Total Variable Cost (excl. insurance)	1270.6	1277.1	1294.8	1366.8	1461.1	1513.4	2042.7	2639.9	4494.9	5334.1	7576.9	19665	54323	82964	147324	147324
TVC plus insurance	1401.1	1408.6	1428.1	1507.6	1611.6	1669.2	2253.1	2911.9	4957.9	5883.5	8357.3	21691	59918	91509	162498	162498

[a] See Table 97 for calculation of economic import parity price for imported seed
[b] See Table 96 for calculation of economic import parity price for fertilizer

[c] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).
[d] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).
[e] 75% of tractor hire costs are assumed to be imported goods and are valued at the SER.
[f] 75% of combine hire costs are assumed to be imported goods and are valued at the SER.
[g] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (See Table 94).

Table 87: Production costs per hectare (financial), large farmer, Zambian improved varieties[a]

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, Zambian improved[b]	0.00	0.00	0.00	0.00	0.00	0.00	6.54	6.54	6.05	6.06	6.07	6.17	6.14	6.09	6.09	6.09
VARIABLE COSTS																
Seed,25 kg[c]	15.56	15.56	15.56	15.56	15.56	19.52	38.00	41.00	63.00	91.50	159.00	296.50	555.00	1098.00	2964.00	2964.00
Basal fertilizer (Compound D),400 kg[d]	94.00	94.00	94.00	94.00	119.6	192.8	214.00	214.00	640.00	640.00	786.16	3168.00	4536.00	6400.00	11758.44	11758.4
Top Dressing (Am. Nitrate), 300 kg[d]	60.48	60.48	60.48	60.48	84.48	139.2	155.10	155.10	336.00	336.00	384.00	2298.00	2604.00	4800.00	8818.83	8818.83
Herbicide	24.60	24.60	24.60	24.60	24.60	30.87	52.10	150.99	375.07	273.76	440.00	805.80	804.00	3053.11	6632.00	6632.00
Pesticide	6.56	6.56	6.56	6.56	6.56	8.23	13.89	40.25	99.97	72.97	207.00	225.00	39.99	813.78	378.00	378.00
Labor, 20 person-days[e]	11.60	11.60	11.60	11.60	11.60	14.40	24.40	70.80	175.80	128.20	200.00	300.00	400.00	1430.35	3000.00	3000.00
Insurance[f]	41.97	41.97	41.97	41.97	47.08	66.88	100.29	211.39	523.62	414.07	473.57	1641.69	2159.78	4660.20	7768.05	7768.05
Tractor hire[g]	171.1	171.1	171.1	171.1	171.1	214.7	362.3	1049.9	2608.1	1903.6	1750.0	7000.0	9800.0	21230.00	30100.0	30100.0
Combine hire	23.60	23.60	23.60	23.60	23.60	29.62	49.98	144.86	359.83	262.64	317.50	680.00	1411.08	2929.06	5000.00	5000.00
Transport and Packing[h]	0.00	0.00	0.00	0.00	0.00	0.00	63.96	185.37	425.96	311.43	354.08	1165.44	818.67	3490.34	6766.67	6766.67
Total Variable Cost (excl. insurance)	407.5	407.5	407.5	407.5	457.1	649.3	973.7	2052.3	5083.7	4020.1	4597.7	15938.74	20968.73	45244.64	75417.94	75417.9
TVC plus insurance	449.4	449.4	449.4	449.4	504.2	716.2	1074.0	2263.7	5607.3	4434.2	5071.3	17580.44	23128.51	49904.84	83185.98	83185.9
Maize price, ZK/ton	100.0	130.0	150.0	177.8	203.3	272.2	314.7	611.1	866.7	888.9	1388.9	3157.8	5555.6	33333.0	40000.0	40000
Value of production	0.0	0.0	0.0	0.0	0.0	0.0	2057.94	3996.7	5243.4	5386.7	8430.6	19483.5	34111.1	202979.7	243600.0	243600
Net margin							1084.24	1944.4	159.68	1366.6	3832.8	3544.8	13142.4	157735.1	168182.1	168182
Break-even yield (tons)							3.09	3.36	5.87	4.52	3.31	5.05	3.77	1.36	1.89	1.89
NM return on var.cost (%)							111.35	94.74	3.14	33.99	83.36	22.24	62.88	348.63	223.0	223.0
NM return to labor, ZK/day							1085.46	1947.9	168.47	1372.97	3842.82	3559.76	13162.4	157806.6	168332.1	168332

[a] Based on estimates of variable costs/ha for small commercial (10-50 ha), and large commercial (>50 ha) farmers by the Farm Management Section, Department of Agriculture, Lusaka, for 1988, 1989, 1990, 1992.
[b] See Table 98.
[c] Source: Zambia Seed Company.
[d] Source: ZCF, Fertilizer Selling Prices per Metric Tonne, 1981-91; 1978-81 estimated
[e] For years other than 1988, 1989, 1990, 1992, the casual labor daily rate is based on the average rate, adjusted according to nominal ZK/SDR exchange rates (Table 94) for each year. The labor requirement for large farmers is estimated at 20 person-days (Farm Management Section, GRZ).
[f] 10.3 % of variable cost (Farm Management Section, GRZ)
[g] Tractor use by large farmers is estimated at 14 hours/ha (Farm Management Section, GRZ)
[h] Based on per-bag costs reported for 1988, 1989, 1990, 1992 multiplied by the estimated yield for that season

Table 88: Production costs per hectare (economic), large farmer, Zambian improved varieties

YEAR	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94-2001
Estimated yield, tons, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	6.54	6.54	6.05	6.06	6.07	6.17	6.14	6.09	6.09	6.09
VARIABLE COSTS																
Seed, 25 kg	0.00	0.00	0.00	0.00	0.00	0.00	38.00	41.00	63.00	91.50	159.00	296.50	555.00	1098.00	2964.00	2964.00
Basal fertilizer (Compound D),400 kg[a]	0.00	0.00	0.00	0.00	0.00	0.00	468.74	573.20	728.71	923.45	1509.7	3143.28	8697.69	15380.4	30326.8	30326.8
Top Dressing (Am. Nitrate), 300 kg[a]	0.00	0.00	0.00	0.00	0.00	0.00	269.23	110.99	417.36	537.86	886.40	1883.50	5174.07	9029.51	17807.9	17807.9
Herbicide[b]	0.00	0.00	0.00	0.00	0.00	0.00	116.04	173.44	295.17	348.19	681.56	1133.52	1542.33	5290.37	12384.4	12384.4
Pesticide[c]	0.00	0.00	0.00	0.00	0.00	0.00	30.94	46.23	78.67	92.81	320.64	316.51	76.71	1410.10	705.86	705.86
Labor, 20 person-days	0.00	0.00	0.00	0.00	0.00	0.00	24.40	70.80	175.80	128.20	200.00	300.00	400.00	1430.35	3000.00	3000.00
Insurance	0.00	0.00	0.00	0.00	0.00	0.00	206.83	267.70	456.14	543.15	773.36	2010.16	5489.77	8399.55	14973.0	14973.0
Tractor hire[d]	0.00	0.00	0.00	0.00	0.00	0.00	806.89	1206.1	2052.5	2421.2	2710.8	9846.9	32575.6	36786.9	56207.7	56207.7
Combine hire[e]	0.00	0.00	0.00	0.00	0.00	0.00	111.32	166.39	283.18	334.04	491.81	956.55	2706.90	5075.42	9336.83	9336.83
Transport and Packing[f]	0.00	0.00	0.00	0.00	0.00	0.00	142.46	210.89	334.15	396.09	548.48	1639.43	1570.47	6047.99	12635.8	12635.8
Total Variable Cost (excl. insurance)	0.00	0.00	0.00	0.00	0.00	0.00	2008.0	2598.9	4428.5	5273.3	7508.3	19516.2	53298.7	81549.0	145369.	145369.
TVC plus insurance	0.00	0.00	0.00	0.00	0.00	0.00	2214.8	2866.7	4884.7	5816.5	8281.7	21526.3	58788.5	89948.6	160342	160342

[a] See Table 96 for calculation of economic import parity price for fertilizer
[b] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).
[c] Assumed that import content is 75%; this proportion is adjusted by the SER (see Table 94).

[d] 75% of tractor hire costs are assumed to be imported goods and are valued at the SER.

[e] 75% of combine hire costs are assumed to be imported goods and are valued at the SER.

[f] It is assumed that 65% of the costs in this category are transport-related, and 35% are bagging costs. 75% of transport and bagging costs (jute bags are imported) are assumed to be imported goods, and are valued at the SER (See Table 94).

APPENDIX 8

APPENDIX 8

GRZ AND DONOR EXPENDITURES ON MAIZE EXTENSION, 1978-91

Table 89: Estimated GRZ and donor expenditures on maize extension, 1978-91 (financial values) [a]

ml. ZK

ITEM	1978	1979	1980	1981	1982	1983
Lima Program			.23	.34	.57	.39
Integrated Development Zone/ Integrated Rural Dev. Program (IRDP) for Eastern, Northern Provinces	.47	.53	.73	1.14	1.17	.81
TOTAL MAIZE-RELATED EXPENDITURES	.47	.53	.96	1.48	1.74	1.2

Table 89:

ITEM
Personal E
Allowanc
Purchase
Purchase
Training
CAPIT
Lima P
Villag
Motor
Staff
Seed
NAT
Pers
Re
Pu
Pu
Of
R
S
C F
I

Table 89: Estimated GRZ and donor expenditures on maize extension, 1978-91 (financial values)(con't)[a]

ml. ZK

ITEM	1984	1985	1986	1987	1988
Personal Emoluments	5.559	6.049	8.989	6.455	8.502
Allowances	.1264	.2035	.4134	.272	1.330
Purchase of Goods	.3993	.3043	.479	.5337	1.363
Purchase of Services	.1203	.1454	.2289	.2048	.5036
Training Expenses	.1346	.2085	.35	.3236	.6724
CAPITAL EXPENDITURES					
Lima Program[b]	.209	.1402	.2122	.5114	.4452
Village Agricultural Project, No.Prov.[c]	.2502	.4766	1.973	2.271	3.365
Motor Vehicles		.0457	.0045	.0204	.0029
Staff Housing			.0257	.1676	
Seed Control Institute[b]			.4246	.3848	
NAT'L FARMING INFORMATION SERVICE					
Personal Emoluments	.1431	.1303	.2171	.1748	.3606
Recurrent Charges	.004	.011	.0315	.0601	.0905
Purchase of Goods	.0339	.0635	.1045	.2059	.2742
Purchase of Services	.0042	.0095	.0202	.2925	.3975
Office Equipment, Vehicles		.0279	.0880	.1953	.0756
Rural Information Services		.0093	.0487	.0605	
Staff Housing		.0265	.0264	.0725	
CAPITAL EXPENDITURES -- MAWD HEADQUARTERS					
Integrated Rural Dev. Program (IRDP)[d]	.9641	1.681	4.743	7.790	6.913
IRDP-NW Province[e]	2.239	.9849	1.381	1.643	1.702
IRDP-Serenje, Mpika, Chinsali[f]	.0453	.7319	2.061		.00092
Central Prov. Maize Production Project[g]	.1913	.0747	1.252	1.548	2.13
So. Prov. Ag.Dev. Project[h]	1.988	1.733	2.917	1.117	1.172
North-Western Area Dev. Project[i]	.412	1.335	1.788	2.558	3.356

Table 89: Estimated GRZ and donor expenditures on maize extension, 1978-91 (financial values)(con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988
Eastern Province Ag. Dev. Project[h]		4.386	7.222	2.19	.912
Oxen Supply Training Centre[j]		.004	.0033	.0047	2.358
Ag. Res. and Development[c]				.4954	.6691
Agricultural Extension Services[d]					.0376
Staff Housing			.0192	.0975	.3085
TOTAL MAIZE-RELATED EXPENDITURES	12.823	18.782	35.022	29.648	36.942

[a] 1978-1983, based on SIDA budgets from annual reports. 1984-91, based on actual expenditures reported in GRZ Financial Reports. 40 percent of total expenditures in each category are attributed to maize extension, except where noted
[b] Partially funded by SIDA and FINNIDA
[c] Partially funded by NORAD
[d] Partially funded by SIDA
[e] Partially funded by the Federal Republic of Germany
[f] Partially funded by the United Kingdom
[g] Partially funded by EEC; 100% of expenditures attributed to maize
[h] Partially funded by World Bank, IDA loan
[i] Partially funded by IFAD, UK, GTZ, FINNIDA
[j] Partially funded by Netherlands

Table 89: Es
(fi

Table 89: Estimated GRZ and donor expenditures on maize extension, 1978-91 (financial values)(con't)

ml. ZK

ITEM	1989	1990	1991[i]
Personal Emoluments	14.334	20.561	4.746
Allowances	1.417	3.393	.7308
Purchase of Goods	2.109	3.771	.6768
Purchase of Services	.726	1.514	2.308
Training Expenses	4.997	.8667	.1292
CAPITAL EXPENDITURES			
Lima Program[b]	.3539	.6385	.04
Village Agricultural Project, No.Prov.[c]	3.412	3.294	
Motor Vehicles, Movable Assets	.4191	1.983	4.271
Staff Housing			
Seed Control Institute[b]			
NAT'L FARMING INFORMATION SERVICE			
Personal Emoluments	.4023	1.188	3.715
Recurrent Charges	.1386	.6197	.606
Purchase of Goods	.3769	1.367	.5216
Purchase of Services	.5807	1.228	5.222
Office Equipment, Vehicles	.1332	.5123	.7752
Rural Information Services	.0195	.0289	.050
Staff Housing	.0875	.1103	.1404
CAPITAL EXPENDITURES -- MAWD HEADQUARTERS			
Integrated Rural Dev. Program (IRDP)[d]	10.218	26.989	.36
IRDP-NW Province[e]	1.549	6.192	1.575
IRDP-Serenje, Mpika, Chinsali[f]			
Central Prov. Maize Production Project[g]	2.282	4.9	192.547
So. Prov. Ag. Dev. Project[h]	1.301	.7274	.080
North-Western Area Dev. Project[i]	4.427	16.839	1.271

Table 89: Est
(financia

Based c
are attrib
Partial
Partial
Partial
Partial
Partial
Partial
Partial
Partial
Partial
1991 c

Table 89: Estimated GRZ and donor expenditures on maize extension, 1978-91 (financial values)(con't)

ml. ZK

ITEM	1989	1990	1991
Eastern Province Ag. Dev. Project[h]	.459	.1244	.080
Oxen Supply Training Centre[j]	.1005	.5168	1.68
Ag. Res. and Development[c]	.0284	.03	.6
Agricultural Extension Services[d]	1.25		1.360
Staff Housing	.0345	.1082	.728
Valley Development	.2944		1.360
TOTAL MAIZE-RELATED EXPENDITURES	51.450	97.5	225.572

[a] Based on actual expenditures reported in GRZ Financial Reports, 1984-91. 40 percent of total expenditures in each category are attributed to maize extension, except where noted
[b] Partially funded by SIDA and FINNIDA
[c] Partially funded by NORAD
[d] Partially funded by SIDA and NORAD
[e] Partially funded by the Federal Republic of Germany
[f] Partially funded by the United Kingdom
[g] Partially funded by EEC; 100% of expenditures attributed to maize
[h] Partially funded by World Bank, IDA loan
[i] Partially funded by IFAD, UK, GTZ, FINNIDA
[j] Partially funded by Netherlands
[1] 1991 data are total provisions for each category; actual expenditure data not available

Tabl

ITEM
Lima
Integ Dev. Prov
TOT

Table 90: Estimated GRZ and donor expenditures on maize extension, 1978-91 (economic values)

ml. ZK

ITEM	1978	1979	1980	1981	1982	1983
Lima Program[c]			.809	1.3	2.13	1.09
Integrated Development Zone/ Integrated Rural Dev. Program (IRDP) for Eastern, Northern Provinces[d]	1.62	1.85	2.56	4.09	4.42	3.05
TOTAL MAIZE-RELATED EXPENDITURES	1.62	1.85	3.369	5.39	6.55	4.14

Table 90: Estimated GRZ and donor expenditures on maize extension, 1978-91 (economic values)(con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988
Personal Emoluments[a]	5.559	6.049	8.989	6.455	8.502
Allowances[a]	.1264	.2035	.4134	.272	1.33
Purchase of Goods[b]	.8894	.3495	.377	.6788	2.112
Purchase of Services[b]	.2679	.167	.180	.2605	.7801
Training Expenses[a]	.1346	.2085	.350	.3236	.6724
CAPITAL EXPENDITURES[c]					
Lima Program	.4997	.1638	.161	.669	.7222
Village Agricultural Project, No.Prov.	.5982	.557	1.497	2.971	5.458
Motor Vehicles		.0534	.00341	.0267	.0047
Staff Housing			.0195	.2192	
Seed Control Institute			.322	.5034	
NAT'L FARMING INFORMATION SERVICE					
Personal Emoluments[d]	.1431	.1303	.2171	.1748	.3606
Recurrent Charges[e]	.00891	.0123	.0248	.0764	.1402
Purchase of Goods[e]	.0755	.0729	.0822	.2619	.4247
Purchase of Services[e]	.0094	.0109	.0159	.372	.6157
Office Equipment, Vehicles[f]		.0326	.0668	.2555	.1226
Rural Information Services[e]		.0107	.0383	.077	
Staff Housing[f]		.031	.02	.0948	
CAPITAL EXPENDITURES -- MAWD HEADQUARTERS[g]					
Integrated Rural Dev. Program (IRDP)	2.305	1.964	3.598	10.190	11.214
IRDP-NW Province	5.352	1.151	1.048	2.149	2.747
IRDP-Serenje, Mpika, Chinsali	.1083	.8552	1.563		.0015
Central Prov. Maize Production Project	.4574	.0873	.9494	2.025	3.455
So. Prov. Ag.Dev. Project	4.752	2.025	2.213		1.461
North-Western Area Dev. Project	.986	1.560	1.356	3.346	5.444

Ta

N
E
C
A
A
S
T

Table 90: Estimated GRZ and donor expenditures on maize extension, 1978-91 (economic values)(con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988
Eastern Province Ag. Dev. Project		5.125	5.479	2.864	1.48
Oxen Supply Training Centre		.00467	.0025	.00615	3.825
Ag. Res. and Development				.648	1.085
Agricultural Extension Services					.061
Staff Housing			.0146	.1275	.500
TOTAL MAIZE-RELATED EXPENDITURES	22.273	20.825	29	36.51	52.974

Ta

Table 90: Estimated GRZ and donor expenditures on maize extension, 1984-91 (economic values)(con't)

ml. ZK

ITEM	1989	1990	1991
Personal Emoluments[a]	14.334	20.561	4.746
Allowances[a]	1.417	3.393	.731
Purchase of Goods[b]	2.967	7.233	1.173
Purchase of Services[b]	1.021	2.904	3.999
Training Expenses[a]	4.997	.8667	.1292
CAPITAL EXPENDITURES[c]			
Lima Program	.517	1.303	.0732
Village Agricultural Project, No.Prov.	4.985	6.722	
Motor Vehicles, Movable Assets	.6123	4.046	7.818
Staff Housing			
Seed Control Institute			
NAT'L FARMING INFORMATION SERVICE			
Personal Emoluments[d]	.4023	1.188	3.715
Recurrent Charges[e]	.195	1.189	1.050
Purchase of Goods[e]	.5302	2.622	.9038
Purchase of Services[e]	.8169	2.356	9.049
Office Equipment, Vehicles[f]	.1946	1.045	1.419
Rural Information Services[e]	.0274	.0554	.0866
Staff Housing[f]	.1278	.2251	.257
CAPITAL EXPENDITURES -- MAWD HEADQUARTERS[g]			
Integrated Rural Dev. Program (IRDP)	14.928	55.078	.659
IRDP-NW Province	2.263	12.637	2.883
IRDP-Serenje, Mpika, Chinsali			
Central Prov. Maize Production Project	3.333	9.999	352.454
So. Prov. Ag.Dev. Project	1.9	1.484	.1464
North-Western Area Dev. Project	6.468	34.365	2.326

Table 90: Estimated GRZ and donor expenditures on maize extension, 1984-91 (economic values)(con't)

mln ZK

ITEM	1989	1990	1991
Eastern Province Ag. Dev. Project	.6706	.2539	.1464
Oxen Supply Training Centre	.1468	1.055	3.075
Ag. Res. and Development	.0415	.0612	1.098
Agricultural Extension Services	1.827		2.489
Staff Housing	.0504	.2208	1.333
Valley Development	.4301		2.489
TOTAL MAIZE-RELATED EXPENDITURES	65.203	170.861	404.25

[a] No tradeable goods
[b] 75% of expenditures are considered tradeable goods and valued at the SER
[c] 85% of all expenditures in this category are considered tradeable goods and valued at the SER
[d] No tradeable goods
[e] 75% of expenditures are considered tradeable goods and valued at the SER
[f] 85% of expenditures are considered tradeable goods and valued at the SER
[g] 85% of all expenditures in this category are considered tradeable goods and valued at the SER

APPENDIX 9

APPENDIX 9

ESTIMATED GRZ AND DONOR EXPENDITURES ON MAIZE MARKETING AND RELATED EXPENDITURES

Table 91: Estimated GRZ and donor expenditures on maize marketing and related expenditures, 1978-94[a] (financial)

ml. ZK

ITEM	1978[e]	1979[e]	1980[e]	1981[e]	1982[e]	1983[e]
Dept. of Cooperatives and Marketing						
Personal Emoluments						
Allowances						
Purchase of Goods						
Purchase of Services						
Motor Vehicles, movable assets						
Rural Storage Facilities						
ECU Project[b]						
TOTAL, est. Dept. of Coop/Mkting expenditures	n/a	n/a	n/a	n/a	n/a	n/a
SIDA support to cooperative sector[f]	1.19	1.37	1.37	2.58	3.3	2.9
TOTAL, Dept. of Coop/Mkting and SIDA support	1.19	1.37	1.37	2.58	3.3	2.9
SUBSIDIES						
Fertilizer Handling[c]			25.0	21.0	63.0	8.0
Fertilizer Price Differential Subsidy[c]			36.0	27.5	31.6	11.9
Subsidies to Namboard			97.0	40.0	32.0	17.1
Subsidies to Cooperative Unions						37.1
Milling Subsidy						
Import Subsidy			8.2	8.3	30.3	54.6
Seed Subsidy						
Coupon Program						
TOTAL, est. subsidies[d]	100	100	154	87.1	138.0	124.7
GRAND TOTAL, Dept. of Coop/Mkting expenditures, SIDA support and subsidies	101.19	101.37	155.37	89.68	141.3	127.6

Table 91: Estimated GRZ and donor expenditures on maize marketing and related expenditures, 1978-94[a] (financial)(con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Dept. of Cooperatives and Marketing											
Personal Emoluments	1.748	1.815	2.444	2.414	3.053	3.865	7.441	22.61			
Allowances	.0088	.245	.142	.118	.171	.185	1.645	.504			
Purchase of Goods	.0382	.067	.1635	.1802	.2676	.371	.5385	1.091			
Purchase of Services	.0421	.0655	.1724	.1715	.6005	.5375	.7467	.684			
Motor Vehicles, movable assets			1.249	.415		.05	.751	1.364			
Rural Storage Facilities				.506	.091	.09	.090	.251			
ECU Project[b]					.5						
TOTAL, est. Dept. of Coop/Mkting expenditures	1.837	1.972	4.170	3.804	4.683	5.098	11.21	26.5	48.69	48.69	48.69
SIDA support to cooperative sector[f]	3.33	4.24	32.11	23.56	27.98	65.94	137.23	294.95	573.74	573.74	573.74
TOTAL, Dept. of Coop/Mkting and SIDA support	5.167	6.21	36.28	27.36	32.66	71.04	148.44	321.45	622.43	622.43	622.43
SUBSIDIES											
Fertilizer Handling[c]	6.56			164.7	164.7	285.6	760				
Fertilizer Price Differential Subsidy[c]	9.52										
Subsidies to Namboard	7										
Subsidies to Cooperative Unions	58.5	31.3			770	700	1304				
Milling Subsidy					478.3						
Seed Subsidy				9.7							
Coupon Program						600	1300				
TOTAL, est. subsidies[d]	81.6	134	565	638.4	1413	1586	3364	6983	6415	3207	0
GRAND TOTAL, Dept. of Coop/Mkting expenditures, SIDA support and subsidies	86.77	140.21	601.28	665.76	1445.66	1657.04	3512.44	7304.45	7037.43	3829.43	622.43

[a] Based on actual expenditures reported in GRZ Financial Reports, 1984-91, and subsidy estimates in GRZ, 1990. 100 percent of total expenditures in each category are attributed to maize marketing. 1991 estimates are provisional or estimates based on 1990 levels; actual expenditure data was not available. 1992 and 1993 estimates assume GRZ spending on subsidies declines to 50% and 25% of 1991

expenditures, respectively. Subsidy expenditures for the period 1994-2000 are assumed to decline to 0. Dept. of Coop/Mkting expenditures are assumed to remain constant at 1991 levels for the 1992-2000 period.

[b] Partially funded by World Bank

[c] 80% of total expenditures were attributed to maize

[d] Subsidy category expenditures above do not add to this total, since complete information about breakdown of subsidy expenditures was not available for any year. Total estimated subsidies data are from GRZ, 1990

[e] Expenditure details were not available for 1978-83. 1978, 1979 totals are estimated; 1980-83 totals are from GRZ, 1990

[f] Data are from budgets in SIDA Annual Reports, 1978-92; 70% of total support to the cooperative sector was attributed to maize. Lesser amounts of support were also provided by other donors, e.g. Norad and Finnida, but detailed expenditure data was not available.

Table 92: Estimated GRZ and donor expenditures on maize marketing and related expenditures, 1978-94 (economic)

ml. ZK

ITEM	1978	1979	1980	1981	1982	1983
Dept. of Coop. and Marketing						
Personal Emoluments[a]						
Allowances[a]						
Purchase of Goods[b]						
Purchase of Services[b]						
Motor Vehicles, movable assets[c]						
Rural Storage Facilities[c]						
ECU Project[c]						
TOTAL, est. Dept. of Coop/Mkt. expend.						
SIDA support to cooperative sector[f]	4.11	4.77	4.81	9.26	12.44	8.17
TOTAL, Dept. of Coop/Mkting and SIDA support	4.11	4.77	4.81	9.26	12.44	8.17
SUBSIDIES						
Fertilizer Handling						
Fertilizer Price Differential Subsidy						
Subsidies to Namboard						
Subsidies to Coop. Unions						
Milling Subsidy						
Seed Subsidy						
Coupon Program[d]						
TOTAL, est. subsidies[e]	93.24	94.08	145.84	84.39	140.45	94.89
GRAND TOTAL, Dept. of Coop/Mkt. expend., SIDA support and subsidies	97.34	98.86	150.65	93.65	152.89	103.1

Table 92: Estimated GRZ and donor expenditures on maize marketing and related expenditures, 1978-94 (economic)(con't)

ml. ZK

ITEM	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Dept. of Coop. and Marketing											
Personal Emoluments[a]	1.748	1.815	2.444	2.414	3.053	3.865	7.441	22.61			
Allowances[a]	.0088	.0245	.1415	.1176	.1708	.1846	1.645	.504			
Purchase of Goods[b]	.085	.077	.1287	.2292	.4145	.5219	1.033	1.89			
Purchase of Services[b]	.0938	.0752	.1357	.218	.930	.756	1.432	1.185			
Motor Vehicles, movable assets[c]			.947	.544		.073	1.532	2.497			
Rural Storage Facilities[c]				.662	.1476	.132	.1837	.4585			
ECU Project[c]					.811						
TOTAL, est. Dept. of Coop/Mkt. expend.	1.936	1.991	3.79	4.184	5.527	5.532	13.27	29.14	53.54	48.69	48.7
SIDA support to cooperative sector[f]	7.96	4.95	24.36	30.82	45.39	96.33	280.1	539.9	1137.7	1137.7	1138
TOTAL, Dept. of Coop/Mkting and SIDA support	9.9	6.95	28.15	35.0	50.92	101.87	293.3	569.0	1191.3	1186.4	1186
SUBSIDIES											
Fertilizer Handling											
Fertilizer Price Differential Subsidy											
Subsidies to Namboard											
Subsidies to Coop. Unions											
Milling Subsidy											
Seed Subsidy											
Coupon Program[d]											
TOTAL, est. subsidies[e]	52.68	73.59	201.44	392.5	1466.9	1482.9	4393.7	8180.7	8141.5	4070.1	0
GRAND TOTAL, Dept. of Coop/Mkt. expend., SIDA support and subsidies	62.57	80.54	229.59	427.5	1517.9	1584.7	4687.0	8749.7	9332.7	5256.5	1186

[a] No tradeable goods in this category
[b] 75% of expenditures are considered tradeable goods and valued at the SER
[c] 85% of expenditures are considered tradeable goods and valued at the SER
[d] Not included in economic analysis
[e] For 1978-84, 1985-87, 1988-93, 27%, 47% and 64% of total subsidies are included in the economic analysis. It is estimated that approximately 73%, 53% and 36% of subsidies respectively are expenditures on coupons and other transfer categories, which are not included in economic analysis. The remainder are considered to be costs of production or marketing, not transfers. Of the proportion included in the economic analysis, 85% of expenditures are considered to be tradeable items, and valued at the SER.

The 27-73, 47-53 and 64-36 proportions were derived at as follows:

Of the above subsidies:

Fertilizer handling -- covered 50% of the cost of marketing by Namboard, PCUs; 100% is included in the economic analysis

Fertilizer price differential subsidy -- difference between landed cost and (cheaper) price to farmers; not included since the economic import parity price is already being used in the economic analysis (discontinued after 1984)

Subsidies to Namboard, Coop Unions -- included a price differential subsidy to cover the difference between Namboard/PCU purchase and selling price of maize; subsidies to cover inter- and intra-provincial maize movement; a price differential subsidy to cover the difference between buying and selling prices of imported maize, when necessary. Of these, all are included in the economic analysis except the price differential subsidy to cover the difference between Namboard/PCU buying and selling prices, which is considered a transfer to consumers rather than a cost of production or marketing. No breakdown of Namboard/Coop Union subsidies is available that would indicate the proportion of this transfer in the total subsidy. It is estimated by assuming that the costs of the coupon program, starting in 1989, since it fulfilled the same function in reducing consumer price, serve as a proxy for the consumer transfer part of the subsidy paid to Namboard/Coop Unions before 1989. In 1989 and 1990, the coupon program represented 36% of total maize subsidies.

Seed subsidy -- covered additional cost of imported seed when imports were necessary; 100% included in the economic analysis because Zambian-produced seed is valued at its domestic price, not the import parity price in the economic analysis

Import subsidy--price differential subsidy on commercial imports of maize to cover the difference between the buying and selling prices of imported maize; imports of maize were necessary from 1978-87, and, though breakdowns only exist for 1980-1984, for those years it represented approximately 15% of total subsidies. Not included in economic analysis, because maize is valued at import parity price.

Coupon program--provision of coupons to urban residents to lower the cost of mealie meal; as a transfer, not included in the economic analysis

Milling subsidy -- price differential subsidy to millers in years when the into-mill price of maize and the mealie meal selling price did not cover all milling costs; 100% included in the economic analysis.

APPENDIX 10

APPENDIX 10

CALCULATION OF SHADOW EXCHANGE RATE AND IMPORT PARITY PRICES

Table 93: Actual SEK/SDR end-of-period exchange rates, 1979-92[a]

Year	SEK/ SDR
1979	5.4623
1980	5.5771
1981	6.484
1982	8.0466
1983	8.3766
1984	8.8116
1985	8.365
1986	8.3409
1987	8.2963
1988	8.2855
1989	8.1833
1990	8.1063
1991	7.9096
1992	7.8896

[a] Source: IMF International Financial Statistics

Table 94: Calculation of shadow exchange rate[a]

Date	Nominal K/US$	Constant Real K/US$	Zambia Prices	Industrial Country Prices	Real K/US$	Nominal K/SDR	Constant Real K/SDR	Real K/SDR	Actual US$/SDR	Cross Constant Real K/US$[b]
1978	0.79	3.89	32.29	60.50	1.47	1.02	4.00	1.91	1.30	3.07
1979	0.78	3.91	35.43	66.00	1.45	1.02	4.03	1.90	1.32	3.06
1980	0.80	3.92	39.55	73.60	1.49	1.02	4.03	1.90	1.28	3.16
1981	0.88	4.02	44.69	81.00	1.59	1.02	4.14	1.85	1.16	3.56
1982	0.93	4.24	50.76	87.20	1.60	1.02	4.37	1.75	1.10	3.96
1983	1.51	4.82	60.71	91.80	2.28	1.28	4.96	1.94	1.05	4.74
1984	2.20	5.53	72.86	96.10	2.90	2.16	5.69	2.85	0.98	5.80
1985	5.70	7.29	100.00	100.00	5.70	6.26	7.50	6.26	1.10	6.83
1986	12.71	10.82	151.85	102.30	8.56	15.55	11.13	10.48	1.22	9.10
1987	8.00	15.03	217.16	105.30	3.88	11.35	15.47	5.50	1.42	10.90
1988	10.00	22.65	337.80	108.70	3.22	13.46	23.31	4.33	1.35	17.32
1989	21.65	42.65	663.46	113.40	3.70	27.94	43.88	4.78	1.31	33.39
1990	42.73	131.44	2142.00	118.80	2.37	60.98	135.23	3.38	1.42	95.05
1991	89.29	245.37	4247.70	126.20	2.65	126.58	252.44	3.76	1.43	176.53
1992	161.29	483.46	8495.40	128.10	2.43	232.56	497.39	3.51	1.43	347.82

[a] Source: International Monetary Fund International Financial Statistics

[b] The cross-constant real K/US$ rate is used as the shadow exchange rate to convert kwacha values into dollar values in the economic analysis. The method for estimating the shadow exchange rate follows Harber, 1991 and 1992. The shadow exchange rate is based upon purchasing power parity principles, using a projection of what was considered to be an appropriate exchange rate in September, 1985. Harber (1991) calculated the "appropriate" exchange rate as follows:

> "The parallel rate in September 1985 was approximately K8/US$. A general rule of thumb to use in estimating appropriate or equilibrium exchange rates is to deduct 20-30 percent from parallel rates to remove the risk premium included in the parallel rate. Assuming a 25 percent risk premium in September 1985, the "appropriate" exchange rate for that time is estimated at K6/US$ or K6.17/SDR. To arrive at the "appropriate" rate for other time periods, this rate is adjusted according to movements in Zambia's consumer prices and the Industrial Country price index from the International Financial Statistics in order to find the nominal exchange rate which would maintain a constant real exchange rate of K6/US$ in September 1985." (Harber, 1991:10)

The K/SDR rate is then converted back to U.S. dollar terms using the US$/SDR exchange rate to arrive at the cross constant real K/US$ exchange rate, used here as the shadow exchange rate. The cross constant exchange rate is used in order to eliminate the fluctuations of the US$ against other (non-kwacha) currencies which would be reflected in a direct US$/K rate calculation

Table 95: Calculation of economic import parity price for maize

Year	Official Price Zim$[a]	Exch. Rate US/Zim$[a]	Price USD	SER ZK/USD[b]	Nominal ZK/USD[b]	Pan-Territorial Price ZK	Transport Cost to Zambia Border ZK[c]	Border Price ZK[c]	Rail Transport LVGSN-LSK[d]	Rail Transport LSK-NDOLA[d]	Truck Transport 1-50 Km ZK/Ton/Km[e]	Truck Transport 51-100 Km ZK/Ton/Km[e]
1978	57.10	1.48	84.51	3.07	0.79	259.44	63.86	323.30	118.75	187.50	0.35	0.28
1979	63.90	1.47	93.93	3.06	0.78	287.43	63.65	351.08	118.28	186.75	0.35	0.29
1980	89.00	1.55	137.95	3.16	0.8	435.92	65.73	501.65	122.08	192.75	0.35	0.29
1981	137.00	1.45	198.65	3.56	0.88	707.19	74.05	781.24	137.28	216.75	0.36	0.30
1982	137.00	1.32	180.84	3.96	0.93	716.13	82.37	798.49	152.12	240.19	0.38	0.31
1983	157.00	0.99	155.43	4.74	1.51	736.74	98.59	835.33	186.79	294.94	0.34	0.29
1984	177.00	0.80	141.60	5.80	2.2	821.28	120.64	941.92	232.75	367.50	0.56	0.45
1985	222.00	0.62	137.64	6.83	5.7	940.08	142.06	1082.15	311.01	491.06	0.80	0.75
1986	222.00	0.60	133.20	9.10	12.71	1212.12	189.28	1401.40	475.12	750.19	0.63	0.55
1987	222.00	0.60	133.20	10.90	8	1451.88	226.72	1678.60	483.31	763.13	1.16	1.02
1988	245.00	0.56	137.20	17.32	10	2376.30	360.26	2736.56	735.78	1161.75	2.25	1.86
1989	285.00	0.47	133.95	33.39	21.65	4472.59	694.51	5167.10	1446.61	2284.13	5.63	4.64
1990	305.00	0.40	122.00	95.05	42.73	11596.10	1977.04	13573.14	3893.58	6147.75	13.81	11.39
1991	360.00	0.32	115.20	176.53	89.29	20336.26	3671.82	24008.08	7349.20	11604.00	22.82	19.32
1992	1070.00	0.19	203.30	347.82	161.29	70711.81	7234.66	77946.46	14306.41	22589.06	45.17	38.26

(continued next page)

Table 95: Calculation of economic import parity price for maize (con't)

Truck Transport 101-200 Km ZK/Ton/Km[c]	Truck Transport 200+ Km ZK/Ton/Km[d]	CIF Lusaka[e]	CIF Ndola[e]	CIF Lvgstn[f]	Farm Gate Lvgstn[g]	Farm Gate Mongu[h]	Farm Gate Ndola[j]	Farm Gate Kabwe[k]	Farm Gate Kasama[l]	Farm Gate Chipata[m]	Farm Gate Solwezi[n]	Farm Gate Mansa[o]	Farm Gate Lusaka[p]	Farm Gate Choma[q]	Weighted Imp. Parity Price[r]
0.22	0.19	474.38	543.13	355.63	327.14	391.35	482.31	383.66	331.74	270.78	433.52	392.88	413.56	373.69	349.23
0.22	0.19	504.47	572.94	386.19	357.46	418.22	509.10	410.46	331.90	296.59	459.88	418.89	440.63	400.40	372.82
0.22	0.19	673.89	744.57	551.82	522.90	572.26	665.49	564.45	487.16	449.86	615.95	574.70	594.81	554.34	526.98
0.23	0.20	996.64	1076.12	859.37	829.81	865.91	968.44	857.93	786.14	740.78	917.79	875.63	888.96	847.58	820.92
0.24	0.21	1030.46	1118.53	878.34	847.35	895.45	1007.69	887.08	816.54	764.25	954.59	910.38	919.62	876.23	848.94
0.23	0.18	1105.66	1213.80	918.86	890.22	974.75	1101.62	961.83	915.75	856.39	1054.77	1015.76	993.48	955.19	929.31
0.33	0.22	1268.86	1403.61	1036.11	991.57	1126.34	1264.87	1085.02	999.94	962.63	1207.63	1159.97	1130.12	1083.35	1055.27
0.47	0.34	1501.37	1681.42	1190.36	1115.70	1324.12	1498.54	1254.91	1125.07	1059.34	1409.98	1336.23	1318.49	1246.12	1218.28
0.43	0.35	2016.66	2291.73	1541.54	1486.45	1783.93	2096.50	1763.00	1753.26	1555.12	2005.48	1929.70	1821.43	1747.06	1738.29
0.80	0.65	2329.77	2609.59	1846.46	1744.71	1993.17	2339.98	1951.99	1704.56	1572.37	2173.27	2034.46	2060.16	1923.94	1860.52
1.55	1.24	3745.99	4171.97	3010.22	2824.34	3141.47	3712.43	3077.34	2484.07	2354.58	3393.96	3128.77	3286.46	3026.22	2850.11
3.94	3.66	7130.43	7967.94	5683.81	5219.60	5552.78	6987.02	5617.77	3863.59	3399.13	6047.06	5264.38	6149.50	5381.45	4977.51
9.67	9.30	18824.03	21078.20	14930.45	13790.97	14726.48	18581.41	15022.00	10914.40	9330.72	16190.31	14199.28	16327.23	14373.42	13530.81
15.14	12.55	33758.09	38012.89	26408.89	24476.84	28057.93	33680.03	27380.72	21670.44	19991.14	30455.88	27771.18	29425.23	26790.71	25667.73
29.97	24.82	100047.51	108330.2	85741.11	81914.87	85730.29	96709.29	84380.52	72942.11	69764.03	90331.25	85020.34	88426.63	83215.00	80914.14

[a] Source: Government of Zimbabwe, Government Maize Board Annual Reports 1978-92

[b] See Table 94.

[c] Personal communication, J. Oliver, MAFF Logistics and Control Center. Assumed that 75% of total rail cost composed of imported goods, therefore 75% of total cost converted to ZK at SER, 25% at nominal rate.

[d] Closest large depot is approximately 130 kms from Zimbabwe/Zambia border at Chirundu. Transport cost is estimated at USD $.16/ton/km (personal communication, 1993, T. Jayne)

[e] Insurance and unloading costs estimated at 10% of border price

[f] Livingstone price = border price + 10% loading, insurance charges

[g] Livingstone FG = Livingstone CIF - (transport cost*100 km + handling, misc. costs(.1*border price))

[h] Mongu FG = Lusaka CIF- (transport cost*417 km (Lusaka-Mongu)-transportcost*100 km (intra-provincial))

[i] Source: GRZ Ministry of Cooperatives, Dept. of Marketing, Logistics and Information Center, Lusaka, for 1984-90 data; other years estimated. Assumed that 75% of truck transport cost composed of imported goods.

[j] Ndola FG= Ndola CIF - (transport cost*100km + handling, misc (.1*border price)

[k] Kabwe FG = Lusaka CIF - (transport cost*135kms(Lusaka-Kabwe) + transportcost*100km + handling, misc.(.1*border price)

[l] Kasama FG = Ndola CIF - (transport cost*793km(Ndola-Kasama) + transportcost*100km + handling, misc (.1*border price)

[m] Chipata FG = Lusaka CIF - (transport cost*752km(Lusaka-Chipata)+transportationcost*100)+handling,misc. (.1*border price))

[n] Solwezi FG = Ndola CIF - (transport cost*257(Ndola-Solwezi)+transportcost*100km + handling, misc. (.1*border price)

[o] Mansa FG = Ndola CIF - (transport cost*471(Ndola-Mansa)+transportcost*100 km + handling, misc. (1.*border price)

[p] Lusaka FG = Lusaka CIF - (transport cost*100 + handling, misc.(.1*border price)

[q] Choma FG = Lusaka CIF - (transport cost*210 km(Lusaka-Choma)+transportcost*100)+handling,misc.(.1*border cost)

[r] Weighted according to provincial shares in the national maize market. See Table 2: Provincial Shares of the National Maize Market, 1982-92. Shares for other years estimated.

Table 96: Economic import parity prices, Compound D and ammonium nitrate fertilizers

Year	SER ZK/USD[a]	Compound D CIF Lsk USD[b]	Amm. Nitrate CIF Lsk USD[b]	Compound D CIF Lsk ZK[b]	Amm. Nitrate CIF Lsk ZK[b]	Truck Transport 1-50 Km ZK/Ton/Km[c]	Truck Transport 51-100 Km ZK/Ton/Km[c]	Truck Transport 101-200 Km ZK/Ton/Km[c]	Truck Transport 200+ Km ZK/Ton/Km[c]
1978	3.07	162.8	119.8	499.9	367.8	0.35	0.28	0.22	0.19
1979	3.06	162.8	119.8	498.2	366.6	0.35	0.29	0.22	0.19
1980	3.16	162.8	119.8	514.5	378.6	0.35	0.29	0.22	0.19
1981	3.56	162.8	119.8	579.6	426.5	0.36	0.30	0.23	0.20
1982	3.96	162.8	119.8	644.8	474.4	0.38	0.31	0.24	0.21
1983	4.74	162.8	119.8	771.8	567.9	0.34	0.29	0.23	0.18
1984	5.8	162.8	119.8	944.3	694.9	0.56	0.45	0.33	0.22
1985	6.83	162.8	119.8	1112.0	818.3	0.80	0.75	0.47	0.34
1986	9.1	162.8	119.8	1481.6	1090.2	0.63	0.55	0.43	0.35
1987	10.9	162.8	119.8	1774.7	1305.9	1.16	1.02	0.80	0.65
1988	17.32	162.8	119.8	2820.0	2075.0	2.25	1.86	1.55	1.24
1989	33.39	162.8	119.8	5436.5	4000.2	5.63	4.64	3.94	3.66
1990	95.05	162.8	119.8	15475.8	11387.3	13.81	11.39	9.67	9.30
1991	176.53	162.8	119.8	28742.2	21148.9	22.82	19.32	15.14	12.55
1992	347.82	162.8	119.8	56631.2	41670.1	45.17	38.26	29.97	24.82

(continued next page)

Table 96, continued. Economic import parity prices, Compound D and ammonium nitrate fertilizers

	Depot Mongu[e]		Depot Ndola[f]		Depot Kabwe[g]		Depot Kasama[h]	
Year	Comp. D	Amm. Nit.	Comp. D	Amm. Nit.	Comp. D	Amm. Nit.	Comp. D	Amm. Nit.
1978	657.1	511.8	644.5	499.3	607.5	462.3	740.9	595.6
1979	656.3	511.5	643.7	498.9	606.7	462.0	740.1	595.3
1980	674.2	524.7	661.6	512.1	624.7	475.1	758.0	608.5
1981	751.0	582.6	737.8	569.4	698.6	530.2	839.2	670.8
1982	827.8	640.4	813.9	626.6	772.6	585.3	920.4	733.0
1983	953.0	728.7	941.1	716.8	909.0	684.7	1032.4	808.1
1984	1175.5	901.1	1161.0	886.6	1128.3	853.9	1272.5	998.1
1985	1440.0	1116.9	1417.6	1094.4	1361.7	1038.5	1590.0	1266.8
1986	1830.8	1400.2	1807.7	1377.1	1742.9	1312.3	1985.1	1554.5
1987	2325.2	1809.5	2282.3	1766.6	2162.2	1646.4	2611.9	2096.1
1988	3805.1	2985.6	3723.2	2903.7	3497.3	2677.8	4351.9	3532.4
1989	7970.3	6390.5	7728.8	6148.9	6976.0	5396.2	9584.4	8004.6
1990	22040.5	17543.2	21426.7	16929.4	19467.8	14970.5	26141.8	21644.5
1991	38781.8	30429.2	37953.5	29600.9	35592.3	27239.7	44316.3	35963.7
1992	76470.3	60013.1	74832.2	58375.0	70166.3	53709.1	87415.9	70958.7

(continued next page)

Table 96, continued. Economic import parity prices, Compound D and ammonium nitrate fertilizers

Year	Depot Chipata[i] Comp. D	Amm. Nit.	Depot Solwezi[j] Comp. D	Amm. Nit.	Depot Mansa[k] Comp. D	Amm. Nit.	Depot Lusaka[l] Comp. D	Amm. Nit.	Depot Choma[m] Comp. D	Amm. Nit.	Weighted Imp. Parity Price[n] Comp. D	Amm. Nit.
1978	720.7	575.5	685.9	540.7	687.5	542.2	577.8	432.6	617.7	472.5	651.8	506.5
1979	719.9	575.1	685.2	540.4	686.7	541.9	577.0	432.3	616.9	472.2	651.0	506.2
1980	737.8	588.3	703.1	553.5	704.6	555.1	595.0	445.4	634.9	485.3	668.9	519.4
1981	818.0	649.6	781.4	613.0	783.0	614.6	667.6	499.2	709.6	541.2	745.3	576.9
1982	898.2	710.8	859.7	672.4	861.4	674.0	740.2	552.9	784.3	597.0	821.8	634.5
1983	1013.3	789.0	980.4	756.1	981.8	757.5	877.9	653.7	915.7	691.5	948.7	724.4
1984	1249.2	974.8	1209.0	934.5	1210.7	936.3	1083.8	809.3	1130.0	855.5	1171.8	897.4
1985	1553.9	1230.8	1491.7	1168.5	1494.4	1171.3	1298.2	975.1	1369.6	1046.5	1433.0	1109.9
1986	1948.0	1517.4	1884.0	1453.4	1886.8	1456.2	1684.8	1254.2	1758.3	1327.7	1821.8	1391.2
1987	2543.0	2027.2	2424.0	1908.3	2429.2	1913.5	2054.2	1538.4	2190.7	1674.9	2308.6	1792.9
1988	4220.5	3401.0	3993.6	3174.1	4003.5	3184.0	3288.0	2468.5	3548.4	2728.9	3774.2	2954.7
1989	9196.4	7616.6	8526.7	6946.8	8555.9	6976.1	6444.1	4864.3	7212.7	5632.9	7858.2	6278.3
1990	25156.0	20658.7	23454.1	18956.8	23528.5	19031.2	18162.4	13665.1	20115.4	15618.1	21744.2	17246.9
1991	42986.0	34633.4	40689.4	32336.8	40789.8	32437.2	33548.4	25195.8	36183.9	27831.3	38450.9	30098.3
1992	84785.0	68327.8	80242.9	63785.7	80441.5	63984.3	66120.3	49663.1	71332.5	54875.3	75816.9	59359.7
1993	84785.0	68327.8	80242.9	63785.7	80441.5	63984.3	66120.3	49663.1	71332.5	54875.3	75816.9	59359.7

[a] See Table 94.

[b] Source: GRZ, 1989 for CIF in ZK for 1988/89. CIF in USD was obtained by dividing by SER for 1988. The CIF in USD was assumed constant for other years, and converted to ZK by multiplying by the SER for each year.

[c] Source: GRZ Ministry of Cooperatives, Dept. of Marketing, Logistics and Information Center, Lusaka, for 1984-90 data; other years estimated. Assumed that 75% of truck transport cost composed of imported goods.

[d] Livingstone rural depot = Lusaka CIF + transport cost*475km (Lusaka-Livingstone) + transport cost*100 km (intra-provincial)+handling,misc.costs (.1*Lusaka CIF)

[e] Mongu rural depot = Lusaka CIF + transport cost*417 km (Lusaka-Mongu)+transport cost*100 km (intra-provincial) + handling, misc. (.1*Lusaka CIF)

[f] Ndola rural depot = Lusaka CIF + transport cost*351 km (Lusaka-Ndola) + transport cost*100km + handling, misc (.1*Lusaka CIF)

[g] Kabwe rural depot = Lusaka CIF + transport cost*135kms(Lusaka-Kabwe) + transport cost*100km + handling, misc.(.1*Lusaka CIF)

[h] Kasama rural depot = Lusaka CIF + transport cost*858km (Lusaka-Kasama)+transport cost*100km+handling, misc (.1*Lusaka CIF)

[i] Chipata rural depot = Lusaka CIF + transport cost*752km (Lusaka-Chipata) + transportation cost*100 + handling, misc. (.1*Lusaka CIF)

[j] Solwezi rural depot = Lusaka CIF + transport cost*569(Lusaka-Solwezi)+transport cost*100km + handling, misc. (.1* Lusaka CIF)

[k] Mansa rural depot = Lusaka CIF + transport cost*577 (Lusaka-Mansa)+ transport cost*100 km + handling, misc. (1.* Lusaka CIF)

[l] Lusaka rural depot = Lusaka CIF + transport cost*100 + handling, misc.(.1*Lusaka CIF)

[m] Choma rural depot = Lusaka CIF + transport cost*210 km(Lusaka-Choma) + transport cost*100 + handling, misc.(.1*Lusaka CIF)

[n] Weighted according to 1986/7-87/8 average provincial shares in the national fertilizer market. Source: GRZ, 1989. Western: 2.96%; Copperbelt, 4.91%; Central, 24.43 %; Northern, 9.32%; Eastern, 23.88%; Northwestern, 1.46%; Luapula, 2.26%; Lusaka, 11.55%; Southern, 19.23%.

Table 97: Calculation of import parity prices for Zimbabwean short-season maize hybrids (R201, R215)

price/50 kg bag

Year	Off. price Zim$[a]	Exch. rate US/Zim$[a]	Price USD	SER ZK/ USD[b]	Nom. ZK/ USD[b]	Pan-terr. price ZK	Trans. cost to Zambia border ZK[c]	Border price ZK[c]	Rail trans. Lvgstn-Lsk[d]	CIF Lusaka[e]
1978	15.20	1.48	22.50	3.07	0.79	69.08	3.19	72.27	5.94	92.66
1979	15.31	1.47	22.50	3.06	0.78	68.85	3.18	72.03	5.91	92.35
1980	14.52	1.55	22.50	3.16	0.8	71.10	3.29	74.39	6.10	95.37
1981	15.52	1.45	22.50	3.56	0.88	80.10	3.70	83.80	6.86	107.43
1982	17.05	1.32	22.50	3.96	0.93	89.10	4.12	93.22	7.61	119.47
1983	22.73	0.99	22.50	4.74	1.51	106.65	4.93	111.58	9.34	143.24
1984	28.13	0.80	22.50	5.80	2.2	130.50	6.03	136.53	11.64	175.48
1985	36.29	0.62	22.50	6.83	5.7	153.68	7.10	160.78	15.55	208.48
1986	37.50	0.60	22.50	9.10	12.71	204.75	9.46	214.21	23.76	280.81
1987	37.50	0.60	22.50	10.90	8	245.25	11.34	256.59	24.17	332.07
1988	37.50	0.56	21.00	17.32	10	363.72	18.01	381.73	36.79	494.87
1989	50.00	0.47	23.50	33.39	21.65	784.67	34.73	819.39	72.33	1055.6
1990	65.50	0.40	26.20	95.05	42.73	2490.31	98.85	2589.16	194.68	3301.7
1991	72.50	0.32	23.20	176.53	89.29	4095.50	183.59	4279.09	367.46	5502.4
1992	122.11	0.19	23.20	347.82	161.29	8069.42	361.73	8431.16	715.32	10832.7

[a] Source: Economics and Inputs Department, Commercial Farmers' Union, Zimbabwe for 1987-91. Prices for other years estimated. Prices are for short-season Zimbabwean maize hybrids, such as R201, R215, which are most commonly imported by Zambia.

[b] See Table 94.

[c] Closest large depot is approximately 130 kms from Zimbabwe/Zambia border at Chirundu. Transport cost is estimated at USD $.16/ton/km (personal communication, 1993, T. Jayne)

[d] MAFF Logistics and Information Center. Assumed that 75% of total rail cost composed of imported goods, therefore 75% of total cost converted to ZK at SER, 25% at nominal rate.

[e] Insurance, internal transport and unloading costs estimated at 20% of border price. It is assumed that most imported seed is used in Central and Southern Province within 100 kms of Lusaka.

APPENDIX 11

APPENDIX 11

Appendix 11: Calculation of financial and economic ARR

Table 98: ARR financial analysis, benefit-cost method, part I

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT RESEARCH, OTHER PROGRAMS											
Total area (mln hectares)[a,b]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Tot LG[c]	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.050	0.050	0.050	0.050	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.442	0.480	0.685	0.490	0.374	0.504	0.516	0.472	0.599	0.632	0.737
SM/MED, local	0.290	0.314	0.449	0.321	0.245	0.330	0.338	0.309	0.392	0.414	0.483
SM/MED, non-Zambian	0.045	0.049	0.070	0.050	0.038	0.051	0.053	0.048	0.061	0.064	0.075
SM/MED, SR52	0.107	0.117	0.166	0.119	0.091	0.122	0.125	0.115	0.146	0.153	0.179
Yield (tons/ha)[i,j]											
Avg LG	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.43	5.43	5.43	5.43	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22
SM/MED, non-Zambian	.78	0.52	.94	.82	1.16	.96	1.34	1.63	.76	1.62	1.46
SM/MED, SR52	.71	0.48	.86	.75	1.06	.88	1.23	1.49	.69	1.48	1.33
Production (mln tons)[k]											
LG, non-Zambian	0.056	0.056	0.056	0.056	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR-52	0.274	0.274	0.274	0.274	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.189	0.139	0.354	0.222	0.240	0.268	0.381	0.424	0.250	0.564	0.590
SM/MED, non-Zambian	0.035	0.025	0.065	0.041	0.044	0.050	0.071	0.079	0.046	0.104	0.110
SM/MED, SR-52	0.076	.055	0.143	0.089	0.097	0.108	0.153	0.171	0.101	0.227	0.239
TOTAL SM/MED	0.3000	0.220	0.562	0.353	0.381	0.425	0.605	0.674	0.398	0.895	0.938
Total Production	0.630	0.549	0.891	0.682	0.711	0.756	0.935	1.005	0.728	1.225	1.268
Price (ZK/ton)[l]	100	130	150	178	203	272	315	611	867	889	1389

(Continued next page)

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production Value (mln ZK)											
LG, non-Zambian	5.61	7.29	8.41	9.97	9.28	12.42	14.36	27.88	39.55	40.56	63.38
LG, SR52	27.37	35.58	41.05	48.65	57.85	77.44	89.52	173.85	246.56	252.88	395.13
Total LG	32.97	42.87	49.46	58.62	67.12	89.87	103.88	201.74	286.11	293.44	458.50
SM/MED, local	18.94	18.03	53.04	39.53	48.72	72.54	119.75	259.27	217.04	501.23	819.24
SM/MED, non-Zambian	3.50	3.31	9.82	7.30	9.04	13.50	22.21	48.09	40.21	92.52	152.09
SM/MED, SR52	7.59	7.20	21.38	15,86	19.65	29.38	48.30	104.79	87.52	202.05	331.27
Total SM/MED	30.03	28.54	84.24	62.68	77.42	115.82	190.25	412.14	344.77	795.80	1302.59
Total Production Value (1)	63.00	71.41	133.20	121.31	144.55	205.69	294.13	613.88	630.87	1089.24	1761.09
WITH RESEARCH, OTHER PROGRAMS											
Total area (mln hectares)[m,n]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Total Large[o]	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.013	0.005	0.007	0.010
LG, SR52	0.050	0.050	0.050	0.050	0.052	0.052	0.052	0.000	0.000	0.000	0.000
LG, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.047	0.055	0.053	0.050
Total SM/MED[p]	0.442	0.480	0.685	0.490	0.374	0.504	0.516	0.472	0.599	0.632	0.737
SM/MED, local	0.290	0.314	0.449	0.321	0.245	0.330	0.321	0.227	0.246	0.235	0.246
SM/MED, non-Zambian	0.045	0.049	0.070	0.050	0.038	0.051	0.028	0.020	0.017	0.020	0.145
SM/MED, SR52	0.107	0.117	0.166	0.119	0.091	0.122	0.161	0.115	0.124	0.118	0.000
SM/MED, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.111	0.207	0.257	0.346
Yield (tons/ha)[q,r]											
Avg LG	5.50	5.50	5.50	5.50	5.50	5.50	5.62	6.39	6.03	6.03	6.03
LG, non-Zambian	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.43	5.43	5.43	5.43	5.45	5.45	5.45				
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	6.54	6.54	6.05	6.06	6.07
Avg SM/MED	0.96	0.64	1.16	1.02	1.44	1.19	1.65	2.21	1.06	2.33	2.22
SM/MED, local	0.83	0.56	1.00	0.88	1.24	1.03	1.43	1.74	0.81	1.73	1.55
SM/MED, non-Zambian	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55
SM/MED, SR52	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13
SM/MED, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	2.35	2.86	1.33	2.83	2.55

(Continued next page)

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production (mln tons)[1]											
LG, non-Zambian	0.056	0.056	0.056	0.056	0.046	0.046	0.045	0.074	0.029	0.041	0.060
LG, SR52	0.274	0.274	0.274	0.274	0.284	0.284	0.282	0.000	0.000	0.000	0.000
LG, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.310	0.333	0.321	0.302
LG total	0.330	0.330	0.330	0.330	0.330	0.330	0.379	0.384	0.362	0.362	0.362
SM/MED, local	0.240	0.176	0.449	0.282	0.304	0.340	0.459	0.395	0.199	0.407	0.381
SM/MED, non-Zambian	0.061	0.045	0.115	0.072	0.078	0.087	0.066	0.057	0.023	0.058	0.371
SM/MED, SR52	0.121	0.089	0.228	0.143	0.155	0.173	0.316	0.274	0.138	0.281	0.000
SM/MED, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.316	0.275	0.727	0.883
TOTAL SM/MED	0.423	0.309	0.791	0.497	0.537	0.600	0.851	1.042	0.635	1.473	1.636
Total Production	0.754	0.636	1.118	0.825	0.867	0.929	1.214	1.427	1.003	1.834	1.997
Price (ZK/ton)	100	130	150	178	203	272	315	611	867	889	1389
Production value (mln ZK)											
LG, non-Zambian	5.61	7.29	8.41	9.97	9.28	12.42	14.24	45.26	25.25	36.19	82.88
LG, SR52	27.37	35.58	41.05	48.65	57.85	77.44	88.81	0.00	0.00	0.00	0.00
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	16.30	189.20	288.49	285.71	419.84
Total LG	32.97	42.87	49.46	58.62	67.12	89.87	119.36	234.46	313.74	321.90	502.72
SM/MED, local	24.03	22.88	67.31	50.16	61.83	92.56	144.56	241.46	172.83	361.74	529.82
SM/MED, non-Zambian	6.13	5.79	17.19	12.78	15.84	23.65	20.82	34.76	19.60	51.47	514.94
SM/MED, SR52	12.14	11.52	34.21	25.38	31.45	47.05	99.55	167.45	119.45	249.44	0.00
SM/MED, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	2.90	193.28	238.62	646.39	1227.04
Total SM/MED	42.31	40.20	118.71	88.32	109.12	163.26	267.83	636.96	550.50	1309.04	2271.80
Total Production Value (2)	75.28	83.06	168.17	146.94	176.24	253.12	387.19	871.42	864.24	1630.94	2774.52
Add'l Benefit (3)=(2)-(1)	12.28	11.66	34.47	25.63	31.70	47.43	93.06	257.54	233.37	541.70	1013.43
COSTS											
Without Research, Other Programs											
Prod. costs (mln ZK)[1]											
LG, SR52, non-Zambian	28.69	28.69	28.69	28.69	31.98	45.14	63.86	134.15	334.57	264.66	302.66
SM/MED, local, no oxen	6.12	6.51	9.61	6.80	5.34	8.80	15.71	42.69	125.54	103.27	180.06
SM/MED, local, oxen	7.13	7.57	11.21	7.93	6.25	10.30	18.42	50.14	146.53	121.34	214.75
SM/MED, SR52, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR52, non-Zambian, oxen	8.36	8.89	13.13	9.29	7.30	12.07	22.13	52.41	147.44	129.37	231.35
Total Prod. costs (4)	50.31	51.66	62.64	52.74	50.87	76.31	120.12	279.40	754.08	618.64	928.82

(Continued next page)

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
With Research, Other Programs											
Prod. costs (mln ZK)											
LG, SR52, non-Zambian	28.69	28.69	28.69	28.69	31.98	45.14	63.36	28.31	27.77	30.70	51.45
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	8.51	107.16	308.51	235.19	252.55
SM/MED, local, no oxen	9.40	10.03	14.72	10.44	8.94	16.39	23.70	39.54	99.96	78.32	117.25
SM/MED, local, oxen	11.24	11.99	17.62	12.49	10.78	19.91	28.54	46.88	117.90	93.29	140.76
SM/MED, SR52, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR52, non-Zambian, oxen	16.17	17.24	25.34	17.96	15.93	30.28	47.24	65.77	155.22	135.74	200.52
SM/MED, Zambian improved, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.15	8.6	36.24	39.67	74.94
SM/MED, Zambian improved, oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.84	46.74	195.51	216.83	411.2
Total Prod. costs (5)	65.50	67.94	86.37	69.58	67.61	111.73	172.34	343.00	941.11	829.73	1248.68
Research costs (mln ZK)											
GRZ expenditures [u]	0.43	0.53	0.65	0.55	0.74	0.73	1.08	1.16	1.91	2.50	4.51
USAID expenditures [v]						0.83	1.57	4.26	9.33	2.03	
SIDA expenditures [w]		0.06	0.07	0.25	0.26	0.30	0.47	0.73	7.37	7.47	9.47
FAO/UNDP expenditures [x]	0.14	0.13	0.14	0.15	0.16	0.21	0.38	0.99	2.20	0.69	0.87
CIMMYT expenditures [y]			0.01	0.01	0.01	0.03	0.07	0.52	0.96	0.94	1.07
Total Research costs (6)	0.57	0.72	0.86	0.97	1.18	2.10	3.56	7.65	21.77	13.63	15.92
Extension costs (mln ZK) [z]											
GRZ and donor expenditures	.47	.53	.96	1.48	1.74	1.20	12.82	18.78	35.02	29.65	36.94
Total Extension costs (7)	.47	.53	.96	1.48	1.74	1.20	12.82	18.78	35.02	29.65	36.94
Seed industry costs (mln ZK)[aa]											
SIDA expenditures		0.16	0.19	0.48	0.60	0.60	0.82	1.87	14.06	9.25	13.05
Zamseed investment expenditures				1.44	0.30	2.71	0.86	0.94	1.10	0.00	0.25
Total seed industry costs (8)	0.00	0.16	0.19	1.92	0.90	3.30	1.68	2.82	15.15	9.25	13.30

(Continued next page)

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Marketing costs and subsidies(mln ZK)[36]											
GRZ and donor expenditures	101.19	101.37	155.37	89.68	141.30	127.60	86.77	140.21	601.28	665.76	1445.66
Total marketing costs (9)	101.19	101.37	155.37	89.68	141.30	127.60	86.77	140.21	601.28	665.76	1445.66
Total Production, Research, Extension, Seed, Mkting Costs (10)	167.73	170.73	243.76	163.62	212.74	245.93	277.18	512.46	1614.33	1548.02	2760.49
Total Add'l Costs (11)=(10)-(4)	117.42	119.07	181.12	110.91	161.87	169.62	157.07	233.06	860.25	929.38	1831.68
Net Benefit, incl. all costs (12)=(3)-(11)	-105.14	-107.41	-146.64	-85.27	-130.17	-122.19	-64.01	24.48	-626.88	-387.68	-818.25
Net Benefit, including add. prod., research costs only (13)=(3)-[(5)+(6)-(4)]	-3.48	-5.35	9.87	7.8	13.77	9.91	37.27	186.29	24.58	316.98	677.65
Net benefit, incl. add. prod., research,extension costs only (14)=(3)-[(5)+(6)+(7)-(4)]	-3.95	-5.88	8.91	6.32	12.03	8.71	24.44	167.50	-10.45	287.33	640.71
Net benefit, incl. add. prod., research, extension, seed costs only (15)=(3)-[(5)+(6)+(7)+(8)-(4)]	-3.95	-6.04	8.73	4.41	11.13	5.41	22.76	164.69	-25.6	278.08	627.41
IRR (%), including all costs, 1978-2001 ==>	28.3										
1978-91 ==>	-100.0										
IRR (%), including add. prod., research costs only, 1978-2001 ==>	116.4										
1978-91 only ==	114.2										
IRR (%), including add. prod., research and extension costs only, 1978-2001	105.6										
1978-91 only ==>	102.0										
IRR (%), including add. prod., research, extension and seed costs only, 1978-2001 ==>	102.2										
1978-91 only ==>	97.9										

(For footnotes, see end of Part II of table.)

Table 99: ARR financial analysis, benefit-cost method, part II

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/ 2000	2000/ 01
BENEFITS												
WITHOUT RESEARCH, OTHER PROGRAMS												
Total area (mln hectares)[a,b]	0.668	0.579	0.662	0.633	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Tot LG[c]	0.051	0.044	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.007	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.044	0.038	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.617	0.535	0.602	0.573	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
SM/MED, local	0.404	0.350	0.394	0.375	0.288	0.288	0.288	0.288	0.288	0.288	0.288	0.288
SM/MED, non-Zambian	0.063	0.055	0.061	0.058	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
SM/MED, SR52	0.150	0.130	0.146	0.139	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
Yield (tons/ha)[i,j]												
Avg LG	5.50	5.50	3.85	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.86	5.86	4.10	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.45	5.45	3.82	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	1.02	1.20	0.37	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.42
SM/MED, non-Zambian	1.21	1.42	0.38	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
SM/MED, SR52	1.11	1.30	0.34	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Production (mln tons)[k]												
LG, non-Zambian	0.039	0.034	0.032	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR52	0.242	0.209	0.199	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.280	0.242	0.231	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.411	.420	.147	.420	.322	.322	.322	.322	.322	.322	.322	.322
SM/MED, non-Zambian	0.076	.078	.023	.077	.059	.059	.059	.059	.059	.059	.059	.059
SM/MED, SR52	.166	.169	.05	.169	.130	.130	.130	.130	.130	.130	.130	.130
TOTAL SM/MED	.653	.666	.220	.666	.512	.512	.512	.512	.512	.512	.512	.512
Total Production	.933	.908	.451	.996	.842	.842	.842	.842	.842	.842	.842	.842
Price (ZK/ton)[l]	3158	5556	33330	40000	40000	40000	40000	40000	40000	40000	40000	40000

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Production Value (mln ZK)												
LG, non-Zambian	122.54	186.39	1064.59	1825.20	1825.20	1825.20	1825.20	1825.20	1825.20	1825.20	1825.20	1825.20
LG, SR52	762.70	1160.09	6637.44	11379.60	11379.60	11379.60	11379.60	11379.60	11379.60	11379.60	11379.60	11379.60
Total LG	885.25	1346.48	7702.03	13204.80	13204.80	13204.80	13204.80	13204.80	13204.80	13204.80	13204.80	13204.80
SM/MED, local	1297.17	2330.76	4888.96	16798.5	12899.37	12899.37	12899.37	12899.37	12899.37	12899.37	12899.37	12899.37
SM/MED, non-Zambian	240.55	430.85	775.09	3096.98	2378.14	2378.14	2378.14	2378.14	2378.14	2378.14	2378.14	2378.14
SM/MED, SR52	523.77	938.50	1669.93	6753.09	5185.62	5185.62	5185.62	5185.62	5185.62	5185.62	5185.62	5185.62
Total SM/MED	2061.44	3700.11	7333.47	26648.57	20463.13	20463.13	20463.13	20463.13	20463.13	20463.13	20463.13	20463.13
Total Production Value (1)	2946.69	5046.59	15036.0	39853.37	33667.93	33667.93	33667.93	33667.93	33667.93	33667.93	33667.93	33667.93
WITH RESEARCH, OTHER PROGRAMS												
Total area (mln hectares)[m,n]	0.668	0.579	0.662	0.633	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Total Large[o]	0.051	0.044	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian	0.022	0.017	0.015	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
LG, SR52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG, Zambian improved	0.029	0.027	0.045	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Total SM/MED[p]	0.617	0.535	0.602	0.573	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
SM/MED, local	0.182	0.151	0.157	0.149	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
SM/MED, non-Zambian	0.108	0.089	0.093	0.088	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
SM/MED, SR52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM/MED, Zambian improved	0.327	0.295	0.353	0.336	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
Yield (tons/ha)[q,r]												
Avg LG	6.03	6.03	4.30	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03
LG, non-Zambian	5.86	5.86	4.1	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52												
LG, Zambian improved	6.17	6.14	4.30	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09
Avg SM/MED	1.88	2.21	0.37	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
SM/MED, local	1.29	1.52	0.25	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
SM/MED, non-Zambian	2.12	2.49	0.41	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
SM/MED, SR52	1.77	2.08	0.34	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94
SM/MED, Zambian improved	2.12	2.49	0.41	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Production (mln tons)[1]												
LG, non-Zambian	0.130	0.097	0.062	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
LG, SR52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG, Zambian improved	0.177	0.168	0.193	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282
LG total	0.307	0.266	0.255	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362
SM/MED, local	0.235	0.229	0.039	0.212	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162
SM/MED, non-Zambian	0.229	0.222	0.038	0.204	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
SM/MED, SR52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM/MED, Zambian improved	0.694	0.734	0.145	0.779	0.598	0.598	0.598	0.598	0.598	0.598	0.598	0.598
TOTAL SM/MED	1.158	1.184	0.222	1.195	0.918	0.918	0.918	0.918	0.918	0.918	0.918	0.918
Total Production	1.464	1.448	0.486	1.557	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Price (ZK/ton)	3158	5556	33330	40000	40000	40000	40000	40000	40000	40000	40000	40000
Production value (mln ZK)												
LG, non-Zambian	410.98	540.52	2057.99	3201.12	3201.12	3201.12	3201.12	3201.12	3201.12	3201.12	3201.12	3201.12
LG, SR52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total LG	970.75	1476.43	8498.75	14484.67	14484.67	14484.67	14484.67	14484.67	14484.67	14484.67	14484.67	14484.67
SM/MED, local	742.65	1271.18	1304.2	8462.06	6497.92	6497.92	6497.92	6497.92	6497.92	6497.92	6497.92	6497.92
SM/MED, non-Zambian	721.97	1232.43	1264.41	8172.91	6275.88	6275.88	6275.88	6275.88	6275.88	6275.88	6275.88	6275.88
SM/MED, SR52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, Zambian improved	2190.68	4076.03	4823.20	31176.15	23939.80	23939.80	23939.80	23939.80	23939.80	23939.80	23939.80	23939.80
Total SM/MED	3655.29	6579.64	7391.82	47811.12	36713.60	36713.60	36713.60	36713.60	36713.60	36713.60	36713.60	36713.60
Total Production Value (2)	4626.04	8056.07	15890.52	62295.75	51198.27	51198.27	51198.27	51198.27	51198.27	51198.27	51198.27	51198.27
COSTS												
Without Research, Other Programs												
Prod. costs (mln ZK)[1]												
LG, SR52, non-Zambian	890.08	1015.44	2977.60	4958.80	4958.80	4958.80	4958.80	4958.80	4958.80	4958.80	4958.80	4958.80
SM/MED, local, no oxen	241.08	263.83	982.93	2127.72	1633.85	1633.85	1633.85	1633.85	1633.85	1633.85	1633.85	1633.85
SM/MED, local, oxen	332.95	361.60	977.02	2223.86	1707.68	1707.68	1707.68	1707.68	1707.68	1707.68	1707.68	1707.68
SM/MED, SR52, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR52, non-Zambian, oxen	351.36	412.52	1084.53	2514.77	1931.06	1931.06	1931.06	1931.06	1931.06	1931.06	1931.06	1931.06
Total Prod. costs (4)	1805.47	2053.39	6016.09	11825.16	10231.4	10231.4	10231.4	10231.4	10231.4	10231.4	10231.4	10231.4

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
With Research, Other Programs												
Prod. costs (mln ZK)												
LG, SR52, non-Zambian	388.08	382.82	747.38	1130.61	1130.61	1130.61	1130.61	1130.61	1130.61	1130.61	1130.61	1130.61
LG, Zambian improved	505.09	634.58	2242.72	3853.17	3853.17	3853.17	3853.17	3853.17	3853.17	3853.17	3853.17	3853.17
SM/MED, local, no oxen	181.68	189.47	528.91	1112.07	853.95	853.95	853.95	853.95	853.95	853.95	853.95	853.95
SM/MED, local, oxen	237.72	251.34	557.17	1213.40	931.76	931.76	931.76	931.76	931.76	931.76	931.76	931.76
SM/MED, SR52, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR52, non-Zambian, oxen	376.59	404.59	839.61	1841.67	1414.20	1414.20	1414.20	1414.20	1414.20	1414.20	1414.20	1414.20
SM/MED, Zambian improved, no oxen	168.13	194.54	547.21	1104.69	848.24	848.24	848.24	848.24	848.24	848.24	848.24	848.24
SM/MED, Zambian improved, oxen	983.96	1148.28	2737.98	5636.17	4327.95	4327.95	4327.95	4327.95	4327.95	4327.95	4327.95	4327.95
Total Prod. costs (5)	2841.24	3205.62	8200.97	15891.73	13359.86	13359.86	13359.86	13359.86	13359.86	13359.86	13359.86	13359.86
Research costs (mln ZK)												
GRZ expenditures[u]	5.16	14.08	112.10	205.96	205.96	205.96	205.96	205.96	205.96	205.96	205.96	205.96
USAID expenditures[v]												
SIDA expenditures[w]	21.28	52.75	103.28	189.75	189.75	189.75	189.75	189.75	189.75	189.75	189.75	189.75
FAO/UNDP expenditures[x]	1.84	3.72	7.67	14.10								
CIMMYT expenditures[y]	2.37	3.70	7.51	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23	14.23
Total Research costs (6)	30.65	74.25	230.56	424.03	409.93	409.93	409.93	409.93	409.93	409.93	409.93	409.93
Extension costs (mln ZK)[z]												
GRZ and donor expenditures	51.45	97.50	225.57	414.43	414.43	414.43	414.43	414.43	414.43	414.43	414.43	414.43
Total Extension costs (7)	51.45	97.50	225.57	414.43	414.43	414.43	414.43	414.43	414.43	414.43	414.43	414.43
Seed industry costs (mln ZK)[aa]												
SIDA expenditures	22.87	49.45	102.63	188.56	188.56	188.56	188.56	188.56	188.56	188.56	188.56	188.56
Zamseed investment expenditures	0.75	2.88	1.19	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61
Total seed industry costs (8)	23.61	52.33	103.82	205.17	205.17	205.17	205.17	205.17	205.17	205.17	205.17	205.17

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Marketing costs and subsidies(mln ZK) bb/												
GRZ and donor expenditures	1657.04	3512.44	7304.45	7037.43	3829.43	622.43	622.43	622.43	622.43	622.43	622.43	622.43
Total marketing costs (9)	1657.04	3512.44	7304.45	7037.43	3829.43	622.43	622.43	622.43	622.43	622.43	622.43	622.43
Total Production, Research, Extension, Seed, Mkting Costs (10)	6459.39	10734.14	15798.35	20764.79	15011.83	15011.83	15011.83	15011.83	15011.83	15011.83	15011.83	14389.4
Total Add'l Costs (11)=(10)-(4)	4653.92	8680.75	9782.26	8939.64	4780.44	4780.44	4780.44	4780.44	4780.44	4780.44	4780.44	4158.01
Net Benefit, incl. all costs (12)=(3)-(11)	-2974.56	-5671.26	-8927.7	13502.78	12749.91	12749.91	12749.91	12749.91	12749.91	12749.91	12749.91	13372.34
Net Benefit, including add. prod., research costs only (13)=(3)-[(5)+(6)-(4)]	612.94	1783.02	-1560.87	17951.82	13991.94	13991.54	13991.54	13991.54	13991.54	13991.54	13991.54	13991.54
Net benefit, incl. add. prod., research, extension costs only (14)=(3)-[(5)+(6)+(7)-(4)]	561.49	1685.52	-1786.44	17537.3	13577.51	13577.51	13577.51	13577.51	13577.51	13577.51	13577.51	13577.51
Net benefit, incl. add. prod., research, extension, seed costs only (15)=(3)-[(5)+(6)+(7)+(8)-(4)]	537.88	1633.19	-1890.27	17332.21	13372.34	13372.34	13372.34	13372.34	13372.34	13372.34	13372.34	13372.34

[a] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62% of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.

[b] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1987) for other years.

[c] LG refers to large farmers.

[d] Non-Zambian hybrids refer to CG4141, PNR473, R201, R215, ZS 206, and ZS225.

[e] Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6, Tables 53-62)and MSU/MAFF/RDSB Maize Adoption Survey for 1978-83. 1984-2000 projections are based on the without-research assumption of continued availability of SR-52 and non-Zambian hybrids. Large farmers are assumed to plant SR52 and non-Zambian hybrids in the same proportions during 1984-2000 as in 1983.

[f] Here SR52 refers to the Zambian-produced SR52, originally derived from parents imported from (then) Northern Rhodesia at the time of Zambia's independence in 1964.

[g] SM/MED refers to small and medium-scale farmers.

[h] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-83. Projections for the 1984-2000 without-research case were based on the assumption of continued availability of local, SR52 and non-Zambian varieties, and that farmers continued to plant the varieties in the same proportion during 1984-2000 as in 1983.

[i] Average yields for large farmers are estimated at 5.5 tons/ha on average before improved Zambian varieties became available (Gibson, personal communication, 1993). Average yields for small/medium farmers were obtained by dividing CSO maize production estimates by estimates of maize area planted by small/medium farmers 1978-83. For remaining years yield estimates were derived from CSO area data and yield estimates (see j).

[j] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.

[k] Sources: CSO, World Bank for 1978-83 (see Table 2). 1983-1991 estimates based on CSO area data and yield estimates (see j). 1992-2000 estimates based on 1991.

[l] Sources: CSO, MAWD.

[m] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62 per cent of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.

[n] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1987) for other years.

[o] Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6, Tables 53-62)and MSU/MAFF/RDSB Maize Adoption Survey for 1978-91. 1992-2000 projections are based on 1991 data.

[p] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-91. Projections for 1992-2000 were based on 1991 data.

[q] Average yields for large farmers are estimated at 5.5 tons/ha on average before improved Zambian varieties became available (Gibson, personal communication, 1993). Average large farmer yields were estimated to increase to 6 tons/ha and above following the introduction of improved Zambian varieties. Average yields for small/medium farmers were obtained by dividing CSO maize production estimates by estimates of maize area planted by small/medium farmers 1978-91. 1992-2000 estimates were based on 1991 data.

[r] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.

[s] Sources: CSO, World Bank for 1978-91 (see Table 2). 1992-2000 estimates based on 1991 data.

[t] See Appendix 7. Estimates of per cent of SM/MED farmers using oxen, hand hoe based on MSU/MAFF/RDSB Maize Adoption Survey, 1991

[u] See Appendix 2, Table 33. 1992-2000 expenditure estimates based on 1991 levels.

[v] See Appendix 2, Table 35. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[w] See Appendix 2, Table 36. 1986-91 converted to ZK using nominal ZK/SDR and SEK/SDR rates (Appendix 10, Tables 93-94). 1992-2000 expenditures are estimated.

[x] See Appendix 2, Table 37. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[y] See Appendix 2, Table 38. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[z] See Appendix 8, Table 89. 1992-2000 estimates based on 1991 expenditure.

[aa] See Appendix 2, Tables 36, 38. 1992-2000 estimates based on 1991 expenditure.

[bb] See Appendix 9, Table 91. 1992 and 1993 estimates assume GRZ spending on subsidies declines to 50% and 25% of 1991 expenditures, respectively. Subsidy expenditures for the period 1994-2000 are assumed to decline to 0. Dept. of Coop/Mkting expenditures are assumed to remain constant at 1991 levels for the 1992-2000 period.1992-2000 expenditures estimated at 0 based on GRZ plan to end its participation in maize marketing

Table 100: ARB economic analysis

Table 100: ARR economic analysis, benefit-cost method, part I

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT RESEARCH, OTHER PROGRAMS											
Total area (mln hectares)[a,b]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Tot LG[c]	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.050	0.050	0.050	0.050	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.442	0.480	0.685	0.490	0.374	0.504	0.516	0.472	0.599	0.632	0.737
SM/MED, local	0.290	0.314	0.449	0.321	0.245	0.330	0.338	0.309	0.392	0.414	0.483
SM/MED, non-Zambian	0.045	0.049	0.070	0.050	0.038	0.051	0.053	0.048	0.061	0.064	0.075
SM/MED,SR52	0.107	0.117	0.166	0.119	0.091	0.122	0.125	0.115	0.146	0.153	0.179
Yield (tons/ha)[i,j]											
Avg LG	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.43	5.43	5.43	5.43	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22
SM/MED, non-Zambian	.78	0.52	.94	.82	1.16	.96	1.34	1.63	.76	1.62	1.46
SM/MED,SR52	.71	0.48	.86	.75	1.06	.88	1.23	1.49	.69	1.48	1.33
Production (mln tons)[k]											
LG, non-Zambian	0.056	0.056	0.056	0.056	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR52	0.274	0.274	0.274	0.274	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.189	.139	.354	.222	.240	0.268	0.381	0.424	0.250	0.564	0.590
SM/MED, non-Zambian	0.035	0.025	0.065	0.041	0.044	0.05	0.071	0.079	0.046	0.104	0.110
SM/MED,SR52	0.076	0.055	0.143	0.089	0.097	0.108	0.153	0.171	0.101	0.227	0.239
TOTAL SM/MED	0.300	0.220	0.562	0.353	0.381	0.425	0.605	0.674	0.398	.895	.938
Total Production	0.630	0.549	0.891	0.682	0.711	0.756	0.935	1.005	0.728	1.225	1.268
Price (ZK/ton)[n]	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production value (mln ZK)											
LG, non-Zambian	19.58	20.90	29.54	46.02	38.74	42.40	48.15	55.59	79.32	84.90	130.05
LG, SR52	95.57	102.03	144.22	224.66	241.51	264.38	300.21	346.59	494.53	529.30	810.83
Total LG	115.15	122.93	173.76	270.69	280.25	306.78	348.37	402.18	573.84	614.19	940.88
SM/MED, local	66.14	51.71	186.34	182.52	203.47	249.00	401.59	516.86	435.31	1049.11	1681.14
SM/MED, non-Zambian	12.23	19.48	34.48	33.70	37.76	46.10	74.47	95.86	80.66	193.66	312.09
SM/MED,SR52	26.50	20.65	75.12	73.24	82.06	100.30	161.96	208.90	175.53	422.90	679.79
Total SM/MED	104.87	81.85	295.95	289.45	323.25	395.40	638.02	821.63	691.50	1665.67	2673.02
Total Production Value (1)	220.02	204.78	469.71	560.14	603.50	702.18	986.39	1223.81	1265.35	2279.87	3613.90
WITH RESEARCH, OTHER PROGRAMS											
Total area (mln hectares)[m,n]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Total Large[o]	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.013	0.005	0.007	0.010
LG, SR52	0.050	0.050	0.050	0.050	0.052	0.052	0.052	0.000	0.000	0.000	0.000
LG, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.047	0.055	0.053	0.050
Total SM/MED[p]	0.442	0.480	0.685	0.490	0.374	0.504	0.516	0.472	0.599	0.632	0.737
SM/MED, local	0.290	0.314	0.449	0.321	0.245	0.330	0.321	0.227	0.246	0.235	0.246
SM/MED, non-Zambian	0.045	0.049	0.070	0.050	0.038	0.051	0.028	0.020	0.017	0.020	0.145
SM/MED, SR52	0.107	0.117	0.166	0.119	0.091	0.122	0.161	0.115	0.124	0.118	0.000
SM/MED, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.111	0.207	0.257	0.346
Yield (tons/ha)[q,r]											
Avg LG	5.50	5.50	5.50	5.50	5.50	5.50	5.62	6.39	6.03	6.03	6.03
LG, non-Zambian	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.43	5.43	5.43	5.43	5.45	5.45	5.45				
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	6.54	6.54	6.05	6.06	6.07
Avg SM/MED	0.96	0.64	1.16	1.02	1.44	1.19	1.65	2.21	1.06	2.33	2.22
SM/MED, local	0.83	0.56	1.00	0.88	1.24	1.03	1.43	1.74	0.81	1.73	1.55
SM/MED, non-Zambian	1.36	0.91	1.64	1.44	2.04	1.69	2.35	2.86	1.33	2.83	2.55
SM/MED,SR52	1.13	0.76	1.37	1.20	1.70	1.41	1.96	2.39	1.11	2.37	2.13
SM/MED, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	2.35	2.86	1.33	2.83	2.55

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production (mln tons)'											
LG, non-Zambian	0.056	0.056	0.056	0.056	0.046	0.046	0.045	0.074	0.029	0.041	0.060
LG, SR52	0.274	0.274	0.274	0.274	0.284	0.284	0.282	0.000	0.000	0.000	0.000
LG, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.310	0.333	0.321	0.302
LG total	0.330	0.330	0.330	0.330	0.330	0.330	0.379	0.384	0.362	0.362	0.362
SM/MED, local	0.240	0.176	0.449	0.282	0.304	0.340	0.459	0.395	0.199	0.407	0.381
SM/MED, non-Zambian	0.061	0.045	0.115	0.072	0.078	0.087	0.066	0.057	0.023	0.058	0.371
SM/MED, SR52	0.121	0.089	0.228	0.143	0.155	0.173	0.316	0.274	0.138	0.281	0.000
SM/MED, Zambian improved	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.316	0.275	0.727	0.883
TOTAL SM/MED	0.423	0.309	0.791	0.497	0.537	0.600	0.851	1.042	0.635	1.473	1.636
Total Production	0.754	0.636	1.118	0.825	0.867	0.929	1.214	1.427	1.003	1.834	1.997
Price (ZK/ton)	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Production value (mln ZK)											
LG, non-Zambian	19.58	20.90	29.54	46.02	38.74	42.40	47.77	90.23	50.64	75.75	170.07
LG, SR52	95.57	102.03	144.22	224.66	241.51	264.38	297.84	0.00	0.00	0.00	0.00
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	54.66	377.18	578.63	598.01	861.55
Total LG	115.15	122.93	173.76	270.69	280.25	306.78	400.27	467.41	629.27	673.77	1031.61
SM/MED, local	83.94	65.63	236.48	231.62	258.15	315.99	484.81	481.37	346.64	757.15	1087.24
SM/MED, non-Zambian	21.42	16.61	60.39	59.02	66.14	80.74	69.81	69.30	39.32	107.73	1056.70
SM/MED,SR52	42.40	33.04	120.19	117.18	131.30	160.60	333.85	333.83	239.59	522.10	0.00
SM/MED, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	9.72	385.32	478.60	1352.95	2517.98
Total SM/MED	147.75	115.28	417.06	407.82	455.59	557.33	898.19	1269.82	1104.15	2739.93	4661.91
Total Production Value (2)	262.90	238.21	590.83	678.51	735.84	864.11	1298.46	1737.23	1733.42	3413.70	5693.53
Add'l Benefit (3)=(2)-(1)	42.88	33.43	121.11	118.37	132.34	161.93	312.07	513.42	468.07	1133.83	2079.63
COSTS											
Without Research', Other Programs											
Prod. costs (mln ZK)											
LG, non-Zambian	13.45	13.52	13.71	14.47	12.57	13.02	17.57	22.71	38.67	45.89	65.19
LG, SR52	68.59	68.96	69.85	73.51	81.22	83.79	114.25	147.62	253.07	301.32	429.08
SM/MED, local, no oxen	6.95	7.12	11.19	7.83	6.53	9.89	17.71	43.41	123.88	106.72	188.33
SM/MED, local, oxen	8.20	8.36	13.24	9.25	7.77	11.70	20.98	51.07	144.39	125.77	255.37
SM/MED, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, non-Zambian, oxen	10.35	10.91	16.62	12.63	10.73	16.40	23.61	38.45	87.68	89.99	162.56
SM/MED, SR-52, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR-52, oxen	6.64	6.88	10.68	7.47	6.21	9.47	17.37	37.36	101.97	93.74	169.90
Total Prod. costs (4)	107.61	108.75	124.77	117.02	118.11	133.73	197.08	320.14	708.23	916.69	1154.59

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
With Research, Other Programs											
Prod. costs ('mln ZK)											
LG, non-Zambian	13.45	13.52	13.71	14.47	12.57	13.02	17.44	36.86	24.69	40.95	85.24
LG, SR-52	68.59	68.96	69.85	73.51	81.22	83.79	113.34	0.00	0.00	0.00	0.00
LG, Zambian improved	0.00	0.00	0.00	0.00	0.00	0.00	17.54	135.71	268.75	308.51	412.43
SM/MED, local, no oxen	15.03	15.77	24.11	17.96	15.14	23.04	33.28	47.63	101.29	87.93	141.37
SM/MED, local, oxen	18.47	19.35	29.68	22.14	18.74	28.43	40.83	57.26	119.61	105.62	171.72
SM/MED, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, non-Zambian, oxen	9.62	10.11	15.49	11.81	10.11	15.36	11.68	13.90	20.22	24.91	273.57
SM/MED, SR-52, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR-52, oxen	20.30	21.40	35.29	24.63	20.86	31.74	60.15	73.45	139.59	134.62	0.00
SM/MED, Zambian improved, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.23	11.21	37.12	46.38	96.84
SM/MED, Zambian improved, oxen	0.00	0.00	0.00	0.00	0.00	0.00	1.27	61.86	200.65	255.78	538.28
Total Prod. costs (5)	145.45	149.11	185.43	164.53	158.64	195.38	295.74	437.87	911.92	1004.69	1719.45
Research costs (mln ZK)											
GRZ expenditures[u]	1.09	1.33	1.71	1.30	1.87	1.38	1.66	1.22	1.74	2.89	6.11
USAID expenditures[v]						2.91	3.74	4.99	7.06	2.66	
SIDA expenditures[w]		0.21	0.24	0.90	0.99	0.85	1.12	0.85	5.59	9.77	15.37
FAO/UNDP expenditures[x]	0.47	0.45	0.49	0.55	0.60	0.60	0.91	1.15	1.67	0.91	1.41
CIMMYT expenditures[y]			0.03	0.05	0.06	0.08	0.17	0.61	0.73	1.23	1.74
Total Research costs (6)	1.56	1.99	2.47	2.79	3.52	5.82	7.60	8.82	16.79	17.46	24.62
Extension costs (mln ZK)[z]											
GRZ and donor expenditures	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Total Extension costs (7)	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Seed industry costs (mln ZK)[aa]											
SIDA expenditures		0.57	0.66	1.72	2.26	1.68	1.97	2.19	10.66	12.10	21.16
Zamseed investment expenditures				1.44	0.30	2.71	0.86	0.94	1.10	0.00	0.25
Total seed industry costs (8)	0.00	0.57	0.66	3.16	2.56	4.39	2.83	3.13	11.76	12.10	21.41

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Marketing costs and subsidies (mln ZK)[96]											
GRZ and donor expenditures	97.34	98.86	150.65	93.65	152.85	103.06	62.57	80.54	229.59	427.50	1517.9
Total marketing costs (9)	97.34	98.86	150.65	93.65	152.85	103.06	62.57	80.54	229.59	427.50	1517.90
Total Production, Research, Extension, Seed, Mkting Costs (10)	245.97	252.39	342.58	269.52	324.16	312.78	391.01	551.19	1199.06	1498.26	3336.36
Total Add'l Costs (11)=(10)-(4)	138.37	143.64	217.81	152.51	206.06	179.05	193.93	231.04	490.83	781.60	2181.77
Net Benefit , incl. all costs (12)=(3)-(11)	-95.49	-110.21	-96.7	-34.14	-73.72	-17.12	118.14	282.38	-22.76	352.23	-102.14
Net Benefit, including add. prod., research costs only (13)=(3)-[(5)+(6)-(4)]	3.47	-8.93	57.98	68.06	88.29	94.47	205.81	386.88	247.59	828.34	1490.15
Net benefit, incl. add. prod., research extension costs only (14)=(3)-[(5)+(6)+(7)-(4)]	1.85	-10.78	54.61	62.67	81.74	90.33	183.54	366.05	218.59	791.83	1437.17
Net benefit, incl. add. prod., research extension, seed costs only (15)=(3)-[(5)+(6)+(7)+(8)-(4)]	1.85	-11.35	53.95	59.51	79.17	85.94	180.71	362.92	206.83	779.73	1415.76
IRR (%), including all costs ====> 1978-2001	49.3										
1978-91 ==>											
IRR (%), including add. prod., research costs only, 1978-2001 ==>											
1978-91 ==>											
IRR (%), including add. prod., research and extension costs only, 1978-2001 ==>											
1978-91 ==>											
IRR (%), including add. prod., research, extension and seed costs only, 1978-2001 ==>											
1978-91 ==>											

(For footnotes, see end of Part II of table.)

Table 101: ARR economic analysis, benefit-cost method, part II

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
BENEFITS												
WITHOUT RESEARCH, OTHER PROGRAMS												
Total area (mln hectares)[a,b]	0.668	0.579	0.662	0.633	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Tot LG[c]	0.051	0.044	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.007	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.044	0.038	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.617	0.535	0.602	0.573	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
SM/MED, local	0.404	0.350	0.394	0.375	0.288	0.288	0.288	0.288	0.288	0.288	0.288	0.288
SM/MED, non-Zambian	0.063	0.055	0.061	0.058	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
SM/MED, SR52	0.150	0.130	0.146	0.139	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
Yield (tons/ha)[i,j]												
Avg LG	5.50	5.50	3.85	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.86	5.86	4.10	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR52	5.45	5.45	3.82	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	1.02	1.2	0.37	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
SM/MED, non-Zambian	1.21	1.42	0.38	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
SM/MED, SR52	1.11	1.30	0.34	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Production (mln tons)[k]												
LG, non-Zambian	0.039	0.034	0.032	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR52	0.242	0.209	0.199	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.280	0.242	0.231	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.411	0.420	0.147	0.420	0.322	0.322	0.322	0.409	0.409	0.409	0.409	0.409
SM/MED, non-Zambian	0.076	0.078	0.023	0.077	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
SM/MED, SR52	0.166	0.169	0.05	0.169	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
TOTAL SM/MED	0.653	0.666	0.220	0.666	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512
Total Production	0.933	0.908	0.451	0.996	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842
Price (ZK/ton)[l]	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Production value (mln ZK)												
LG, non-Zambian	193.16	453.95	1171.22	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11
LG, SR52	1202.23	2825.45	7302.21	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26
Total LG	1395.39	3279.40	8473.43	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38
SM/MED, local	2044.69	5676.67	3765.03	33980.9	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54
SM/MED, non-Zambian	379.18	1049.35	596.90	6264.74	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62
SM/MED,SR52	825.52	2285.77	1286.03	13660.51	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75
Total SM/MED	3249.38	9011.79	5647.96	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91
Total Production Value (1)	4644.77	12291.19	11579.36	80617.54	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29
WITH RESEARCH, OTHER PROGRAMS												
Total area (mln hectares)[m,n]	0.668	0.579	0.662	0.633	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Total Large[o]	0.051	0.044	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian	0.022	0.017	0.015	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
LG, SR-52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG, Zambian improved	0.029	0.027	0.045	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Total SM/MED[p]	0.617	0.535	0.602	0.573	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
SM/MED, local	0.182	0.151	0.157	0.149	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
SM/MED, non-Zambian	0.108	0.089	0.093	0.088	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
SM/MED, SR-52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM/MED, Zambian improved	0.327	0.295	0.353	0.353	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
Yield (tons/ha)[q,r]												
Avg LG	6.03	6.03	4.30	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03
LG, non-Zambian	5.86	5.86	4.10	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR-52												
LG, Zambian improved	6.17	6.14	4.30	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09	6.09
Avg SM/MED	1.88	2.21	0.37	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
SM/MED, local	1.29	1.52	0.25	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
SM/MED, non-Zambian	2.12	2.49	0.41	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
SM/MED,SR-52	1.77	2.08	0.34	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94
SM/MED, Zambian improved	2.12	2.49	0.41	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Production (mln tons)[a]												
LG, non-Zambian	0.130	0.097	0.062	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
LG, SR-52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG, Zambian improved	0.177	0.168	0.193	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282
LG total	0.307	0.266	0.255	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362
SM/MED, local	0.235	0.229	0.039	0.212	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162
SM/MED, non-Zambian	0.229	0.222	0.038	0.204	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
SM/MED, SR-52	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SM/MED, Zambian improved	0.694	0.734	0.145	0.819	0.598	0.598	0.598	0.598	0.598	0.598	0.598	0.598
TOTAL SM/MED	1.158	1.184	0.222	1.235	0.918	0.918	0.918	0.918	0.918	0.918	0.918	0.918
Total Production	1.464	1.448	0.486	1.597	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Price (ZK/ton)	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Production value (mln ZK)												
LG, non-Zambian	647.82	1316.47	1584.88	6475.40	6475.40	6475.40	6475.40	6475.40	6475.40	6475.40	6475.40	6475.40
LG, SR-52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG, Zambian improved	882.34	2279.44	4960.08	22824.97	22824.97	22824.97	22824.97	22824.97	22824.97	22824.97	22824.97	22824.97
Total LG	1530.16	3595.90	6544.96	29300.37	29300.37	29300.37	29300.37	29300.37	29300.37	29300.37	29300.37	29300.37
SM/MED, local	1170.62	3096.03	1007.46	17119.81	13144.34	13144.34	13144.34	13144.34	13144.34	13144.34	13144.34	13144.34
SM/MED, non-Zambian	1138.01	3001.63	978.61	16514.43	12695.18	12695.18	12695.18	12695.18	12695.18	12695.18	12695.18	12695.18
SM/MED,SR-52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, Zambian improved	3453.10	9927.36	3714.89	66265.44	48426.71	48426.71	48426.71	48426.71	48426.71	48426.71	48426.71	48426.71
Total SM/MED	5761.73	16025.01	5701.06	99904.69	74266.23	74266.23	74266.23	74266.23	74266.23	74266.23	74266.23	74266.23
Total Production Value (2)	7291.89	19620.92	12246.02	129205.1	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6
Add'l Benefit (3)=(2)-(1)	2647.12	7329.73	666.66	48587.52	35461.32	35461.32	35461.32	35461.32	35461.32	35461.32	35461.32	35461.32
COSTS												
Without Research, Other Programs												
Prod. costs (mln ZK)[c]												
LG, non-Zambian	143.64	343.04	713.77	1267.48	1267.48	1267.48	1267.48	1267.48	1267.48	1267.48	1267.48	1267.48
LG, SR-52	944.65	2245.01	4658.72	8293.41	8293.41	8293.41	8293.41	8293.41	8293.41	8293.41	8293.41	8293.41
SM/MED, local, no oxen	254.90	286.33	997.22	2305.00	1769.98	1769.98	1769.98	1769.98	1769.98	1769.98	1769.98	1769.98
SM/MED, local, oxen	340.69	390.47	989.36	2451.33	1882.34	1882.34	1882.34	1882.34	1882.34	1882.34	1882.34	1882.34
SM/MED, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, non-Zambian, oxen	120.22	172.53	400.18	918.88	705.60	705.60	705.60	705.60	705.60	705.60	705.60	705.60
SM/MED, SR-52, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR-52, oxen	258.85	310.20	783.10	1925.13	1478.29	1478.29	1478.29	1478.29	1478.29	1478.29	1478.29	1478.29
Total Prod. costs (4)	2062.94	3747.59	8542.34	17161.24	15397.11	15397.11	15397.11	15397.11	15397.11	15397.11	15397.11	15397.11

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
With Research, Other Programs												
Prod. costs ('mln ZK)												
LG, non-Zambian	481.74	994.83	1378.13	2222.97	2222.97	2222.97	2222.97	2222.97	2222.97	2222.97	2222.97	2222.97
LG, SR-52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG, Zambian improved	618.45	1612.98	4042.29	7427.06	7427.06	7427.06	7427.06	7427.06	7427.06	7427.06	7427.06	7427.06
SM/MED, local, no oxen	183.83	264.29	663.42	1450.78	1113.89	1113.89	1113.89	1113.89	1113.89	1113.89	1113.89	1113.89
SM/MED, local, oxen	240.48	347.33	729.39	1647.97	1265.29	1265.29	1265.29	1265.29	1265.29	1265.29	1265.29	1265.29
SM/MED, non-Zambian, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, non-Zambian, oxen	399.12	669.59	1306.23	2874.47	2209.03	2209.03	2209.03	2209.03	2209.03	2209.03	2209.03	2209.03
SM/MED, SR-52, no oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, SR-52, oxen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM/MED, Zambian improved, no oxen	169.02	289.92	745.87	1673.09	1222.69	1222.69	1222.69	1222.69	1222.69	1222.69	1222.69	1222.69
SM/MED, Zambian improved, oxen	989.13	1701.72	3890.73	8895.41	6500.79	6500.79	6500.79	6500.79	6500.79	6500.79	6500.79	6500.79
Total Prod. costs (5)	3081.77	5880.66	12756.05	26191.80	21961.72	21961.72	21961.72	21961.72	21961.72	21961.72	21961.72	21961.72
Research costs (mln ZK)												
GRZ expenditures[u]	6.10	24.61	200.77	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66
USAID expenditures[v]												
SIDA expenditures[w]	31.08	107.65	189.05	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27
FAO/UNDP expenditures[x]	2.69	7.58	14.05	27.96								
CIMMYT expenditures[y]	3.46	7.55	13.74	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22
Total Research costs (6)	43.32	147.40	417.61	801.11	773.15	773.15	773.15	773.15	773.15	773.15	773.15	773.15
Extension costs (mln ZK)[z]												
GRZ and donor expenditures	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Total Extension costs (7)	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Seed industry costs (mln ZK)[aa]												
SIDA expenditures	33.41	100.91	187.87	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92
Zamseed investment expenditures	0.75	2.88	1.19	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61
Total seed industry costs (8)	34.15	103.79	189.06	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Marketing costs and subsidies(mln ZK)[a]												
GRZ and donor expenditures	1584.76	4687.02	8749.70	9332.74	5256.52	1186.43	617.0	617.0	617.0	617.0	617.0	617.0
Total marketing costs (9)	1584.76	4687.02	8749.70	9332.74	5256.52	1186.43	617.0	617.0	617.0	617.0	617.0	617.0
Total Production, Research, Extension, Seed, Mkting Costs (10)	4809.21	10989.73	22516.66	37458.89	29124.63	25054.54	24485.11	24485.11	24485.11	24485.11	24485.11	24485.11
Total Add'l Costs (11)=(10)-(4)	2746.27	7242.14	13974.32	20297.65	13727.52	9657.43	9088.0	9088.0	9088.0	9088.0	9088.0	9088.0
Net Benefit , incl. all costs (12)=(3)-(11)	-99.15	87.59	-13307.7	28289.87	21733.79	25803.88	26373.31	26373.31	26373.31	26373.31	26373.31	26373.31
Net Benefit, including add. prod., research costs only (13)=(3)-[(5)+(6)-(4)]	1584.97	5049.26	-3964.65	38755.85	28123.55	28123.55	28123.55	28123.55	28123.55	28123.55	28123.55	28123.55
Net benefit, incl. add. prod., research extension costs only (14)=(3)-[(5)+(6)+(7)-(4)]	1519.76	4878.40	-4368.90	38013.14	27380.84	14356.08	27380.84	27380.84	27380.84	27380.84	27380.84	27380.84
Net benefit, incl. add. prod., research extension, seed costs only (15)=(3)-[(5)+(6)+(7)+(8)-(4)]	1485.61	4774.61	-4557.96	37622.61	26990.31	26990.31	26990.31	26990.31	26990.31	26990.31	26990.31	26990.31

[a] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62% of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.
[b] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1987) for other years.
[c] LG refers to large farmers.
[d] Non-Zambian hybrids refer to CG4141, PNR473, R201, R215, ZS 206, and ZS225.
[e] Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6, Tables 53-62)and MSU/MAFF/RDSB Maize Adoption Survey for 1978-83. 1984-2000 projections are based on the without-research assumption of continued availability of SR-52 and non-Zambian hybrids. Large farmers are assumed to plant SR52 and non-Zambian hybrids in the same proportions during 1984-2000 as in 1983.
[f] Here SR52 refers to the Zambian-produced SR52, originally derived from parents imported from (then) Northern Rhodesia at the time of Zambia's independence in 1964.
[g] SM/MED refers to small and medium-scale farmers.

[h] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-83. Projections for the 1984-2000 without-research case were based on the assumption of continued availability of local, SR52 and non-Zambian varieties, and that farmers continued to plant the varieties in the same proportion during 1984-2000 as in 1983.

[i] Average yields for large farmers are estimated at 5.5 tons/ha on average before improved Zambian varieties became available (Gibson, personal communication, 1993). Average yields for small/medium farmers were obtained by dividing CSO maize production estimates by estimates of maize area planted by small/medium farmers 1978-83. For remaining years yield estimates were derived from CSO area data and yield estimates (see j).

[j] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.

[k] Sources: CSO, World Bank for 1978-83 (see Table 2). 1983-1991 estimates based on CSO area data and yield estimates (see j). 1992-2000 estimates based on 1991.

[l] Import parity price. See Appendix 10, Table 95.

[m] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62 per cent of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.

[n] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1987) for other years.

[o] Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6, Tables 53-62)and MSU/MAFF/RDSB Maize Adoption Survey for 1978-91. 1992-2000 projections are based on 1991 data.

[p] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-91. Projections for 1992-2000 were based on 1991 data.

[q] Average yields for large farmers are estimated at 5.5 tons/ha on average before improved Zambian varieties became available (Gibson, personal communication, 1993). Average large farmer yields were estimated to increase to 6 tons/ha and above following the introduction of improved Zambian varieties. Average yields for small/medium farmers were obtained by dividing CSO maize production estimates by estimates of maize area planted by small/medium farmers 1978-91. 1992-2000 estimates were based on 1991 data.

[r] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.

[s] Sources: CSO, World Bank for 1978-91 (see Table 2). 1992-2000 estimates based on 1991 data.

[t] See Appendix 7. Estimates of per cent of SM/MED farmers using oxen, hand hoe based on MSU/MAFF/RDSB Maize Adoption Survey, 1991

[u] See Appendix 2, Table 34. 1992-2000 expenditure estimates based on 1991 levels.

[v] See Appendix 2, Table 35. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[w] See Appendix 2, Table 36. 1986-91 converted to ZK using nominal ZK/SDR and SEK/SDR rates (Appendix 10, Tables 93-94). 1992-2000 expenditures are estimated.

[x] See Appendix 2, Table 37. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[y] See Appendix 2, Table 38. Converted to ZK using nominal ZK/SDR and USD/SDR rates (Appendix 10, Table 94).

[z] See Appendix 8, Table 90. 1992-2000 estimates based on 1991 expenditure.

[aa] See Appendix 2, Tables 36, 38. 1992-2000 estimates based on 1991 expenditure.

[bb] See Appendix 9, Table 92. 1992 and 1993 estimates assume GRZ spending on subsidies declines to 50% and 25% of 1991 expenditures, respectively. Subsidy expenditures for the period 1994-2000 are assumed to decline to 0. Dept. of Coop/Mkting expenditures are assumed to remain constant at 1991 levels for the 1992-2000 period.1992-2000 expenditures estimated at 0 based on GRZ plan to end its participation in maize marketing

Table 102: ARR economic analysis, Akino-Hayami method, part I

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT RESEARCH, OTHER PROGRAMS											
Total area (mln hectares)[a,b]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Tot LG[c]	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.050	0.050	0.050	0.050	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.442	0.480	0.685	0.490	0.374	0.504	0.516	0.472	0.599	0.632	0.737
SM/MED, local	0.290	0.314	0.449	0.321	0.245	0.330	0.338	0.309	0.392	0.414	0.483
SM/MED, non-Zambian	0.045	0.049	0.070	0.050	0.038	0.051	0.053	0.048	0.061	0.064	0.075
SM/MED,SR52	0.107	0.117	0.166	0.119	0.091	0.122	0.125	0.115	0.146	0.153	0.179
Yield (tons/ha)[i,j]											
Avg LG	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.84	5.84	5.84	5.84	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR-52	5.43	5.43	5.43	5.43	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	0.65	0.44	.79	0.69	.98	.81	1.13	1.37	0.64	1.36	1.22
SM/MED, non-Zambian	.78	0.52	.94	.82	1.16	.96	1.34	1.63	.76	1.62	1.46
SM/MED,SR-52	.71	0.48	.86	.75	1.06	.88	1.23	1.49	.69	1.48	1.33
Production (mln tons)[k]											
LG, non-Zambian	0.056	0.056	0.056	0.056	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR-52	0.274	0.274	0.274	0.274	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.189	.139	.354	.222	.240	0.268	0.381	0.424	0.250	0.564	0.590
SM/MED, non-Zambian	0.035	0.025	0.065	0.041	0.044	0.05	0.071	0.079	0.046	0.104	0.110
SM/MED,SR-52	0.076	0.055	0.143	0.089	0.097	0.108	0.153	0.171	0.101	0.227	0.239
TOTAL SM/MED	0.300	0.220	0.562	0.353	0.381	0.425	0.605	0.674	0.398	.895	.938
Total Production	0.630	0.549	0.891	0.682	0.711	0.756	0.935	1.005	0.728	1.225	1.268
Price (ZK/ton)[l]	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production value (mln ZK)											
L.G. non Zambian	19.58	20.90	29.54	46.02	38.74	42.40	48.15	55.59	79.32	84.90	130.05
L.G. SR-52	95.57	102.03	144.22	224.66	241.51	264.38	300.21	346.59	494.53	529.30	810.83

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production value (mln ZK)											
LG, non-Zambian	19.58	20.90	29.54	46.02	38.74	42.40	48.15	55.59	79.32	84.90	130.05
LG, SR-52	95.57	102.03	144.22	224.66	241.51	264.38	300.21	346.59	494.53	529.30	810.83
Total LG	115.15	122.93	173.76	270.69	280.25	306.78	348.37	402.18	573.84	614.19	940.88
SM/MED, local	66.14	51.71	186.34	182.52	203.47	249.00	401.59	516.86	435.31	1049.11	1681.14
SM/MED, non-Zambian	12.23	19.48	34.48	33.70	37.76	46.10	74.47	95.86	80.66	193.66	312.09
SM/MED,SR-52	26.50	20.65	75.12	73.24	82.06	100.30	161.96	208.90	175.53	422.90	679.79
Total SM/MED	104.87	81.85	295.95	289.45	323.25	395.40	638.02	821.63	691.50	1665.67	2673.02
Total Production Value	220.02	204.78	469.71	560.14	603.50	702.18	986.39	1223.81	1265.35	2279.87	3613.90
WITH RESEARCH, OTHER PROGRAMS											
Total area cultivated (mln hectares)[m]	0.502	0.540	0.745	0.550	0.434	0.564	0.576	0.532	0.659	0.692	0.797
Fertilized SM/MED area	.30	.32	.46	.33	.25	.34	.35	.36	.47	.51	.61
Area in improved varieties[n]	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.158	0.262	0.310	0.396
Proportion, improved varieties and SM/MED fertilized area (1)	.59	.60	.62	.60	.58	.60	.62	.62	.66	.68	.73
Weighted yield, local,imported, SR-52, without research, other programs (tons/ha)[o]	1.26	1.02	1.2	1.24	1.64	1.34	1.62	1.89	1.10	1.77	1.59
Weighted yield, local, SR52, imported, improved varieties with research, other programs(tons/ha)[p]	1.5	1.18	1.5	1.5	2.000	1.65	2.06	2.68	1.51	2.65	2.51
Yield gain	.24	.17	.31	.26	.36	.31	.44	.79	.41	.88	.92
Yield gain/yield with research,other programs(2)	.16	.14	.2	.17	.18	.19	.21	.3	.27	.33	.37
K-factor (3) = (1) x (2)[p]	0.100	0.08	0.13	0.10	0.10	0.11	0.13	0.18	0.18	0.23	0.27
Price (ZK/ton)	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production (mln tons)	0.75	0.64	1.12	0.82	0.87	0.93	1.21	1.43	1.00	1.83	2.00
Total Production Value (mln ZK) (4)	262.90	238.21	590.83	678.51	735.84	864.11	1298.46	1737.23	1733.42	3413.70	5693.53
Price elasticity of supply[q]	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Price elasticity of demand[q]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Benefit 1: Area A0C (3) x (4)[r]	25.38	19.97	74.87	70.89	76.72	97.33	172.13	320.41	310.50	771.90	1524.53
Benefit 2: Area ABC[s]	4.45	3.04	17.22	13.44	14.52	19.90	41.41	107.26	100.94	316.79	740.91
Total benefits (mln ZK)	29.83	23.01	92.09	84.33	91.23	117.22	213.54	427.68	411.44	1088.69	2265.44
Total add'l prod. costs[t]	37.85	40.37	60.66	47.51	40.53	61.64	98.66	117.73	203.69	288.03	564.87
Total research costs[u]	1.56	1.99	2.47	2.79	3.52	5.82	7.60	8.82	16.79	17.46	24.62
Total extension costs[v]	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Total seed costs[w]	0.00	0.57	0.66	3.16	2.56	4.39	2.83	3.13	11.76	12.10	21.41
Total marketing costs[x]	97.34	98.86	150.65	93.65	152.89	103.06	62.57	80.54	229.59	427.57	1517.90
Total net benefit, all costs (mln ZK)	-108.54	-120.63	-125.72	-68.18	-114.82	-61.83	19.61	196.63	-79.39	307.09	83.67

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
IRR (%), including all costs, 1978-2001	10.21										

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
IRR (%), including all costs, 1978-2001 ==>	39.23										
IRR (%), including all costs, 1978-91 ==>											
Total net benefit, add. prod, res. costs only	-9.58	-19.34	28.96	34.02	47.18	49.76	107.28	301.13	190.96	783.20	1675.96
IRR (%) for above costs, 1978-2001 ==>	114.17										
IRR (%) for above costs, 1978-91 ==>	112.39										
Total net benefit, add. prod.,res.,ext. costs	-11.20	-21.19	25.59	28.63	40.63	45.62	85.01	280.30	161.96	746.69	1622.98
IRR (%) for above costs, 1978-2001 ==>	102.69										
IRR (%) for above costs, 1978-91 ==>	99.71										
Total net ben., add. prod.,res.,ext.,seed costs	-11.20	-21.77	24.93	25.47	38.07	41.23	82.18	277.17	150.20	734.59	1601.57
IRR (%) for above costs, 1978-2001 ==>	100.25										
IRR (%) for above costs, 1978-91 ==>	96.89										

(For footnotes, see end of Part II of table.)

Table 103: ARR economic analysis, Akino-Hayami method, part II

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
BENEFITS												
WITHOUT RESEARCH, OTHER PROGRAMS												
Total area (mln hectares)[a,b]	0.668	0.579	0.662	0.633	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Tot LG[c]	0.051	0.044	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
LG, non-Zambian[d,e]	0.007	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
LG, SR52[f]	0.044	0.038	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Tot SM/MED[g,h]	0.617	0.535	0.602	0.573	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
SM/MED, local	0.404	0.350	0.394	0.375	0.288	0.288	0.288	0.288	0.288	0.288	0.288	0.288
SM/MED, non-Zambian	0.063	0.055	0.061	0.058	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
SM/MED,SR-52	0.150	0.130	0.146	0.139	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
Yield (tons/ha)[i,j]												
Avg LG	5.50	5.50	3.85	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
LG, non-Zambian	5.86	5.86	4.10	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85	5.85
LG, SR-52	5.45	5.45	3.82	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45
SM/MED, local	1.02	1.2	0.37	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
SM/MED, non-Zambian	1.21	1.42	0.38	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
SM/MED,SR-52	1.11	1.30	0.34	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Production (mln tons)[k]												
LG, non-Zambian	0.039	0.034	0.032	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
LG, SR-52	0.242	0.209	0.199	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
TOTAL LG	0.280	0.242	0.231	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
SM/MED, local	0.411	0.420	0.147	0.420	0.322	0.322	0.322	0.409	0.409	0.409	0.409	0.409
SM/MED, non-Zambian	0.076	0.078	0.023	0.077	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
SM/MED,SR-52	0.166	0.169	0.05	0.169	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
TOTAL SM/MED	0.653	0.666	0.220	0.666	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512
Total Production	0.933	0.908	0.451	0.996	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842
Price (ZK/ton)[l]	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Production value (mln ZK)												
LG, non-Zambian	193.16	453.95	1171.22	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11	3692.11
LG, SR-52	1202.23	2825.45	7302.21	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26	23019.26
Total LG	1395.39	3279.40	8473.43	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.38	26711.3
SM/MED, local	2044.69	5676.67	3765.03	33980.9	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54	26093.54
SM/MED, non-Zambian	379.18	1049.35	596.90	6264.74	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62	4810.62
SM/MED, SR-52	825.52	2285.77	1286.03	13660.51	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75	10989.75
Total SM/MED	3249.38	9011.79	5647.96	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91	41393.91
Total Production Value	4644.77	12291.19	11579.36	80617.54	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29	68105.29
WITH RESEARCH, OTHER PROGRAMS												
Total area cultivated (mln hectares)[m]	0.668	0.579	0.622	0.630	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Fertilized SM/MED area	.53	.46	.52	.52	.38	.38	.38	.38	.38	.38	.38	.38
Area in improved varieties[n]	0.356	0.322	0.290	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Proportion, improved varieties and fertilized SM/MED area	0.65	0.61	0.66	0.66	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Weighted yield, local, imported, SR52 w/o research, other programs (tons/ha)[o]	1.4	1.57	0.68	1.57	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Weighted yield, local, SR52, imported, improved varieties with research, other programs (tons/ha)[o]	2.19	2.51	.73	2.52	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
Yield gain	0.8	0.94	0.04	0.95	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Yield gain/yield with research, other programs(2)	0.360	0.37	0.06	0.38	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
K-factor (3) = (1) x (2)[p]	0.24	0.23	0.04	0.25	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Price (ZK/ton)	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Total Production (mln tons)	1.46	1.45	0.49	1.60	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Total Production Value (mln ZK) (4)	7291.89	19620.92	12246.02	129205.1	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6	103566.6
Price elasticity of supply[q]	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Price elasticity of demand[q]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Benefit 1: Area A0C (3)x(4)[r]	1731.03	4443.47	487.13	31870.95	19639.77	19639.77	19639.77	19639.77	19639.77	19639.77	19639.77	19639.77
Benefit 2: Area ABC[s]	745.84	1826.37	35.17	14268.79	6759.73	6759.73	6759.73	6759.73	6759.73	6759.73	6759.73	6759.73
Total benefits (mln ZK)	2476.86	6269.78	522.31	46139.73	26399.5	26399.5	26399.5	26399.5	26399.5	26399.5	26399.5	26399.5

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Total add'l prod. costs[t]	1018.83	2133.07	4213.7	9030.56	6564.61	6564.61	6564.61	6564.61	6564.61	6564.61	6564.61	6564.61
Total research costs[u]	43.32	147.40	417.61	801.11	773.15	773.15	773.15	773.15	773.15	773.15	773.15	773.15
Total extension costs[v]	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Total seed costs[w]	34.15	103.79	189.06	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53
Total marketing costs[x]	1584.76	4687.02	8749.70	9332.74	5256.52	1186.43	617	617	617	617	617	617
Total net benefit , all costs (mln ZK)	-269.4	-972.37	-13452.0	25842.08	12671.97	16742.06	17311.49	17311.49	17311.49	17311.49	17311.49	17311.49
Total net benefit, add. prod, res. costs only	1414.71	3989.31	-4109.01	36308.06	19061.74	19061.74	19061.74	19061.74	19061.74	19061.74	19061.74	19061.74
Total net benefit, add. prod.,res.,ext. costs	1349.51	3818.44	-4513.25	35565.35	18319.03	18319.03	18319.03	18319.03	18319.03	18319.03	18319.03	18319.03
Total net benefit, add. prod.,res.,ext.,seed costs	1315.36	3714.65	-4702.31	35174.82	17928.49	17928.49	17928.49	17928.49	17928.49	17928.49	17928.49	17928.49

[a] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62% of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.
[b] Allocation of maize area between large and small/medium farmers is based on CSO estimates for 1989, 1990, and estimates in Gibson (1987) for other years.
[c] LG refers to large farmers.
[d] Non-Zambian hybrids refer to CG4141, PNR473, R201, R215, ZS 206, and ZS225.
[e] Estimates of large farmer area planted to specific varieties are based on Zamseed sales records (Appendix 6, Tables 53-62)and MSU/MAFF/RDSB Maize Adoption Survey for 1978-83. 1984-2000 projections are based on the without-research assumption of continued availability of SR-52 and non-Zambian hybrids. Large farmers are assumed to plant SR52 and non-Zambian hybrids in the same proportions during 1984-2000 as in 1983.
[f] Here SR52 refers to the Zambian-produced SR52, originally derived from parents imported from (then) Northern Rhodesia at the time of Zambia's independence in 1964.
[g] SM/MED refers to small and medium-scale farmers.
[h] MSU/MAFF/RDSB Maize Adoption Survey data were used to allocate total maize area between different varieties between 1978-83. Projections for the 1984-2000 without-research case were based on the assumption of continued availability of local, SR52 and non-Zambian varieties, and that farmers continued to plant the varieties in the same proportion during 1984-2000 as in 1983.

[i] Average yields for large farmers are estimated at 5.5 tons/ha on average before improved Zambian varieties became available (Gibson, personal communication, 1993). Average yields for small/medium farmers were obtained by dividing CSO maize production estimates by estimates of maize area planted by small/medium farmers 1978-83. For remaining years yield estimates were derived from CSO area data and yield estimates (see j).
[j] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.
[k] Sources: CSO, World Bank for 1978-83 (see Table 2). 1983-1991 estimates based on CSO area data and yield estimates (see j). 1992-2000 estimates based on 1991.
[l] Import parity price. See Appendix 10, Table 95.
[m] Sources: 1979 (WB, 1979); 1982-91 CSO Crop Forecasting Survey; 1978, 1980, 1981, 1992-2000 estimates based on marketing data in Table 2 (marketed amount is on average 62 per cent of production); average yields in 1978, 1980, 1981 are estimated at 1.5 tons/ha. This analysis assumes that total area planted to maize remains the same in the with and without research scenarios.
[n] See Table 12.

[o] The yield advantage of improved Zambian varieties over SR52 is estimated at 20 per cent (Ristanovic, 1988). Results of on-farm trials of improved and local maize varieties show that the average ratio of Zambian hybrid yields to local yields was 1.64 from 1984-91. Gibson (personal communication, 1993) estimates that yields of non-Zambian hybrids are 5-10 per cent higher than SR52 on large farms, and 20 per cent higher than SR52 on small and medium farms. On this basis, it is assumed that SR52 yields are 1.37 x local yields; yields of Zambian improved varieties are 1.64 x local yields; yields of Zimbabwean hybrids are 1.075 x SR52 on large farms, and 1.64 x local yields on small/medium farms.

[p] The k-factor is the shift in in the production function resulting from the adoption of improved varieties. The shift in the supply curve (Figure 14) can be approximated by (1 + elasticity of supply).

[q] Based on estimates by Harber (1992) and Nakaponda (1992).

[r] See Figure 14. A0C = KP_oQ_o.

[s] See Figure 14. ABC = $1/2(P_oQ_o)*[K(1+\text{elast. of supply})]^2/\text{elast. of supply} + \text{elast. of demand}$.

[t] See Appendix 7.

[u] See Appendix 2, Tables 34-38. 1992-2000 expenditure estimates based on 1991 levels.

[v] See Appendix 8, Table 90.

[w] See Appendix 2, Tables 36, 39. 1992-2000 expenditures are estimated.

[x] See Appendix 9, Table 92. 1992 and 1993 estimates assume GRZ spending on subsidies declines to 50% and 25% of 1991 expenditures, respectively. Subsidy expenditures for the period 1994-2000 are assumed to decline to 0. Dept. of Coop/Mkting expenditures are assumed to remain constant at 1991 levels for the 1992-2000 period. 1992-2000 expenditures estimated at 0 based on GRZ plan to end its participation in maize marketing.

APPENDIX 12

APPENDIX 12

CALCULATION OF SUPPLY FUNCTIONS FOR SOUTHERN, EASTERN, NORTHERN PROVINCES AND THE REST OF THE ECONOMY

1.0. Southern Province

Maize production in Southern Province (SP) grew from 277,767 tons in 1971-72 to 419,986 tons in 1987-88, an increase of more than 50 percent. Southern Province is the country's most important maize-producing area after Central Province, producing one-third of the country's maize in 1971-72, and maize is regularly exported to deficit provinces . Maize-growing areas in SP Region I and SP Region II differ greatly, with Region I far less favorable for growing maize. Drought-tolerant sorghum is an important staple grain, as well as maize. Key parameters and assumptions used in constructing the supply equations are detailed in Table 104.

Estimation of provincial maize consumption and exports, 1971-72 and 1987-88

SP's estimated 1971 population is 511,034. There is no official data on the proportions of the SP population living in Region I vs. Region II. Region I areas of SP include Gwembe District and the very southern part of Kalomo District.

<u>Region I production</u>

The population of Gwembe District, almost all of which lies within Region I, is used as a proxy for total Region I population in SP. Because of the unfavorable conditions, it is assumed that SP Region I (SPRI) produces less than the country average per capita consumption, and, before the implementation of policies and availability of technology, produced roughly 63 kg of maize per capita. Per capita consumption of maize in Region I is estimated at 139 kg annually, based on estimated consumption in Region I areas of Eastern Province (ARPT 1991). Total SPRI consumption in 1971 is estimated as 78,699*139 kg=10,939 tons.

For SP Region I, the main effect of policies/technology is assumed to be the adoption of hybrids with fertilizer, as well as improved access to fertilizer for local maize. It is assumed that in the absence of policies no fertilizer would have been used on Region I SP maize. Yields of local maize rise 114.3 percent with a full application of fertilizer (Table 20). An estimated 27 percent of maize area in Region I SP was planted to improved Zambian hybrids in 1987-88. In the with policy scenario, it is assumed that half of local maize area, and all of the Zambian improved hybrid area received full fertilization. The overall impact of policies/technology was to increase production by 126.5 percent, from 8,606 tons in the absence of policies to an estimated production of 19,490 tons in 1987-88 (Table 104).

Region II production

In the without-policy scenario estimated from 1971-72 production data, SP Region II is assumed to produce more than its consumption requirement, exporting about 2.3 times its regional consumption needs.

Assuming that these relationships hold constant, it is estimated that in the absence of policies, in 1987-88, SP Region II farmers would have produced their own consumption needs, or 146,356 tons plus an additional 230 percent for export, or a total of 485,902 tons. With actual SPRII production estimated at 400,496 tons, this implies a decrease of 17.6 percent after policies and improved technology (Table 104).

Of total maize production in SP in 1971-2, small farmers produced 61.1 percent and large farmers produced 38.9 percent (Table 104). Assuming this proportion would have held constant in the absence of policies, of the total 485,902 tons (assumed) produced in 1987-88 (without policies), small farmers would have produced 296,886 tons and large farmers would have produced 189,016 tons.

Between the early 1970s (no policies, no technology) and the late 1980s, the breakdown of maize production changed; the small/medium share rose to 80 percent nationwide and large farmer production declined to 20 percent (GRZ 1990).

Large farmers, SPRII: In the projected no-policy/no technology situation for 1987-88, total SPRII production is estimated at 485,902 tons. If large farmers were still producing 38.9 percent of this, their production would have been 189,016 tons. In the actual, with technology/policy situation of 1987-88, large farmer production is estimated at 20 percent of total production (400,496), or 80,099. This represents a decline of 57.6 percent after policies/improved technology.

Small/medium farmers, SPRII: In the projected no-policy/no technology situation for 1987-88, total SPRII production is estimated at 485,902 tons. If small/medium farmers were still producing 61.1 percent of the total, their production would have been 296,886. In the actual, with technology/policy situation of 1987/88, small/medium farmer production is estimated at 80 percent of total production (400,496), or 320,397. This represents an increase of 7.9 percent in small/medium production after policies/improved technology.

Table 104 : Maize production parameters, Southern Province

	(1) Population	(2) Per cap. maize cons.(kg)	(3) Provincial cons. requirement (mt)	(4) Actual production of maize (mt)	(5) Estimated maize production without policies (mt)	(6) Est. % change in production after policies,imp technology
1971-2	511,034[a]			277,767[b]		
Region I sm/med	78,699[c]	139[d]	10,939[e]	4,835[f]		
Region II	432,335[g]	190[h]	82,144[e]	272,779		
sm/med				166,668[b]		
large				106,111[b]		
1987-8	910,512[j]			419,986[j]		
Region I sm/med	140,219[c]	139[d]	19,490[e]	19,490[k]	8,606[f]	+126.5%[g]
Region II	770,293	190[h]	146,356[e]	400,496[i]	485,902[l]	-17.6%
sm/med				320,397[m]	296,886[n]	+7.9%
large				80,099[m]	189,016[n]	-57.6%

[a] estimated, based on 1969 population estimate of 496,041 and 1.5 percent growth rate for Southern Province between 1969-74(CSO 1985)
[b] CSO 1978
[c] estimated at 15.4 percent of total SP province population, based on proportion of Gwembe District population to the rest of SP in 1969 (CSO 1985).
[d] Region I is drier and less suitable for maize cultivation than Region II. Sorghum is more drought-tolerant, and an important staple in Region I diets. Estimated per capita maize consumption is based on a food balance sheet prepared for Mambwe district, in the Region I portion of Eastern Province by ARPT (1991)
[e] [(1)*(2)]/1000
[f] Estimated. Production by SPRI sm/med farmers in 1987-8 was assumed to be 19,490 tons, based on an ARPT(1991) report predicting that Mambwe farmers (Eastern Province, RI) would be able to produce enough maize to supply 138 kg/per capita, under similar R conditions. This is the with-policy situation. The effect of policies/technology in SPR1 has been adoption of both hybrids and fertilizer. It is assumed that in the absence of policies no fertilizer would have been used on Region I SP maize. In the without-policy case, 11.2 percent of maize area is assumed to be sown to SR52, and the remainder to local maize (MSU/MAFF/RDSB survey estimates). In the with-policy case, 73 percent of maize area is sown to locals, and 27 percent to Zambian improved hybrids (MSU/MAFF/RDSB). In the with-policy case, half of the local maize area and all of the Zambian hybrid area is assumed to be fertilized. Under these assumptions, an estimated 12,700 total hectares were planted to maize in SPRI in 1987-88. If the same area were planted under the no-policy assumptions (11.2 percent SR52, 88.8 percent under local maize, no fertilizer), an estimated 8,606 tons of maize would have been produced, fulfilling 44.2 percent of R consumption requirements. By the same logic, it is assumed that in the absence of fertilizer in the 1971-72 season, farmers would have produced 44.2 percent of maize consumption requirements, or an estimated 4,835 tons.
[g] Residual between actual provincial production and estimated production for SP Region I.
[h] CIMMYT 1990
[i] Based on estimates from GRZ (1990).

[j] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that Southern Province had 12.09 percent of the country's population (CSO 1985). The population estimate for the province in 1987-88 assumes that this proportion has not changed.
[k] Assumed.
[l] In the without-policy scenario estimated from 1971-72 production data, SP Region II is assumed to produce more than its consumption requirement, exporting about 2.3 times its regional consumption needs. Assuming that these relationships hold constant, it is estimated that in the absence of policies, in 1987/88, SP Region II farmers would have produced their own consumption needs, or 146,356 tons plus an additional 230 percent for export, or a total of 485,902 tons. Actual SPRII production is estimated at 400,496 tons.
[m] Based on GRZ (1990) estimates that country-wide by the late 1980s, large farmers were producing 20 percent and small farmers 80 percent of maize.
[n] Assumes proportions prevailing in 1971-72; small/med farmers produce 61.1 percent, large 38.9 percent.

1.1.1. Southern Province, Region II small/medium farmers

S_0

S_0 represents the estimated supply of maize without improved technologies, fertilizer or policies.
$S_0 = a_1 P^e$
$Q_o = 296,886$ (Table 104)
Since Southern Province exports maize to other provinces, the economic import parity price minus transportation costs between Lusaka and Choma farmgates, ZK1923.9, is used in the without-policy case (Appendix 10, Table 95).
$P = 1923.9$
$e = .65$ (Harber 1992, Nakaponda 1992)
substituting these values,
$a_1 = 2177.03$

Estimation of S_{SR52}

$S_{SR52} = (1+h_{SR52})a_1 P^e$
where
$h_{SR52} = (1+e)*k_{SR52}$
SR52 has an estimated 33.3 percent yield advantage over local with no fertilizer. From MSU/MAFF/RDSB survey data, the average proportion of small/medium maize area in Southern Province Region II under SR52 in the year before adoption was 24.8 percent. Thus

(a) $k_{SR52,.25} = (.248/4) * .333 = .03$
$h_{SR52,.25} = (1+e)*k_{SR52,.25}$
$Q_{SR52,.25} = 307,010$

(b) $k_{SR52,.5} = (.248/2).*.333 = .04$
$h_{SR52,.5} = (1+e)*k_{SR52,.5}$
$Q_{SR52,.5} = 317,134$

(c) $k_{SR52,.75} = (.248*.75)*. 333 = .08$
$h_{SR52,.75} = (1+e)*k_{SR52,.75}$
$Q_{SR52,.75} = 327,257$

Estimation of S_{Zimb}

With no fertilizer, the yield advantage of Zimbabwean hybrids over locals is approximately 33.3 percent. From MSU/MAFF/RDSB survey data, the average proportion of small/medium maize area in Southern Province under Zimbabwean hybrids in the year before adoption was about 2.3 percent.
$S_{Zimb} = (1+h_{Zimb})(1+h_{SR52})a_1 P^e$
where

$h_{Zimb} = (1+e)*k_{Zimb}$

(a) $k_{Zimb.25} = (.023/4)*.33 = .002$
$h_{Zimb.25} = (1+e)*k_{Zimb.25}$
$Q_{Zimb.25} = 307{,}981$

(b) $k_{Zimb.5} = (.023/2)*.33 = .004$
$h_{Zimb.5} = (1+e)*k_{Zimb.5}$
$Q_{Zimb.5} = 319{,}140$

(c) $k_{Zimb.75} = (.023*.75)*.33 = .006$
$h_{Zimb.75} = (1+e)*k_{Zimb.75}$
$Q_{Zimb.75} = 330{,}362$

Estimation of S_{Zam}

With no fertilizer, the estimated yield advantage of Zambian varieties over locals is 33.3 percent. The average proportion of small/medium maize area in Southern Province Region II under Zambian hybrids in 1987-88 was 61 percent.
$S_{Zamb} = (1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_l P^e$
where
$h_{Zam} = (1+e)*k_{Zam}$

(a) $k_{Zam.25} = (.606/4) * .33 = .05$
$h_{Zam.25} = (1+e)*k_{Zam.25}$
$Q_{Zam.25} = 332{,}591$

(b) $k_{Zam.5} = (.606/2) * .33 = .10$
$h_{Zam.5} = (1+e)*k_{Zam.5}$
$Q_{Zam.5} = 369{,}984$

(c) $k_{Zam.75} = (.606*.75) * .33 = .15$
$h_{Zam.75} = (1+e)*k_{Zam.75}$
$Q_{Zam.75} = 409{,}064$

Estimation of S_{Pol}

$S_{Pol} = (1+h_{Pol})+(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_l P'^e$
where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol} = (1+e)*k_{Pol,}$
$h_{fert} = (1+e)*k_{fert}$
$h'_{Zam} = (1+e)*k'_{Zam}$
$h'_{Zimb} = (1+e)*k'_{Zimb}$

$k'_{Zam} = .606* .346 = .21$
$k'_{Zimb} = .0248*.346 = .09$

k'_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer results in a 73.3 percent increase over no fertilizer.
From MSU/MAFF/RDSB survey results, 39.4 percent of small/medium maize area in Central Province was under local varieties in 1987/88. It is assumed that half of local maize area is fertilized.
$k'_{fert}=.1997*.733=.14$
$k_{pol} = -.04$

$Q_{Pol}=320,397$

1.1.2. Southern Province, Region I, small/medium farmers

S_0

Parameters and assumptions are given in Table 104.
$S=a_l P^e$
$Q_o= 8,606$ (Table 104)
Since SP Region I is a maize deficit area, the import parity price minus transport costs between Lusaka and Choma farmgate is used in the without-policy case.
P=ZK1923.9
Substituting,
$a_l=63.1$

Estimation of S_{SR52}

$S_{SR52}= (1+h_{SR52})a_l P^e$
where $h_{SR52}=(1+e)*k_{SR52}$
Maize scientists estimate that at 0 fertilizer SR52 has a -28.6 percent yield disadvantage compared to local varieties in Region I. From MSU/MAFF/RDSB survey data, the average proportion of small/medium maize area in Southern Province Region I under SR52 in the year before adoption was 11.2 percent.

(a) $k_{SR52,.25}=(.112/4) *-.286=-.008$
$h_{SR52.25}=(1+e)*k_{SR52.25}$
$Q_{SR52,.25} =8,492$

(b) $k_{SR52,.5}=(.112/2).*-.286=-.016$
$h_{SR52.5}=(1+e)*k_{SR52.5}$
$Q_{SR52,.5} = 8,379$

(c) $k_{SR52,.75}=(.112*.75)*-.286=-.024$
$h_{SR52.75}=(1+e)*k_{SR52.75}$
$Q_{SR52,.75} = 8,265$

Estimation of S_{Zimb}

MSU/MAFF/RDSB survey estimates indicate that none of SPR1 maize area was planted to Zimbabwean hybrids.

Estimation of S_{Zam}

With no fertilizer, the estimated yield advantage of Zambian varieties over locals is 42.9 percent. The average proportion of small/medium maize area in Southern Province Region I under Zambian hybrids in 1987-88 was 27 percent.
$S_{Zam}=(1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_I P^e$
where $h_{Zam}=(1+e)*k_{Zam}$
(a) $k_{Zam.25}=(.27/4) * 429=.03$
$h_{Zam.25}=(1+e)*k_{Zam.25}$
$Q_{Zam.25}=8{,}898$

(b) $k_{Zam.5}=(.27/2) * .429=.06$
$h_{Zam.5}=(1+e)*k_{Zam.5}$
$Q_{Zam.5}=9{,}179$

(c) $k_{Zam.75}=(.27*.75) * .429=.09$
$h_{Zam.75}=(1+e)*k_{Zam.75}$
$Q_{Zam.75}=9{,}449$

Estimation of S_{Pol}

In Southern Province Region I, the yield advantage of Zambian hybrids over local varieties, if both receive full fertilization, is 80 percent. The assumed producer price in this with-policy case, P′, is the actual pan-territorial price in 1987-88, ZK889.

$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_I P'^e$
where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol}=(1+e)*k_{Pol},$
$h_{fert}=(1+e)*k_{fert}$
$h'_{Zam}=(1+e)*k'_{Zam}$
$h'_{Zimb}=(1+e)*k'_{Zimb}$

$k'_{Zam}=.27* .8=.22$
k'_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer results in a 114.3 percent increase over no fertilizer. Survey results indicate that 73 percent of small/medium maize area in SPRI was under local varieties in 1987/88. It is assumed that half of local maize area is fertilized.

$k'_{fert}=.365*1.143=.42$

k_{pol} = .38
Q_{Pol} = 19,490

1.1.3. Southern Province, Region II, large farmers

S_0

$S = a_l P^e$
Q_o = 189,016
The assumed producer price is the import parity price minus transport costs to Choma farmgate (Appendix 10, Table 95).
P= ZK1923.9/ton.
Substituting,
a_l = 1386.0

Estimation of S_{Zimb}

From MSU/MAFF/RDSB survey data, the average proportion of large farmer maize area under Zimbabwean hybrids in the year before adoption was about 13 percent. The estimated yield increase of Zimbabwean hybrids over SR52 (full fertilizer) is 7.3 percent. Thus
$S_{Zimb} = (1+h_{Zimb})a_l P^e$
where $h_{Zimb} = (1+e)*k_{Zimb}$
$k_{Zimb} = .13*.073 = .0095$
Q_{Zimb} = 191,992

Estimation of S_{Zam}

The average proportion of large farmer maize area under Zambian hybrids in 1987-88 was about 88.4 percent. The estimated yield increase of Zambian hybrids over SR52 is 11.2 percent.
$S_{Zamb} = (1+h_{Zam})(1+h_{Zimb})a_l P^e$
where $h_{Zam} = (1+e)*k_{Zam}$
$k_{Zam} = .884 * .1119 = .0989$

Q_{Zam} = 219,874

Estimation of S_{Pol}

The assumed price in the with-policy case is the actual pan-territorial maize price.
$S_{Pol} = (1+h_{Pol})(1+h_{Zam})(1+h_{Zimb})a_l P'^e$
where P' = ZK889
$h_{Pol} = S_{Pol} / (1+h_{Zam})(1+h_{Zimb})a_l P'^e$
$h_{Pol} = (1+e)k_{Pol}$
k_{pol} = -.247
S_{Pol} = 80,099

i
p
r
p
b
a
c
p
2

1.2. Eastern Province

Maize production in Eastern Province has grown from 111,690 tons in 1971-72 to 451,164 tons in 1987-88, more than quadrupling in less than 20 years. Like Southern Province, characteristics of Region I and Region II maize-growing areas differ greatly. Parameters and assumptions underlying the EP analysis are presented in Table 105.

The total population of EP in 1987-88 is estimated as 870,597 persons. While there are no official estimates of EP population residing in Regions I and II, Jha et al. estimate that 83 percent of EP's population lives in the plateau, or Region II, areas, and 17 percent live in the valleys, Region I (1991). In 1987-88, the estimated Region I population was 148,002, and 722,595 for Region II (Table 105).

Per capita consumption is estimated at 190 kg in Region II and 139 kg in Region I areas of Eastern Province, based on CIMMYT and ARPT estimates (CIMMYT 1990; ARPT 1991). Multiplying this amount by the EP population, total consumption of maize in EP in 1987/88 is estimated at 157,578 tons.

In the without-policy scenario estimated from 1971-72 production data, EP Region II is assumed to produce more than its consumption requirement, exporting about 11.6 percent over provincial consumption needs. Because of the unfavorable conditions, it is assumed that EP Region I produced less than the country average per capita consumption, and, before the implementation of policies and availability of technology, produced roughly 80 kg of maize per capita.

Assuming that these relationships hold constant, it is estimated that in the absence of policies, in 1987-88, EP Region II farmers would have produced their own consumption needs, or 137,293 tons plus an additional 24.2 percent for export, or a total of 170,532 tons. With actual EPRII production estimated at 430,592 tons, this implies an increase of 152.5 percent due to policies and improved technology (Table 108).

For EP Region I, the effect of policies/technology is assumed to be mainly improved access to fertilizer for local maize. It is assumed that in the absence of policies no fertilizer would have been used on Region I EP maize. Yields of local maize rise 114.3 percent with a full application of fertilizer (Table 20). Only a small proportion of maize area in Region I EP, 6.8 percent, was planted to improved Zambian hybrids in 1987/8. In the with-policy scenario, it is assumed that half of local maize area, and all of the Zambian improved hybrid area received full fertilization. The overall impact of policies/technology is estimated to have increased production by 74.7 percent, from 11,777 tons in the absence of policies to an estimated production of 20,572 tons in 1987-88 (Table 105).

Table 105: Maize production parameters, Eastern Province

	(1) Population	(2) Per cap. maize cons.(kg)	(3) Provincial cons. requirement (mt)	(4) Actual production of maize (mt)	(5) Estimated maize production without policies (mt)	(6) Est. % change in production after policies,imp technology
1971-2	533,222[a]	181	96,513[c]	111,690[d]		
Region I	90,648[e]	139[f]	12,600[c]	7,220[g]		
Region II	442,574[e]	190[b]	84,089[c]	104,470[h]		
1987-8	870,597[i]	181	157,578[c]	451,164[j]	182,309[k]	+147.5
Region I	148,002[e]	139[f]	20,572[c]	20,572[l]	11,777[g]	+74.7[g]
Region II	722,595[e]	190[b]	137,293[c]	430,592[h]	170,532[k]	+152.5

[a] estimated, based on 1969 population estimate of 509,515 (CSO 1985) and 2.3 percent growth rate for Eastern Province between 1969-74(CSO 1985)

[b] CIMMYT 1990.

[c] [(1)*(2)]/1000

[d] CSO 1978

[e] Jha et al. 1991 estimate that in 1986, 17 percent of Eastern Province's population lived in Valley areas (Region I), and 83 percent lived on the Plateau (Region II) (p.175). It is assumed that the proportions were the same in the early 1970s.

[f] Region I is drier and less suitable for maize cultivation than Region II. Sorghum is more drought-tolerant, and an important staple in Region I diets. Estimated per capita maize consumption is based on a food balance sheet prepared for Mambwe district by ARPT (1991)

[g] Estimated. Production by EPRI sm/med farmers in 1987-88 was assumed to be 20,572 tons, based on an ARPT(1991) report predicting that Mambwe farmers would be able to produce enough maize to supply 138 kg/per capita. This is the with-policy situation. Relatively little maize area in EPRI is sown to hybrid maize; the main impact of policies/technology has been easier access to fertilizer for local maize. It is assumed that in the absence of policies no fertilizer would have been used on Region I EP maize. In the without-policy case, an estimated 96.4 percent of maize area was sown to local maize, and 3.63 percent to SR52 (MSU/MAFF/RDSB survey estimates). In the with policy case, 93.2 percent of maize area is sown to locals, and 6.8 percent to Zambian improved hybrids (MSU/MAFF/RDSB). In the with-policy case, half of the local maize area and all of the Zambian hybrid area is assumed to be fertilized. Under these assumptions, an estimated 17,002 hectares total was planted to maize in EPRI in 1987/88. If the same area were planted under the no-policy assumptions (no fertilizer), an estimated 11,777 tons of maize would have been produced, fulfilling 57.3 percent of R consumption requirements. By the same logic, it is assumed that in the absence of fertilizer in 1971-72 season, farmers would have produced 57.3 percent of maize consumption requirements, or an estimated 7,220 tons.

[h] Residual between actual provincial production and estimated production for EP Region I.

[i] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that Eastern Province had 11.56 percent of the country's population (CSO 1985). The population estimate for the province in 1987-88 assumes that this proportion has not changed.

[j] GRZ 1990.

[k] Based on 1970-71 data, it is estimated that EPRII produced its per capita consumption needs plus an additional 24.2 percent for export. It is assumed that the same would be produced in 1987-88 in the absence of policies, consumption needs plus 24.2 percent for export.

[l] Assumed.

1.2.1. Eastern Province, Region II, small/medium farmers

Table 105 summarize parameters and assumptions used for calculating RII small/medium farmer supply shifts.

S_0

$S = a_I P^e$
$Q_o = 170{,}532$
The assumed producer price in this without-policy case is assumed to be the import parity price minus transport costs to Chipata farmgates (Table 95, Appendix 10).

P=ZK 1572.4/ton
Substituting,
$a_I = 1425.8$

Estimation of S_{SR52}

$S_{SR52} = (1 + h_{SR52}) a_I P^e$
where $h_{SR52} = (1+e) k_{SR52}$
Maize scientists estimate that at 0 fertilizer SR52 has a 33.3 percent advantage over local maize varieties. The average proportion of small/medium maize area in Eastern Province Region II under SR52 in the year before adoption was 31.7 percent.

(a) $k_{SR52,.25} = (.317/4) * .333 = .03$
$h_{SR52,.25} = (1+e) k_{SR52,.25}$
$Q_{SR52,.25} = 177{,}965$

(b) $k_{SR52,.5} = (.317/2). * .333 = .05$
$h_{SR52,.5} = (1+e) k_{SR52,.5}$
$Q_{SR52,.5} = 185{,}398$

(c) $k_{SR52,.75} = (.317 * .75) * . 333 = .08$
$h_{SR52,.75} = (1+e) k_{SR52,.75}$
$Q_{SR52,.75} = 192{,}831$

Estimation of S_{Zimb}

With no fertilizer, the yield advantage of Zimbabwean hybrids over locals is approximately 33.3 percent. An average 1.8 percent of small/medium maize area in Eastern Province was planted to Zimbabwean hybrids in the year before adoption.
$S_{Zimb} = (1 + h_{Zimb})(1 + h_{SR52}) a_I P^e$
where $h_{Zimb} = (1+e) k_{Zimb}$

(a) $k_{Zimb.25} = (.018/4) * .33 = .002$
$h_{Zimb.25} = (1+e) * k_{Zimb.25}$
$Q_{Zimb.25} = 178{,}406$

(b) $k_{Zimb.5}=(.018/2)*.33=.004$
$h_{Zimb.5}=(1+e)*k_{Zimb.5}$
$Q_{Zimb.5}=186{,}316$

(c) $k_{Zimb.75}=(.018*.75)*.33=.005$
$h_{Zimb.75}=(1+e)*k_{Zimb.75}$
$Q_{Zimb.75}=194{,}263$

Estimation of S_{Zam}

The estimated yield advantage of Zambian varieties over locals is 33.3 percent. From survey data, the average proportion of small/medium maize area in Eastern Province Region II under Zambian hybrids in 1987/8 was 34.3 percent.

$S_{Zam}=(1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_1P^e$
where $h_{Zam}= (1+e)k_{Zam}$
(a) $k_{Zam.25}=(.343/4) * .33=.03$
$h_{Zam.25}=(1+e)k_{Zam.25}$
$Q_{Zam.25}=186{,}820$

(b) $k_{Zam.5}=(.343/2) * .33=.06$
$h_{Zam.5}=(1+e)k_{Zam.5}$
$Q_{Zam.5}=203{,}890$

(c) $k_{Zam.75}=(.343*.75) * .33=.09$
$h_{Zam.75}=(1+e)k_{Zam.75}$
$Q_{Zam.75}=221{,}749$

Estimation of S_{Pol}

In Eastern Province Region II, the yield advantage of both Zimbabwean and Zambian hybrids over local varieties, if they receive full fertilization, is 34.6 percent.
The with-policy price is the actual pan-territorial price for 1987-88, ZK889.
$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_1P'^e$
where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol}=(1+e)*k_{Pol}$,
$h_{fert}=(1+e)*k_{fert}$
$h'_{Zam}=(1+e)*k'_{Zam}$
$h'_{Zimb}=(1+e)*k'_{Zimb}$

$k'_{Zam}=.343* .346=.12$
$k'_{Zimb}=.012*.346=.004$
k'_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer results in a 73.3 percent increase over no fertilizer. Survey results indicate that 64.5 percent of small/medium maize area in

Central Province was under local varieties in 1987-88. It is assumed that half of local maize area is fertilized.
$k'_{fert}=.3225*.733=.24$
$k_{Pol} = .72$

$Q_{Pol}=430{,}592$

1.2.2. Eastern Province, Region I, small/medium farmers

See Table 105 for data and assumptions used in calculating the supply shifts for EPRI small/medium farmers.

S_0

$S=a_1P^e$
$Q_o= 11{,}777$ (Table 105)
Since EP Region I is a deficit region, the assumed producer price is the import parity price minus transport costs between Lusaka and Chipata for 1987-88 (Table 95 Appendix 10).
$P=1572.4$
Substituting,
$a_1=98.5$

Estimation of S_{SR52}

$S_{SR52}= (1+h_{SR52})a_1P^e$
while $h_{SR52}=(1+e)*k_{SR52}$
With no fertilizer, SR52 has a -28.6 percent yield disadvantage compared to local varieties in Region I. The average proportion of small/medium maize area in Eastern Province Region I under SR52 in the year before adoption was 3.6 percent.

(a) $k_{SR52,.25}=(.036/4) *-.286=-.0026$
$h_{SR52,.25}=(1+e)*k_{SR52,.25}$
$Q_{SR52,.25} =11{,}727$

(b) $k_{SR52,.5}=(.036/2).*-.286=-.0052$
$h_{SR52,.5}=(1+e)*k_{SR52,.5}$
$Q_{SR52,.5} = 11{,}676$

(c) $k_{SR52,.75}=(.036*.75)*-.286=-.0078$
$h_{SR52,.75}=(1+e)*k_{SR52,.75}$
$Q_{SR52,.75} = 11{,}626$

Estimation of S_{Zimb}

According to MSU/MAFF/RDSB survey estimates, none of EPR1 maize area was planted to Zimbabwean hybrids.

Estimation of S_{Zam}

The estimated yield advantage of Zambian varieties over locals, with no fertilizer, is 42.9 percent. The average proportion of small/medium maize area in Eastern Province Region I under Zambian hybrids in 1987-88 was 6.8 percent.

$S_{Zam}=(1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_1P^e$
where $h_{Zam}=(1+e)*k_{Zam}$
(a) $k_{Zam.25}=(.068/4)' * 429=.01$
$h_{Zam,.25}=(1+e)*k_{Zam,.25}$
$Q_{Zam.25}=11,868$

(b) $k_{Zam.5}=(.068/2) * .429=.01$
$h_{Zam,.5}=(1+e)*k_{Zam,.5}$
$Q_{Zam.5}=11,957$

(c) $k_{Zam.75}=(.068*.75) * .429=.02$
$h_{Zam,.75}=(1+e)*k_{Zam,.75}$
$Q_{Zam.75}=12,045$

Estimation of S_{Pol}

In Eastern Province Region I, the yield advantage of Zambian hybrids over local varieties, if both receive full fertilization, is estimated at 80 percent. In the with-policy case, the producer price is the actual pan-territorial price for 1987-88, ZK 889.

$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_1P'^e$
where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol}=(1+e)*k_{Pol,}$
$h_{fert}=(1+e)*k_{fert}$
$h'_{Zam}=(1+e)*k'_{Zam}$
$h'_{Zimb}=(1+e)*k'_{Zimb}$

$k'_{Zam}=.068* .8=.054$
k'_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer results in a 114.3 percent increase over no fertilizer. An estimated 93.2 percent of small/medium maize area in EPRI was under local varieties in 1987-88. It is assumed that half of local maize area is fertilized.
$k'_{fert}=.466*1.143=.53$
$k_{pol} = .15$
$Q_{Pol}= 20,572$

1.3. Northern Province, Region III, small/medium farmers

Maize production in Northern Province has grown from 61,389 tons in 1971-72 to 194,404 tons in 1987-88, more than a 300 percent increase in less than 20 years.

Table 106: Maize production parameters, Northern Province

	(1) Population	(2) Per cap. maize cons.(kg)	(3) Provincial cons. requirement (mt)	(4) Actual production of maize (mt)	(5) Estimated maize production without policies (mt)	(6) Est. % change in production after policies,imp technology
1971-2	560,466[a]	110[c]	61,651[d]	61,389[e]		
1987-8	896,203[b]	110[c]	98,582[d]	194,404[f]	98,582	+97.2

[a] estimated, based on 1969 population estimate of 545,096 (CSO 1985) and 1.4 percent growth rate for Northern Province between 1969-74(CSO 1985)
[b] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that northern Province had 11.9 percent of the country's population (CSO 1985). The population estimate for the province for 1987-88 assumes that this proportion has not changed.
[c] Provincial production 1971-2 (CSO 1978) divided by population.
[d] [(1)*(2)]/1000
[e] CSO 1978
[f] GRZ 1990.
[g] Estimated provincial consumption requirements = 896,203 (inhabitants)*110 kg = 98,582 tons.

The total population of NP in 1987-88 is estimated as 896,203 persons. It is assumed that Northern Province is autarkic in maize, so that local demand=local supply. Maize consumption is estimated at 110 kg per capita based on 1971 population and production data. Maize consumption is lower here than in other parts of Zambia because maize is a relatively new crop in most of the province. Millet and sorghum are more traditional staples. Multiplying this amount by the NP population, total consumption of maize in NP in 1987/88 is estimated at 98,582 tons (Table 106).

S_0

$S_0=a_I P^e$
Q_o= 98,582 (Table 106)
Since NP is assumed autarkic, the producer price is assumed to be ZK 1405/ton, based on Jansen's estimate of maize price in Northern Province in 1968-69, prior to pan-territorial pricing, of ZK 41.1/ton, and is adjusted to 1987-88 prices (1977, 99).

P=1405
Substituting,
a_I=886.8

Estimation of S_{SR52}

$S_{SR52} = (1+h_{SR52})a_lP^e$

where $h_{SR52}=(1+e)k_{SR52}$
If no fertilizer is used, SR52 is estimated to have a 14.3 percent yield advantage over local maize varieties (Table 20). About 17.4 percent of maize area was under SR52 in NP in the year before adoption of improved varieties, according to survey data.

(a) $k_{SR52,.25}=(.174/4)*.143=.006$
$h_{SR52,.25}=(1+e)k_{SR52,.25}$
$Q_{SR52,.25}$ = 99,593

(b) $k_{SR52,.5}=(.174/2)*.143=.0124$
$h_{SR52,.5}=(1+e)k_{SR52,.5}$
$Q_{SR52,.5}$ =100,604

(c) $k_{SR52,.75}=(.174*.75)*.143=.0186$
$h_{SR52,.75}=(1+e)k_{SR52,.75}$
$Q_{SR52,.75}$ = 101,615

Estimation of S_{Zimb}

The average proportion of maize area under non-SR52 Zimbabwean hybrids in the year before adoption was about 4.6 percent. With no fertilizer, the yield difference between local varieties and Zimbabwean hybrids is estimated at 157.1 percent.

$S_{Zimb} = (1+h_{Zimb})(1+h_{SR52})a_lP^e$
where $h_{Zimb}=(1+e)k_{Zimb}$
(a) $k_{Zimb.25}=(.046/4)*1.57=.02$
$h_{Zimb,.25}=(1+e)k_{Zimb,.25}$
$Q_{Zimb.25}$=102,563

(b) $k_{Zimb.5}= (.046/2)*1.57=.04$
$h_{Zimb,.5}=(1+e)k_{Zimb,.5}$
$Q_{Zimb.5}$ =106,604

(c) $k_{Zimb.75}=(.046*.75)*1.57=.05$
$h_{Zimb,.75}=(1+e)k_{Zimb,.75}$
$Q_{Zimb.75}$=110,705

Estimation of S_{Zam}

The average proportion of maize area under Zambian hybrids in 1987-88 was 35.2 percent. The estimated yield advantage of Zambian hybrids over local varieties (all unfertilized) is 185.7 percent.

$S_{Zam}=(1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_1P^e$
where $h_{Zam}=(1+e)k_{Zam}$

(a) $k_{Zam.25}=(.352/4)*1.857=.163$
$h_{Zam,.25}=(1+e)k_{Zam,.25}$
$Q_{Zam.25}=130{,}220$

(b) $k_{Zam.5}=(.352/2)*1.857=.327$
$h_{Zam,.5}=(1+e)k_{Zam,.5}$
$Q_{Zam.5}=164{,}096$

(c) $k_{Zam.75}=(.352*.75)*1.857=.49$
$h_{Zam.75}=(1+e)k_{Zam,.75}$
$Q_{Zam.75}=200{,}261$

Estimation of S_{Pol}

In Northern Province, the yield advantage of Zimbabwean hybrids over locals (full fertilization) is 51.5 percent, and that of Zambian hybrids over locals (full fertilization) is 63.6 percent. The with-policy price is the actual pan-territorial price in 1987-88, ZK889.

$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_1P'^e$
where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol}=(1+e)*k_{Pol}$,
$h_{fert}=(1+e)*k_{fert}$
$h'_{Zam}=(1+e)*k'_{Zam}$
$h'_{Zimb}=(1+e)*k'_{Zimb}$

$k'_{Zam}=.352*.636=.2240$
$k'_{Zimb}=.046*.515=.024$

k_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer results in a more than doubling of local yields in Region III. As in the other provinces, it is estimated that one-half of local maize area is fertilized.
$k'_{fert}=.301*1.36=.4085$
$k_{pol} = .07$
$Q_{Pol}=194{,}404$

1.4. Lusaka Province, urban; Copperbelt Province, urban

Table 107 shows the estimated population and maize consumption requirements in 1987-88 for the principal urban areas in Zambia, Lusaka and the Copperbelt. Lusaka is estimated to require 136,166 tons and Copperbelt towns 288,987 tons.

Table 107: Estimated maize consumption, urban Lusaka and Copperbelt Provinces, 1987-88

	Population	Per cap. maize cons.(kg)	Urban cons. requirement (mt)
Lusaka	716,661[1]	190[3]	136,166[4]
Copperbelt	1,520,985[2]	190[3]	288,987[4]

[1] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that Lusaka Province had 12.2 percent of the country's population, and urban Lusaka represented 78 percent of that total (CSO 1985). The population estimate for the province for 1987-88 assumes that this proportion has not changed.
[2] Estimated from Zambia mid-1988 population estimate (7,531,119)(Africa South of the Sahara, 1993). No provincial estimates were available for that year. The 1980 census showed that Copperbelt Province had 22 percent of the country's population, and urban Copperbelt towns contained 92 percent of that total (CSO 1985). The population estimate for the province for 1987-88 assumes that this proportion has not changed.
[3] CIMMYT 1990. Per capita total maize utilization, 1986-88.
[4] [(1)*(2)]/1000

1.5. Rest of economy

The rest of the maize economy includes the rural areas of Copperbelt and Lusaka Provinces, and Luapula, Northwestern and Western Provinces. In 1971-72, these provinces produced 85,158 tons of maize, 10 percent of the national total (CSO 1978). By 1987-88, it had tripled, to 256,760 tons, representing 14 percent of national production (GRZ 1990). Although there are a few large farmers in Copperbelt and Lusaka Provinces, for the purposes of this analysis, it is assumed that all are small/medium farmers.

S_0

It is assumed that, in the absence of policies and technology improvements, these other provinces would have continued to produce 10 percent of the national maize total. The total of S_0 estimates from Central, Southern Eastern and Northern Provinces (Table 108) is 1,397,271 tons. If this represents 90 percent of total maize production in the absence of policies, total production would have been 1,552,523 tons. Ten percent of this total is 155,252 tons.

$Q_o = 155,252$

Since these provinces are net maize importers, the relevant producer price in the without-policy case is assumed to be the import parity price minus transport costs. In this case, the average of Lusaka farmgate and Copperbelt farmgate prices is used, since these two provinces account for more than half of production in the rest of the economy (Table 95, Appendix 10).

$P=2200.1$
Substituting,
$a_1=1043.4$

Half of the remaining provinces are in Region II, the rest in Region III. In calculating the yield advantage of maize varieties under various fertilizer levels, the average of results from the two regions was used (Table 20). No maize adoption data is available for these particular provinces, since they were not included in the MSU/MAFF/RDSB Survey. The average of small/medium areas in Central (Region II) and Northern Provinces (Region III) were substituted, since agroecological conditions are similar to those in Lusaka and Copperbelt Provinces, the two dominant provinces in the "other" group.

Estimation of S_{SR52}

$S_{SR52}= (1+h_{SR52})a_1P^e$
where
$h_{SR52}= (1+e)*k_{SR52}$
If no fertilizer is used, SR52 is estimated to have a 23.8 percent yield advantage over local maize varieties (Table 20). About 24.4 percent of maize area was estimated to be under SR52 in the year before adoption of improved varieties.

(a) $k_{SR52,.25}=(.244/4)*.238=.02$
$h_{SR52,.25}= (1+e)*k_{SR52,.25}$
$Q_{SR52,.25} = 158,971$

(b) $k_{SR52,.5}=(.244/2)*.238=.03$
$h_{SR52,.5}= (1+e)*k_{SR52,.5}$
$Q_{SR52,.5} =162,690$

(c) $k_{SR52,.75}=(.244*.75)*.238=.04$
$Q_{SR52,.75} = 166,409$

Estimation of S_{Zimb}

The average proportion of maize area under non-SR52 Zimbabwean hybrids in the year before adoption is estimated at 2.9 percent. With no fertilizer, the yield difference between local varieties and Zimbabwean hybrids is estimated at 95.2 percent.

$S_{Zimb}= (1+h_{Zimb})(1+h_{SR52})a_1P^e$
$h_{Zimb}=(1+e)*k_{Zimb}$

(a) $k_{Zimb.25}=(.029/4)*.952=.0069$
$h_{Zimb,.25}= (1+e)*k_{Zimb,.25}$
$Q_{Zimb.25}=160,781$

(b) $k_{Zimb.5} = (.029/4)*.952 = .0138$
$h_{Zimb,.5} = (1+e)*k_{Zimb,.5}$
$Q_{Zimb.5} = (1+k_{Zimb.5})(1+k_{SR52.5})a_1P^e = 166,396$

(c) $k_{Zimb.75} = (.029*.75)*.95 = .0207$
$h_{Zimb,.75} = (1+e)*k_{Zimb,.75}$
$Q_{Zimb.75} = 172,094$

Estimation of S_{Zam}

The average proportion of maize area under Zambian hybrids in 1987/8 was estimated at 35.3 percent. The estimated yield advantage of Zambian hybrids over local varieties (all unfertilized) is 109.5 percent.
$S_{Zam} = (1+h_{Zam})(1+h_{Zimb})(1+h_{SR52})a_1P^e$
where $h_{Zam} = (1+e)k_{Zam}$
(a) $k_{Zam.25} = (.353/4)*1.1 = .10$
$h_{Zam,.25} = (1+e)*k_{Zam,.25}$
$Q_{Zam.25} = 186,534$

(b) $k_{Zam.5} = (.353/2)*1.1 = .19$
$h_{Zam,.5} = (1+e)*k_{Zam,.5}$
$Q_{Zam.5} = 219,700$

(c) $k_{Zam.75} = (.353*.75)*1.1 = .29$
$h_{Zam,.75} = (1+e)*k_{Zam,.75}$
$Q_{Zam.75} = 254,789$

Estimation of S_{Pol}

The yield advantage of Zimbabwean hybrids over locals (full fertilization) is 43.1 percent, and that of Zambian hybrids over locals (full fertilization) is 49.1 percent. The with-policy price, P′, is the actual pan-territorial price, ZK889.

$S_{Pol} = (1+h_{Pol})(1+h_{fert})(1+h'_{Zam})(1+h'_{Zimb})a_1P'^e$

where $P' = 889$, the pan-territorial maize price paid by GRZ
and $h_{Pol} = (1+e)*k_{Pol}$,
$h_{fert} = (1+e)*k_{fert}$
$h'_{Zam} = (1+e)*k'_{Zam}$
$h'_{Zimb} = (1+e)*k'_{Zimb}$

$k'_{Zam} = .353*.491 = .17$
$k'_{Zimb} = .029*.431 = .01$
k_{fert} captures the effect of fertilizer availability on the yield of local varieties. Application of full levels of fertilizer is estimated to result in a more than doubling of

local yields. As in the other provinces, it is estimated that one-half of local maize area is fertilized.

k_{fert}=.310*1.05=.32

k_{pol} = .29

Q_{Pol}=256,760

Table 108: Summary of results, supply curve estimation

	Reg.2 Central Province sm/med	Reg.2 Central Province large	Reg.1 Southern Province sm/med	Reg.2 Southern Province sm/med	Reg.2 Southern Province large	Reg.1 Eastern Province sm/med	Reg.2 Eastern Province sm/med	Reg.3 North. Province sm/med	Rest of econ.
a	1893.3	2622.1	63.1	2177.03	1386.0	98.5	1425.8	886.8	2200.1
P^a	1952	1952	1923.9	1923.9	1923.9	1572.4	1572.4	1405	2200.1
P'^b	889	889	889	889	889	889	889	889	889
Q_0	260,632	360,956	8,606	296,886	189,016	11,777	170,532	98,582	155,252
k_{SRS2}(25%)	.0262	...	-.008	.021	...	-.0026	.0264	.0062	.015
k_{SRS2}(50%)	.0523	...	-.016	.0413	...	-.0052	.0528	.0124	.029
k_{SRS2}(75%)	.0785	...	-.024	.062	...	-.0078	.0793	.0186	.044
Q_{SRS2}(25%)	271,885	...	8,492	307,010	...	11,727	177,965	99,593	158,971
Q_{SRS2}(50%)	283,138	...	8,379	317,134	...	11,676	185,398	100,604	162,690
Q_{SRS2}(75%)	294,390	...	8,265	327,257	...	11,626	192,831	101,615	166,409
k_{Zimb}(25%)	.0010	.0095[c]		.0019	.0095[c]	...	.0015	.0181	.0069
k_{Zimb}(50%)	.0020			.0038		...	.0030	.0361	.0138
k_{Zimb}(75%)	.0030			.0058		...	.0045	.0542	.0207
Q_{Zimb}(25%)	272,333	366,639[c]		307,981	191,992[c]	...	178,406	102,563	160,781
Q_{Zimb}(50%)	284,072			319,140		...	186,316	106,604	166,396
Q_{Zimb}(75%)	295,848			330,362		...	194,263	110,705	172,094
k_{Zam}(25%)	.03	.0989[c]	.03	.05	.0989[c]	.01	.0286	.1634	.10
k_{Zam}(50%)	.06		.06	.10		.01	.0572	.3269	.19
k_{Zam}(75%)	.09		.09	.15		.02	.0858	.4903	.29
Q_{Zam}(25%)	285,552	419,885[c]	8,898	332,591	219,874[c]	11,868	186,820	130,220	186,534
Q_{Zam}(50%)	311,648		9,179	369,984		11,957	203,890	164,096	219,700
Q_{Zam}(75%)	338,927		9,449	409,064		12,045	221,749	200,261	254,789
k'_{zimb}	.0042			.09		...	.0042	.0237	.01
k'_{zam}	.12		.22	.21		.05	.12	.22	.17
k'_{fert}	.23		.42	.14		.5326	.24	.4085	.32
k_{pd}	.342	-.364	.38	-.04	-.247	.15	.72	.070	.29
Q_{pd}	409,349	102,337	19,490	320,397	80,099	20,572	430,592	194,404	256,760

[a] P=economic import parity price minus transportation costs, except for Northern Province, which is the estimated local market price
[b] pan-territorial price
[c] large farmer analysis assumes area planted to specified variety is the same with or without technology and policies

APPENDIX 13

APPENDIX 13

REVISED ARR ESTIMATES, WITHOUT-POLICY CASE

Table 109: Revised ARR to technology investments in the absence of price and marketing policies, 25 percent of with-policy area planted to non-local varieties

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT											
Total Production	1.601	1.601	1.601	1.601	1.601	1.601	1.601	1.601	.945	1.601	1.601
Price (ZK/ton)	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production Value (1)	559.09	596.85	843.65	1314.22	1359.08	1487.75	1689.40	1950.36	1641.88	2978.53	4562.78
WITH											
Total Production	1.601	1.601	1.601	1.601	1.601	1.601	1.349	1.450	1.051	1.782	1.782
Price (ZK/ton) /	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production Value (2)	559.09	596.85	843.65	1314.22	1359.08	1487.75	1423.03	1766.99	1827.43	3315.90	5078.90
Add'l Benefit (3)=(2)-(1)	0.00	0.00	0.00	0.00	0.00	0.00	-266.36	-183.37	185.55	337.36	516.12
COSTS											
With Research											
Research costs (mln ZK)											
GRZ expenditures	1.09	1.33	1.71	1.30	1.87	1.38	1.66	1.22	1.74	2.89	6.11
USAID expenditures						2.91	3.74	4.99	7.06	2.66	
SIDA expenditures		0.21	0.24	0.90	0.99	0.85	1.12	0.85	5.59	9.77	15.37
FAO/UNDP expenditures	0.47	0.45	0.49	0.55	0.60	0.60	0.91	1.15	1.67	0.91	1.41
CIMMYT expenditures			0.03	0.05	0.06	0.08	0.17	0.61	0.73	1.23	1.74
Total Research costs (6)	1.56	1.99	2.47	2.79	3.52	5.82	7.60	8.82	16.79	17.46	24.62
Extension costs (mln ZK)											
GRZ and donor expenditures	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Total Extension costs (7)	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97

	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Seed industry costs (mln ZK)											
SIDA expenditures		0.57	0.66	1.72	2.26	1.68	1.97	2.19	10.66	12.10	21.16
Zamseed investment expenditures				1.44	0.30	2.71	0.86	0.94	1.10	0.00	0.25
Total seed industry costs (8)		0.57	0.66	3.16	2.56	4.39	2.83	3.13	11.76	12.10	21.41
Total Production, Research, Extension, Seed, Mkting Costs (10)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Total Add'l Costs (11)=(10)-(4)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Net Benefit , incl. all costs (12)=(3)-(11)	-3.18	-4.41	-6.50	-11.34	-12.64	-14.34	-299.06	-216.15	128	271 .29	417.11
IRR (%), including all costs ====> 1978-2001	129.59										
1978-91 ==>	125.47										

Table 109 (con't)

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
BENEFITS												
WITHOUT RESEARCH												
Total Production	1.601	1.601	0.640	1.601	1.601	1.601	1.601	1.601	1.601	1.601	1.601	1.601
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.1
Total Production Value (1)	7968.57	21661.66	16436.73	129536.6	129536.6	129536.6	129536.6	129536.6	129536.6	129536.6	129536.6	129537
WITH RESEARCH												
Total Production	1.782	1.782	1.182	1.782	1.782	1.782	1.782	1.782	1.782	1.782	1.782	1.782
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Production value (mln ZK)												
Total Production Value (2)	8869.92	24111.90	30339.26	144189.0	144189.0	144189.0	144189.0	144189.0	144189.0	144189.0	144189.0	144189.0
Add'l Benefit (3)=(2)-(1)	901.36	2450.24	13902.5	14652.4	14652.4	14652.4	14652.4	14652.4	14652.4	14652.4	14652.4	14652.4
COSTS												
With Research												
Research costs (mln ZK)												
GRZ expenditures	6.10	24.61	200.77	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66
USAID expenditures												
SIDA expenditures	31.08	107.65	189.05	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27
FAO/UNDP expenditures	2.69	7.58	14.05	27.96								
CIMMYT expenditures	3.46	7.55	13.74	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22
Total Research costs (6)	43.32	147.40	417.61	801.11	773.15	773.15	773.15	773.15	773.15	773.15	773.15	773.15

	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Extension costs (mln ZK)												
GRZ and donor expenditures	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Total Extension costs (7)	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Seed industry costs (mln ZK)												
SIDA expenditures	33.41	100.91	187.87	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92
Zamseed investment expenditures	0.75	2.88	1.19	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61
Total seed industry costs (8)	34.15	103.79	189.06	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53
Total Production, Research, Extension,												
	142.68	422.06	1010.92	1934.35	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39
Net Benefit , incl. all costs (12)=(3)-(11)	758.68	2028.18	12891.61	12718.07	12746.02	12746.02	12746.02	12746.02	12746.02	12746.02	12746.02	12746.0
IRR (%), including all costs ====> 1978-2001												
1978-91												

Table 110: Revised ARR, assuming 50 percent of with-policy area planted to SR52, Zimbabwean, Zambian varieties

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT RESEARCH											
Total Production	1.641	1.641	1.641	1.641	1.641	1.641	1.641	1.641	0.968	1.641	1.641
Price (ZK/ton) a/	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production Value (1)	573.16	611.88	864.89	1347.31	1393.29	1525.2	1731.92	1999.46	1683.21	3053.51	4677.64
WITH RESEARCH											
Total Production	1.641	1.641	1.641	1.641	1.641	1.641	1.462	1.572	1.139	1.930	1.930
Price (ZK/ton) a/	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production Value (2)	573.16	611.88	864.89	1347.31	1393.29	1525.2	1542.76	1914.92	1979.39	3591.20	5501.32
Add'l Benefit (3)=(2)-(1)	0.00	0.00	0.00	0.00	0.00	0.00	-189.16	-84.54	296.18	537.69	823.68
COSTS											
With Research											
Research costs (mln ZK)											
GRZ expenditures	1.09	1.33	1.71	1.30	1.87	1.38	1.66	1.22	1.74	2.89	6.11
USAID expenditures						2.91	3.74	4.99	7.06	2.66	
SIDA expenditures		0.21	0.24	0.90	0.99	0.85	1.12	0.85	5.59	9.77	15.37
FAO/UNDP expenditures	0.47	0.45	0.49	0.55	0.60	0.60	0.91	1.15	1.67	0.91	1.41
CIMMYT expenditures			0.03	0.05	0.06	0.08	0.17	0.61	0.73	1.23	1.74
Total Research costs (6)	1.56	1.99	2.47	2.79	3.52	5.82	7.60	8.82	16.79	17.46	24.62

	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Extension costs (mln ZK)											
GRZ and donor expenditures	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Total Extension costs (7)	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Seed industry costs (mln ZK)											
SIDA expenditures		0.57	0.66	1.72	2.26	1.68	1.97	2.19	10.66	12.10	21.16
Zamseed investment expenditures				1.44	0.30	2.71	0.86	0.94	1.10	0.00	0.25
Total seed industry costs (8)		0.57	0.66	3.16	2.56	4.39	2.83	3.13	11.76	12.10	21.41
Total Production, Research, Extension,											
Seed, Mkting Costs (10)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Total Add'l Costs (11)=(10)-(4)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Net Benefit , incl. all costs (12)=(3)-(11)	-3.18	-4.41	-6.50	-11.34	-12.64	-14.34	388.81	587.68	832.46	1548.28	2374.00
IRR (%), including all costs ====> 1978-2001	84.78										
1978-91 ==>	67.60										

Table 110, con't

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
BENEFITS												
WITHOUT RESEARCH												
Total Production	1.641	1.641	.656	1.641	1.641	1.641	1.641	1.641	1.641	1.641	1.641	1.641
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Total Production Value (1)	8169.16	22206.95	16850.50	132797.4	132797.4	132797.4	132797.4	132797.4	132797.4	132797.4	132797.4	132797.4
WITH RESEARCH												
Total Production	1.930	1.930	0.772	1.930	1.930	1.930	1.930	1.930	1.930	1.930	1.930	1.930
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Total Production Value (2)	9607.66	26117.35	19817.67	156181.5	156181.5	156181.5	156181.5	156181.5	156181.5	156181.5	156181.5	156181.5
Add'l Benefit (3)=(2)-(1)	1438.50	3910.39	2967.20	23384.10	23384.10	23384.10	23384.10	23384.10	23384.10	23384.10	23384.10	23384.10
COSTS												
With Research												
Research costs (mln ZK)												
GRZ expenditures	6.10	24.61	200.77	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66
USAID expenditures												
SIDA expenditures	31.08	107.65	189.05	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27
FAO/UNDP expenditures	2.69	7.58	14.05	27.96								
CIMMYT expenditures	3.46	7.55	13.74	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22

	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
Total Research costs (6)	43.32	147.40	417.61	801.11	773.15	773.15	773.15	773.15	773.15	773.15	773.15	773.15
Extension costs (mln ZK)												
GRZ and donor expenditures	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Total Extension costs (7)	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Seed industry costs (mln ZK)												
SIDA expenditures	33.41	100.91	187.87	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92
Zamseed investment expenditures	0.75	2.88	1.19	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61
Total seed industry costs (8)	34.15	103.79	189.06	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53
Total Production, Research, Extension, Seed Marketing Costs (10)	142.68	422.06	1010.92	1934.35	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39
Net Benefit , incl. all costs (12)=(3)-(11)	1295.82	3488.33	1956.26	21449.75	21477.71	21477.71	21477.71	21477.71	21477.71	21477.71	21477.71	21477.7
IRR (%), including all costs ====> 1978-2001												
1978-91												

Table 111: Revised ARR, assuming 75% of with-policy area planted to SR52, Zimbabwean, Zambian varieties

Category	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
BENEFITS											
WITHOUT RESEARCH											
Total Production	1.682	1.682	1.682	1.682	1.682	1.682	1.682	1.682	.992	1.682	1.682
Price (ZK/ton) a/	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Total Production Value (1)	587.43	627.11	886.41	1380.84	1427.97	1563.16	1775.03	2049.22	1725.11	3129.51	4794.07
WITH RESEARCH											
Total Production	1.682	1.682	1.682	1.682	1.682	1.682	1.580	1.699	1.231	2.086	2.086
Price (ZK/ton) a/	349.23	372.82	526.98	820.92	848.94	929.31	1055.27	1218.28	1738.29	1860.52	2850.11
Production value (mln ZK)											
Total Production Value (2)	587.43	627.11	886.41	1380.84	1427.97	1563.16	1667.40	2069.59	2139.38	3881.12	5945.45
Add'l Benefit (3)=(2)-(1)	0.00	0.00	0.00	0.00	0.00	0.00	-107.63	20.63	414.27	751.61	1151.38
COSTS											
With Research											
Research costs (mln ZK)											
GRZ expenditures	1.09	1.33	1.71	1.30	1.87	1.38	1.66	1.22	1.74	2.89	6.11
USAID expenditures						2.91	3.74	4.99	7.06	2.66	

	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
SIDA expenditures		0.21	0.24	0.90	0.99	0.85	1.12	0.85	5.59	9.77	15.37
FAO/UNDP expenditures	0.47	0.45	0.49	0.55	0.60	0.60	0.91	1.15	1.67	0.91	1.41
CIMMYT expenditures			0.03	0.05	0.06	0.08	0.17	0.61	0.73	1.23	1.74
Total Research costs (6)	1.56	1.99	2.47	2.79	3.52	5.82	7.60	8.82	16.79	17.46	24.62
Extension costs (mln ZK)											
GRZ and donor expenditures	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Total Extension costs (7)	1.62	1.85	3.37	5.39	6.55	4.14	22.27	20.82	29.00	36.51	52.97
Seed industry costs (mln ZK)											
SIDA expenditures		0.57	0.66	1.72	2.26	1.68	1.97	2.19	10.66	12.10	21.16
Zamseed investment expenditures				1.44	0.30	2.71	0.86	0.94	1.10	0.00	0.25
Total seed industry costs (8)		0.57	0.66	3.16	2.56	4.39	2.83	3.13	11.76	12.10	21.41
Total Production, Research, Extension,											
Seed, Mkting Costs (10)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Total Add'l Costs (11)=(10)-(4)	3.18	4.41	6.50	11.34	12.64	14.34	32.70	32.78	57.55	66.07	99.01
Net Benefit , incl. all costs (12)=(3)-(11)	-3.18	-4.41	-6.50	-11.34	-12.64	-14.34	-140.33	-12.41	356.72	685.54	1052.38

Table 111, con't

Category	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
BENEFITS												
WITHOUT RESEARCH												
Total Production	1.682	1.682	.673	1.682	1.682	1.682	1.682	1.682	1.682	1.682	1.682	1.682
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Total Production Value (1)	8372.49	22759.69	17269.91	136102.8	136102.8	136102.8	136102.8	136102.8	136102.8	136102.8	136102.8	136103
WITH RESEARCH												
Total Production	2.086	2.086	0.834	2.086	2.086	2.086	2.086	2.086	2.086	2.086	2.086	2.086
Price (ZK/ton) a/	4977.51	13530.81	25667.73	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14	80914.14
Production value (mln ZK)												
Total Production Value (2)	10383.30	28225.85	21417.15	168790.4	168790.4	168790.4	168790.4	168790.4	168790.4	168790.4	168790.4	168790.4
Add'l Benefit (3)=(2)-(1)	2010.81	5466.16	4147.25	32687.6	32687.6	32687.6	32687.6	32687.6	32687.6	32687.6	32687.6	32687.6
COSTS												
With Research												
Research costs (mln ZK)												
GRZ expenditures	6.10	24.61	200.77	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66	368.66
USAID expenditures												
SIDA expenditures	31.08	107.65	189.05	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27	376.27

	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/2000	2000/01
FAO/UNDP expenditures	2.69	7.58	14.05	27.96								
CIMMYT expenditures	3.46	7.55	13.74	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22	28.22
Total Research costs (6)	43.32	147.40	417.61	801.11	773.15	773.15	773.15	773.15	773.15	773.15	773.15	773.15
Extension costs (mln ZK)												
GRZ and donor expenditures	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Total Extension costs (7)	65.20	170.86	404.25	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71	742.71
Seed industry costs (mln ZK)												
SIDA expenditures	33.41	100.91	187.87	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92	373.92
Zamseed investment expenditures	0.75	2.88	1.19	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61	16.61
Total seed industry costs (8)	34.15	103.79	189.06	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53	390.53
Total Production, Research, Extension, Marketing, Seed Industry Costs	142.68	422.06	1010.92	1934.35	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39	1906.39
Net Benefit , incl. all costs (12)=(3)-(11)	1868.13	5044.11	3136.33	30753.26	30781.20	30781.20	30781.20	30781.20	30781.20	30781.20	30781.20	30781.2

APPENDIX 14

APPENDIX 14

MAIZE INPUT USE, PRICES AND PRODUCTION

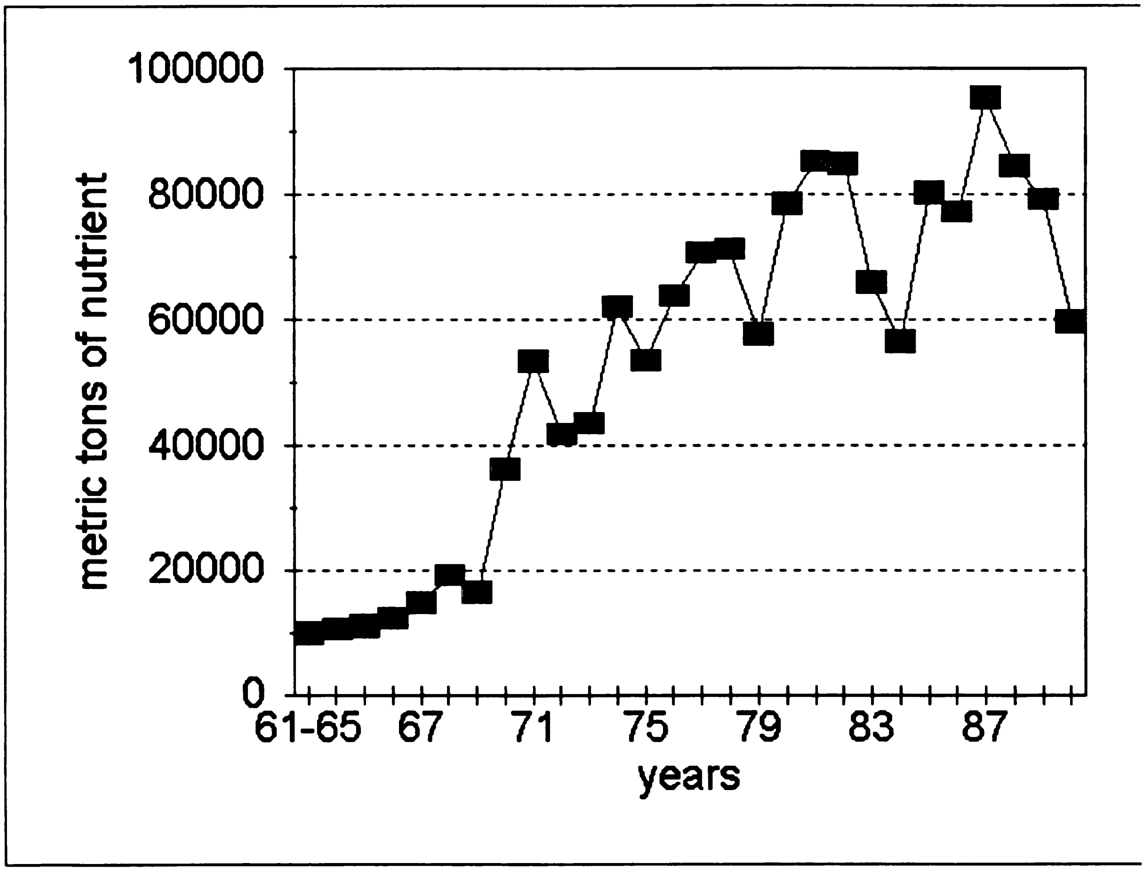


Figure 32: Fertilizer consumption 1961-91

Table 112: Guaranteed producer prices for maize, 1965-86

Harvest year	Maize (ZK/90 kg)	1980 real price (deflated by CPI)
1965	3.72	14.36
1966	3.32	11.65
1967	3.10	10.33
1968	2.90	8.73
1969	3.20	9.41
1970	3.50	10.03
1971	4.00	10.01
1972	4.30	11.05
1973	4.30	10.39
1974	4.30	9.60
1975	5.00	10.14
1976	6.30	10.75
1977	6.30	8.99
1978	6.80	8.33
1979	9.00	10.06
1980	11.70	11.70
1981	13.50	11.84
1982	16.00	12.48
1983	18.30	11.93
1984	24.50	13.31
1985	28.32	11.19
1986	55.00	13.96

Source: Jansen 1990, 203-204

Table 113: Fertilizer consumption 1961-90

Year	Total nutrient (mt)	Total product (mt)	Per cent donated
1961-65	9882	...	...
1964	10550	...	...
1965	11000	...	...
1966	12200	...	...
1967	14800	...	...
1968	19100	...	...
1969	16409	...	...
1970	36199	...	...
1971	53298	...	...
1972	41763	...	...
1973	43451	...	...
1974	62000	...	...
1975	53500	...	...
1976	63800	...	...
1977	70600	...	...
1978	71200	...	...
1979	57715	...	...
1980	78600	...	...
1981	85200	219000	7.3
1982	84800	218000	13.8
1983	65900	166000	6.8
1984	56400	143000	48.2
1985	80200	211000	14.4
1986	77166	191000	45.9
1987	95369	244000	43.3
1988	84620	225000	63.7
1989	79200	208421	20.4
1990	59600	156842	24.2

Source: FAO 1979, 1991; Williams and Allgood 1991

Table 114: Maize imports and exports, 1969-90

Year	Imports ('000 metric tons)	Exports ('000 metric tons)
1969-70	31	...
1970-71	261	...
1971-72	63	...
1972-73	...	...
1973-74	...	...
1974-75	...	...
1975-76	...	...
1976-77	...	...
1977-78	23	...
1978-79	43	...
1979-80	200	...
1980-81	200	...
1981-82	60	...
1982-83	111.6	...
1983-84	99.0	...
1984-85	95.4	...
1985-86	97.2	...
1986-87	14.4	...
1987-88	63.9	...
1988-89	...	...
1989-90	...	270

Source: GRZ 1990; Wood 1990, 33

Table 115: Funding required for maize purchases, 1983-90

Year	Mkted bags '000	Official price ZK/ bag	Value mln ZK	CPI 1985= 100	Real mln ZK
1983	5,902	18.30	108.0	60.7	177.9
1984	6,348	24.50	155.5	72.9	213.3
1985	7,070	28.32	200.2	100	200.2
1986	10,607	55.00	583.4	152	383.8
1987	7,296	78.00	569.1	217.2	262.0
1988	14,990	80.00	1199.2	337.8	355.0
1989	13,559	125.00	1694.9	663.4	255.5
1990	7,100	284.20	2017.8	1674.4	120.5

Source: calculated from GRZ 1990

Table 116: Nominal and real maize producer prices, 1980-92

Year	CPI 1985=100	Nominal ZK/ton	Real ZK/ton
1980	39.5	130	329.1
1981	44.7	150	335.6
1982	50.8	177.8	350.0
1983	60.7	203.3	335.0
1984	72.9	272.2	373.4
1985	100	314.7	314.7
1986	152	611.1	402.0
1987	217.2	866.7	399.0
1988	337.8	888.9	263.1
1989	663.4	1388.9	209.4
1990	1674.4	3157.8	188.6
1991	3224.9	8888.9	275.6
1992	9394.1	13333.3	141.9

Source: calculated from Sipula 1993

Table 117: Nominal and real prices of fertilizers used on maize, 1985-91

	CPI	Compound D,ZK/50kg		Urea ZK/50kg	
Year	1985=100	Nominal	Real	Nominal	Real
1985	100	26.75	26.75	26.75	26.75
1986	152	26.75	17.60	26.75	17.60
1987	217.2	80	36.83	65	29.93
1988	337.8	80	23.68	65	19.24
1989	663.4	98.27	14.81	71	10.70
1990	1674.4	396	23.65	384	22.93
1991	3224.9	1572.36	48.76	1601.87	49.67

Source: GRZ 1990, 58; Sipula 1993

Table 118: Government subsidies paid to the maize sector[1]

Year	Subsidies as proportion of total gov't budget (percent)
1980	9.3
1981	6.3
1982	8.4
1983	8.4
1984	5.5
1985	6.1
1986	10.5
1987	10.9
1988	16.9
1989	16.1
1990	13.7

Source: GRZ 1990, 13

[1] Assumes 80 percent of total agricultural subsidies go to the maize subsector; does not include research, extension or 15 percent premium to NCZ for domestic fertilizer marketing

Table 119: Nominal and real into-mill and retail meal prices, 1980-92

Year	CPI 1985 =100	Into-mill ZK/90kg Nominal	Real	% of prod. price	Breakfast ZK/25kg[1] Nominal	Real	Roller ZK/25kg[2] Nominal	Real
1980	39.3	10.21	25.8	87	4.1	10.4	3.8	9.5
1981	44.7	13.5	30.2	100	6.6	14.8	5	11.2
1982	50.8	16	31.5	100	7.3	14.3	6.3	12.4
1983	60.7	18.3	30.1	100	10.3	17.0	8.6	14.1
1984	72.9	26	35.7	106	12.9	17.7	10.7	14.7
1985	100	35	35.0	124	19.2	19.2	14.9	14.9
1986	152	35	23.0	64	19.2	12.6	14.9	9.8
1987	217.2	35	16.1	45	19.2	8.8	14.9	6.8
1988	337.8	35	10.4	44	19.2	5.7	14.9	4.4
1989	663.4	160	24.1	128	114.5	17.3	82.3	12.4
1990	1674.4	442	26.4	156	269	16.1	198	11.8
1991	3224.9	1100	34.1	138	570	17.7	320	9.9
1992	9394.1	1800	19.2	150	1800.5	19.2	1354	14.4

Source: Sipula 1993

[1] Breakfast meal is a highly refined product, with an average extraction rate of 68 percent, and is preferred by urban consumers

[2] Roller meal is less refined than breakfast meal; its average extraction rate is 92% (GRZ 1990, 3)

BIBLIOGRAPHY

BIBLIOGRAPHY

Abidogun, A. 1982. Cocoa research in Nigeria: an ex-post investment analysis. *Nigerian Journal of Economic and Social Studies.*

Adaptive Research Planning Team, Central Province. 1990. *An evaluation and reassessment of adaptive research in Central Province. ARPT Central Province, Kabwe Research Station.* Kabwe: Central Province Adaptive Research Planning Team. Mimeo.

__________. 1988. *Provincial ARPT annual report (July 1, 1988 to June 30, 1988).* Kabwe: Ministry of Agriculture and Water Development.

Adaptive Research Planning Team, Eastern Province. 1991. *Valley farming systems: annual report 1990/91. Annexure II: notes for local leaders' workshop on land-use planning.* Chipata: Luangwa Integrated Resource Development Project/ARPT.

__________. 1984. *Annual report 1983/84. Annexure I: informal survey of the Luangwa (Chama) farming system.* Msekera: Ministry of Agriculture.

Africa South of the Sahara. 1993. London: Europa Publications.

Akino, M. and Y. Hayami. 1975. Efficiency and equity in public research: rice breeding in Japan's economic development. *American Journal of Agricultural Economics* 57.1: 1-10.

Alreck, P. and R. Settle. 1985. *The survey research handbook.* Homewood, Illinois: Irwin.

Alston, J., G. Edwards and J. Freebairn. 1988. Market distortions and benefits from research. *American Journal of Agricultural Economics* 70.2: 281-288.

Alston, J. and P. Pardey. 1993. Market distortions and technological progress in agriculture. *Technological Forecasting and Social Change* 43: 301-319.

__________. 1988. Self-reinforcing mechanisms in economics. In *The economy as an evolving complex system,* ed. Reading: Addison-Wesley.

Ayer, Y. and G. Schuh. 1972. Social rates of return and other aspects of agricultural research: the case of cotton research in Sao Paulo, Brazil. *American Journal of Agricultural Economics* 54: 557-569.

Bates, R. 1989. *Beyond the miracle of the market: the political economy of agrarian development in Kenya*. Cambridge: Cambridge University Press.

Bates, R. and P. Collier. 1993. The politics and economics of policy reform in Zambia. In *Political and economic interactions in economic policy reform: evidence from eight countries*, ed. Bates and Krueger. Cambridge and Oxford: Blackwell.

Behnke, R. and C. Kerven. 1989. *The efficiency of input supply: impacts on commercial maize production in Northern Province, Zambia*. Kasama: Provincial Planning Unit and ARPT.

Berlan, J. and R. Lewontin. 1983. Breeder's rights and the patenting of life forms. Marseille and Cambridge: Institut National de la Recherche Agronomique, Universite d'Aix Marseille II and Harvard University. Mimeo.

Blackie, M. Undated. Maize in East and Southern Africa. Lilongwe, Malawi: Rockefeller Foundation.

Bolt, R. and I. Holdsworth. 1987. *Farming systems economy and agricultural commercialization in the south eastern plateau of Northern Province, Zambia*. ARPT Economic Studies No. 1. Kasama: Misamfu Regional Research Station.

Bolt, R. and M. Silavwe. 1988. *Maize production in Northern Province: a review of issues from farm level production to provincial policies*. ARPT (NP) Crop Brief No. 1. Kasama: Misamfu Regional Research Station.

Boughton, D. and B. Henry de Frahan. 1994. *Agricultural research impact assessment: the case of maize technology adoption in southern Mali*. MSU International Development Working Paper #94-41. East Lansing: Michigan State University.

Central Statistical Office. 1973a-92a. *Final crop forecast*. Lusaka: Central Statistical Office.

__________. 1985b. *Monthly digest of statistics*. Vol. XXI, No. 4-5. Lusaka: Central Statistical Office.

__________. 1978b. *Agricultural and pastoral production 1971-72 (non-commercial sector)*. Lusaka: Central Statistical Office.

__________. 1976b. *Agricultural and pastoral production statistics 1972 (commercial farms)*. Lusaka: Central Statistical Office.

CIMMYT. 1990. *1989/90 CIMMYT world maize facts and trends: realizing the potential of maize in sub-Saharan Africa*. Mexico, D.F.:CIMMYT.

__________. 1987. *1986 CIMMYT world maize facts and trends: the economics of commercial maize seed production in developing countries*. Mexico, D.F.: CIMMYT.

Crawford, E. 1991. Estimation of the rate of return to agricultural research: examples of alternative methods. East Lansing: Michigan State University. Mimeo.

Edwards, G. and J. Freebairn. 1984. The gains from research into tradeable commodities. *American Journal of Agricultural Economics* 66: 41-49.

Eicher, C. 1994. *Zimbabwe's green revolution: preconditions for replication in Africa*. MSU Staff Paper No. 94-1. East Lansing: Michigan State University.

Eriksen, J., O. Mwanza, O. Svensson, I. Walton. 1989. *Research and seed programme within ASSP: GRZ/SIDA Evaluation Mission*. International Rural Development Centre Working Paper 114. Uppsala: Swedish Agricultural University. .

Evenson, R.E. 1987. *The international agricultural research centers: their impact on spending for national agricultural research and extension*. Washington, D.C.: CGIAR.

Eylands, V. and B. Patel. 1990. Agricultural research. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Food and Agriculture Organization of the United Nations. 1993. *Agriculture: towards 2010*. Rome: FAO.

__________. 1991. *Fertilizer yearbook*. Rome: FAO.

__________. 1979. *Fertilizer yearbook*. Rome: FAO.

FAO/Government Cooperative Programme. 1990. *Development of pest and disease resistant maize (phase II). Zambia: project findings and recommendations* AG:GCP/ZAM/026/NOR. FAO: Lusaka.

Foster, M. 1987. A strategy for transfer of crop production technology to small-scale farmers in Zambia. In *Global 2000: transfer of crop production technology to* *small farmers. Proceedings of the First Global 2000 National Workshop: 29 June -1 July 19.* Lusaka: Global 2000-BCCI.

Gardner, B. 1989. Price supports and optimal spending on agricultural research. Mimeo. College Park: University of Maryland.

Gelaw, B. 1985. *Overview of CIMMYT's maize program.* Paper presented at the First Central, Eastern, and Southern African Maize Workshop, 11 March.

Gibson, P. 1986. Final report of Paul Gibson, maize breeder, Zamare project. Lusaka: ZAMARE/USAID. Mimeo.

Gibson, P. and D. Ristanovic. 1985. *Open pollinated variety development in Zambia.* Paper presented at the First Central, Eastern, and Southern African Maize Workshop, 11 March.

Gittinger, J. 1982. *Economic analysis of agricultural projects.* Baltimore: Johns Hopkins Press.

Global 2000. 1993. Report on the visit of a mission to Zambia June 18-July 8, 1993. Atlanta: Global 2000. Mimeo.

Government of the Republic of Zambia. 1991a. *National research action plan.* Lusaka: Ministry of Agriculture, Food and Fisheries.

__________. 1991b. *An evaluation of the agricultural credit system in Zambia.* Lusaka: Agricultural Credit Study Team.

__________. 1991c. *National seed availability study: seed problems, practices and requirements among small-scale farmers in Zambia.* Lusaka: Ministry of Agriculture, Food and Fisheries.

__________. 1991d. *Rural trade and processing of traditional crops in Zambia.* Lusaka: Ministry of Finance and National Commission for Development Planning in cooperation with ZATPID.

__________. 1991e. *National extension action plan.* Lusaka: Ministry of Agriculture, Food and Fisheries.

__________. 1990. *Evaluation of the performance of Zambia's maize subsector.* Lusaka: Ministry of Agriculture, Food and Fisheries.

__________. 1989. *A new fertilizer marketing system for Zambia.* Lusaka: Ministry of Finance and National Commission for Development Planning, Ministry of Agriculture and Cooperatives in cooperation with the Zambia Agricultural Training, Planning and Institutional Development Project (ZATPID II) and the International Fertilizer Development Center (IFDC).

__________. 1966. *First National Development Plan 1966-70.* Lusaka: Office of National Development and Planning.

Griliches, Z. 1958. Research costs and social returns: hybrid corn and related innovations. *Journal of Political Economy* 66: 419-431.

Guyton, B. and J. Temba. 1992. *Agribusiness firms in Zambia's maize subsector: a review of their characteristics, constraints, and innovations during the 1993-94 maize marketing season.* Washington: USAID ARTS/FARA.

Harber, R. 1992. Annex I: maize market decontrol program (MMDP) project number 611-0223 economic analysis. Lusaka: USAID. Mimeo.

__________. 1991. *Initial macroeconomic analysis for USAID/Zambia's country program strategic plan.* Lusaka: USAID. Mimeo.

Harsh, S., L. Connor and G. Schwab. 1981. *Managing the farm business.* Englewood, N.J.: Prentice Hall.

Hayami, Y. and R. Herdt. 1977. Market price effects of technological change on income distribution in semisubsistence agriculture. *American Journal of Agricultural Economics* 59: 245-56.

Henry de Frahan, B. 1990. The effects of interactions between technology, institutions and policy on the potential returns to farming systems research in semi-arid northeastern Mali. Ph.D. dissertation, Michigan State University.

Hertford, R. and A. Schmitz. 1977. Measuring economic returns to agricultural research. In *Resource allocation and productivity in national and international agricultural research*, ed. T. Arndt, D. Dalrymple, and V. Ruttan. Minneapolis: University of Minnesota Press.

Hoyle, J.C. 1965. Maize growing in Zambia. Lusaka. Mimeo.

Howard, J., S. Kalonge and G. Chitalu. 1994. Improved maize in Zambia: a biography. East Lansing: Michigan State University. Mimeo.

Integrated Rural Development Program. 1986. *Factor allocation and technology adoption in small-scale agriculture: a case study from northern Zambia.* Integrated Rural Development Program Occasional Paper No. 9. Mpika, Zambia: IRDP.

Jansen, D. 1990. Agricultural pricing policy. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

__________. 1988. *Trade, exchange rate, and agricultural pricing policies in Zambia.* Washington: World Bank.

Jansen, D.(Dodge). 1977. *Agricultural policy and performance in Zambia: history, prospects, and proposals for change*. Berkeley: University of California Institute of International Studies.

Jha, D. 1991. Input use and productivity. In *Adopting improved farm technology: a study of smallholder farmers in Eastern Province, Zambia*, eds. R. Celis et al. Washington: IFPRI.

Jha, D., B. Hojjati, and S. Vosti. 1991. The use of improved agricultural technology in Eastern Province. In *Adopting improved farm technology: a study of smallholder farmers in Eastern Province, Zambia*, eds. R. Celis et al. Washington: IFPRI.

Kean, S. and L. Singogo. 1989. *Zambia: organization and management of the Adaptive Research Planning Team (ARPT), Research Branch, Ministry of Agriculture and Water Development*. The Hague: ISNAR.

Kerven, C., R. Bolt, P. Sikana, F. Makondo, K. Mhony and C. Kampamba. 1988. *ARPT input supply and demand report no. 1: input delivery for maize: 1987/88 season*. Kasama: Northern Province Adaptive Research Planning Team.

Klepper, R. 1980. *Agricultural research, developoment planning and the rural poor in Zambia*. Sussex: Institute of Development Studies.

Kolshus, H., F. Mbewe and E. Skjonsberg. 1991. Marketing of agricultural produce and inputs in Northern Province, Zambia. Lusaka: NORAD. Mimeo.

Laker-Ojok, R. 1994. *The rate of return to agricultural research in Uganda: the case of oilseeds and maize*. MSU International Development Working Paper No. 94-42. East Lansing: Michigan State University.

Librero, A.R. and M. Perez. 1987. *Estimating returns to research investment in corn in the Philippines*. Los Baños: PCARD.

Lindner, R. and F. Jarrett. 1978. Supply shifts and the size of research benefits. *American Journal of Agricultural Economics* 60: 48-58.

Little, I.M. and J. Mirrlees. 1974. *Project appraisal and planning for developing countries*. New York: Basic Books.

Lof, G. and R.M. Mulele. 1990. The changing role of the extension service. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Low, A. and S.R. Waddington. 1991. Farming systems adaptive research: achievements and prospects in Southern Africa. *Expl. Agr.* 27: 115-125.

Lu, Y., P. Cline and L. Quance. 1979. *Prospects for productivity growth in U.S. agriculture*. Agr. Econ. Rep. No. 435. Washington, D.C.: USDA-ESCS.

Lukanty, J. and A. Wood. 1990. Agricultural policy in the colonial period. *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Makings, S. 1966. Agricultural change in Northern Rhodesia/Zambia:1945-1965. *Food Research Institute Studies* 6.2.

Maro, P. 1986. Towards secondary service centre-based area planning; a study of Mata, Mwito, TBZ-Nkeyema and Munkuye in Western Province, Zambia. Mongu, Zambia: Provincial Planning Unit. Mimeo.

Marter, A. 1978. *Cassava or maize? A comparative study of the economics of production and market potential of cassava and maize in Zambia*. Lusaka: University of Zambia Rural Development Studies Bureau.

Mazzucato, V. 1991. Non-research policy effects on the rate of return to maize research in Kenya 1955-1988. M.S. thesis, Michigan State University.

McPhillips, J.K. and A.P. Wood. 1990. Soil productivity and fertilizer use. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Mellor, John. 1976. *The new economics of growth: a strategy for India and the developing world*. Ithaca: Cornell University Press.

Meyers, O. 1988. ZAMARE end of tour report: Oval Meyers, Jr., team leader and maize breeder. Urbana-Champaign: U.of Ill. Office of International Agriculture. Mimeo.

Milimo, J. 1991. Land tenure and agricultural development in Eastern Province. In *Adopting improved farm technology: a study of smallholder farmers in Eastern Province, Zambia*, eds. R. Celis et al. Washington: IFPRI.

Minot, Nicholas W. 1984. *Linkages between agricultural research and extension in less developed countries*. CARSOM Working Paper. East Lansing: Michigan State University.

Mwale, W. 1987. Maize production and improvement in Zambia. In *Food grain production in semi-arid Africa,* eds. J.M. Menyonga, T. Bezuneh and A. Youdeowei. Ouagadogou, Burkina Faso: SAFGRAD.

Mwila, C.C. 1987. Small farmer circumstances in relation to agricultural development in Zambia. In *Transfer of crop production technology to small farmers: proceedings of the First Global 2000 National Workshop, 29 June -1 July 1987.* Lusaka: Zambia Global 2000-BCCI.

__________. 1986. The adoption of improved agricultural technology on farms in Zambia. Ph.D. dissertation, University of Bradford, Bradford, U.K.

Nakaponda, B. 1992. Food security in Zambia: an econometric analysis of the maize market. M.S. thesis, Michigan State University.

Norgaard, R. 1988. The biological control of cassava mealybug in Africa. *American Journal of Agricultural Economics* 70.2: 366-71.

Norrby, S. 1986. Appraisal and evaluation of the Swedish support to the Zambian seed programme-a cost-benefit analysis. M.S. research paper, Research Institute of Management Science, Delft (Netherlands) University of Technology.

North, D. 1993. Institutions and credible commitment. *Journal of Institutional and Theoretical Economics* 149.1: 11-22.

__________. 1990. *Institutions, institutional change and economic performance.* Cambridge: Cambridge University Press.

Norton, G. and J. Davis. 1981. Evaluating returns to agricultural research: a review. *American Journal of Agricultural Economics 63*: 685-699.

Norwegian Centre for International Agricultural Development (NORAGRIC) and International Union for the Conservation of Nature and Natural Resources (IUCN). 1989. *Environmental effects of agricultural change and development in Northern Province, Zambia.* A report prepared for the Provincial Planning Unit, Northern Province, Government of the Republic of Zambia and NORAD. Lusaka:NORAD.

Oehmke, J. 1991. The calculation of returns to research in distorted markets. *Agricultural Economics* 5: 83-88.

__________. 1988. The calculation of returns to research in distorted markets. *Agricultural Economics* 2: 291-301.

Oehmke, J., L. Daniel, J. Howard, M.Maredia, R. Bernsten. 1992. *The impact of agricultural research: a review of the ex-post assessment literature with implications for Africa*. Department of Agricultural Economics Staff Paper No. 92-38. East Lansing: Michigan State University.

Olver, R.C. 1987. Zimbabwe maize breeding program. In *Towards self-sufficiency: proceedings of the second Eastern, Central and Southern Africa regional maize workshop*. Harare: CIMMYT.

Pagni, L. 1990. Zambia: copper, a fickle friend. *The Courier* 121: 38-42.

Peterson, W. 1967. Returns to poultry research in the United States. *Journal of Farm Economics* 49: 656-69.

Pray, C.E. 1978. The economics of agricultural research in British Punjab and Pakistani Punjab, 1905-1975. Ph.D. dissertation, University of Pennsylvania.

Pudsey, D., N. Mumba, and A. Christensen. 1990. Integrated approaches to agricultural development. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Ramalho de Castro and G.E. Schuh. 1977. An empirical test of an economic model for establishing research priorities: a Brazil case study. In *Resource allocation and productivity in national and international agricultural research*, eds. T. Arndt, D. Dalrymple and V. Ruttan. Minneapolis: University of Minnesota Press.

Randall, A. 1987. *Resource economics*. New York: John Wiley and Son.

Ranger, T.O. 1971. *The agricultural history of Zambia*. Paper delivered to the History Teacher's Workshop at the University of Zambia, August, 1970. Lusaka: National Educational Company of Zambia.

Ristanovic, D. 1988. Maize breeding for subtropical and tropical environments. Paper presented at the Euromaize '88 workshop on maize breeding and maize production, 6-8 October, Belgrade, Yugoslavia.

Ristanovic, D., P. Gibson and K.N. Rao. 1985. Development and evaluation of maize hybrids in Zambia. In *To feed ourselves: proceedings of the first Eastern, Central and Southern Africa regional maize workshop*. Harare: CIMMYT.

Rohrbach, D. 1988. The growth of smallholder maize production in Zimbabwe: causes and implications for food security. Ph.D. dissertation, Michigan State University.

Schmid, A. 1992. Legal foundations of the market: implications for the formerly socialist countries of Eastern Europe and Africa. *Journal of Economic Issues* 26.3: 707-732.

__________. 1989. *Benefit-cost analysis*. Boulder: Westview Press.

Schmitz, A. and D. Seckler. 1970. Mechanized agriculture and social welfare: the case of the tomato harvester. *American Journal of Agricultural Economics* 52: 569-77.

Schultz, T. 1953. *The economic organization of agriculture*. New York: McGraw-Hill.

Scobie, G. and R. Posada. 1978. The impact of technical change on income distribution: the case of rice in Colombia. *American Journal of Agricultural Economics* 60:85-91.

Scott, J. 1990. Agricultural investment planning. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Sharpe, B. 1990. Nutrition and the commercialization of agriculture. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Shawa, J. and W. Johnson. 1990. Input supply and marketing. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Sipula, K. 1993. Reforms of the maize market system in Zambia: issues of price and market policies, cooperatives and interprovincial transportation. Ph.D. dissertation, Michigan State University.

Smale, M., with Z. Kaunda, H. Makina, M. Mkandawire, M. Msowoya, D. Mwale, and P. Heisey. 1991. *Chimanga cha makolo, hybrids, and composites: an analysis of farmers' adoption of maize technology in Malawi*. CIMMYT Economics Working Paper 91/04. Mexico, D.F.: CIMMYT.

Sterns, J. and R. Bernsten. 1994. *Assessing the impact of cowpea and sorghum research in Northern Cameroon*. MSU International Development Working Paper 94-43. East Lansing: Michigan State University.

Swedish International Development Authority. 1992. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1992/annual review 1991*. Lusaka: SIDA.

__________. 1991. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1991/annual review 1990*. Lusaka: SIDA.

__________. 1990. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1990/annual review 1989*. Lusaka: SIDA.

__________. 1989. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1989/annual review 1988*. Lusaka: SIDA.

__________. 1988. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1988/annual review 1987*. Lusaka: SIDA.

__________. 1987. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1987/annual review 1986*. Lusaka: SIDA.

__________. 1986. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1986/annual review 1985*. Lusaka: SIDA.

__________. 1985. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1985/annual review 1984*. Lusaka: SIDA.

__________. 1984. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1984/annual review 1983*. Lusaka: SIDA.

__________. 1983. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1983/annual review 1982*. Lusaka: SIDA.

__________. 1982. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1982/annual review 1981*. Lusaka: SIDA.

__________. 1981. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1981/annual review 1980*. Lusaka: SIDA.

__________. 1980. *Joint GRZ/SIDA agricultural sector support programme (ASSP) budget 1980/annual review 1979*. Lusaka: SIDA.

Tattersfield, J.R. and E.K. Havazvidi. 1991. The seed industry in Zimbabwe. Paper presented at the Conference on Zimbabwe's Agricultural Revolution: Implications for Southern Africa, 7-11 July, Victoria Falls, Zimbabwe.

Thole, P.N. 1989. Maize seed production in Zambia: trends and problems. In *Maize improvement, production and protection in Eastern and Southern Africa - proceedings of the third Eastern and Southern Africa regional workshop, Nairobi, Kenya 18-22 September*. Harare: CIMMYT.

Timmer, P. 1985. *The role of price policy in rice production in Indonesia.* Harvard Institute for International Development Discussion Paper #196. Cambridge: Harvard University.

United States Agency for International Development. 1993. Agriculture policy conference: part one, government role in agriculture. Lusaka: USAID. Unclassified cable.

__________. 1991 (update), 1988. Project assistance completion report for the Zambia agricultural development, research and extension (ZAMARE) Project. Lusaka: USAID. Mimeo.

__________. 1988. *Audit of the University of Illinois-Urbana-Champaign Contract AFR-0201-C-00-1097 under USAID/Zambia's agricultural development, research and extension project number 611-0201.* Washington: USAID.

University of Illinois. Undated. *Zamare: a success story in Africa.* Office of International Programs. Champaign: University of Illinois.

van der Bijl, G. 1987. *Farming systems in a changing policy environment: a study of the cassava and maize agricultural economy in Kaoma District, Western Province.* Mongu and Lusaka: Provincial Planning Unit and University of Zambia.

Veldkamp, W., K. Jeanes, and F. Shalwindi. 1990. Agro-ecological perspectives in planning. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

Williams, L. and J. Allgood. 1991. *Fertilizer situation and markets in Zambia.* International Fertilizer Development Center. Muscle Shoals, Alabama: IFDC.

Wood, A. 1990. Agricultural policy since independence. In *The dynamics of agricultural policy and reform in Zambia*, ed. A. Wood et al. Ames: Iowa State University Press.

World Bank. 1993. *World development report.* New York: Oxford University Press.

__________. 1992. *Zambia agriculture sector strategy: issues and options. Volume 1:main report.* Washington: World Bank.

__________. 1990. *World development report.* New York: Oxford University Press.

__________. 1984. *Zambia policy options and strategies for agricultural growth.* Washington: World Bank.

__________. 1983. *Zambia agricultural research and extension review*. Regional Mission in Eastern Africa. Washington: World Bank.

Zamseed. 1992. Sales data 1980-92. Lusaka: Zamseed. Mimeo.