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EVALUATION OF SMALLHOLDER AGRICULTURAL
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By

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ABSTRACT

EVALUATION OF SMALLHOLDER AGRICULTURAL TECHNOLOGY IN MALAWI

By

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This thesis contains an analysis of smallholder farmer intercropping technologies from a farming systems and national income perspective. The problem is low adoption rates due to recommendations that are based on biological factors only. Marginal rate of return analysis is used to assess the financial profitability of technology. Primary data were obtained from a farming systems research trial program on maize, common beans and soybean intercropping. Farmers' preferences are used to assess possibilities of adoption. Economic analysis including calculation of social profitability and domestic resource cost ratios is used to assess the value of the program to the nation.

The results show that to improve farmer income, it is important to pay attention to financial and economic analysis rather than just yield. Intercropping treatments perform better than sole crops indicating that intercropping should be given more emphasis. For both soybean and common bean intercropping technologies, Malawi has comparative advantage when measured by net social profit and domestic resource cost ratios.

To my wife Judith, Mom Catherine and Dad Inkosana Hudson Khwechisa.

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My Malawian colleagues were very helpful. Mention should be made of Wyson Mughogho, Thomas Gillard-Byrs, Dick Tinsley, Pickford Sibale, Michael Selenje, Edward Chisala, Steven Kandeya and Lenox Kisyombe. A particular note of thanks is in order for my wife, Judith, who helped me with initial data tabulations and offered moral support.

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TABLE OF CONTENTS

Page

LIST OF TABLES. xi

Chapter

1. INTRODUCTION. 1

1.1 Problem setting and research focus. 1

1.1.1 Smallholder development strategies 2

1.2 Objectives. 4

1.3 Research hypothesis 4

1.3 Overview of methodology 6

1.4 Organization of thesis. 7

Chapter

2. AGRICULTURE AND AGRICULTURAL RESEARCH IN MALAWI . . 8

2.1 Cropping systems and role of maize,
common beans and soybeans. 8

2.1.1 Maize (Zea mays L). 8

2.1.2 Common beans (Phaseolus vulgaris L.). 9

2.1.3 Soybeans (Glycine max L 10

2.1.3.1 Research work on soybeans 12

2.1.3.2 Soybean market 12

2.1.4 Intercropping systems 13

2.1.5 Sole cropping systems. 13

2.1.6 Farmer circumstances 14

2.2 Agricultural research. 17

2.2.1 Agricultural research with a
farming systems perspective 18

Chapter

3. CONCEPTUAL FRAMEWORK AND REVIEW OF LITERATURE. . . . 20

3.1 Assumptions about farmer goal orientation 20

3.1.1 Food security 21

3.1.2 Social obligations 21

3.1.3 Cash-generating activities 21

3.1.4 Profit maximization 22

3.1.5 Risk avoidance 22

3.1.6 Opportunity cost of labor 22

3.1.7 Opportunity cost of capital 22

3.2 Marginal analysis as a model for
evaluating on-farm trials 24

3.2.1 Advantages and disadvantages
of marginal analysis 25

3.2.2 Farmer opinions 26

3.3 Economic analysis 27

Chapter

4. THE EXPERIMENTAL PROGRAM 29

4.1 Year One 29

4.2 Year Two 30

4.3 Year Three 30

4.4 Year Four 31

4.5 Trend across years 31

4.6 Experimental design 32

4.7 Fertilizer application 33

4.8 Statistical inference 35

Chapter

5. FINANCIAL ANALYSIS 40

5.1 Data 40

5.1.1 Description of Lilongwe ADD surveys 40

5.1.2 Summary of the 1989 rapid appraisal survey 43

5.1.3 Average yield 44

5.1.4 Adjusted yield 44

5.2 Methodology 46

5.2.1 Partial budgets 46

5.2.2 Dominance analysis 46

5.2.3 Rate of return analysis 47

5.2.4 Returns to labor analysis 47

5.2.5 Food security 48

5.2.6 Minimum returns analysis. 48

5.2.7 Field crop prices 49

5.2.7.1 Maize prices 50

5.2.7.2 Pulse prices 51

5.2.8 Produce transportation 51

5.2.9 Labor time per operation 52

5.2.10 Opportunity cost of labor 52

5.3 Results 53

5.3.1 Thiwi Lifidzi local maize Intercropping recommendation domain 54

5.3.2 Thiwi Lifidzi MH12 intercropping recommendation domain 57

5.3.3 Lilongwe RDP local maize intercropping recommendation domain 61

5.3.4 Lilongwe RDP MH12 intercropping recommendation domain 65

5.3.5 Food 70

Chapter

6. ECONOMIC ANALYSIS 72

6.1 Social profitability and domestic resource costs 72

6.2 Calculating social profitability 74

6.3 Social profitability implications 82

6.4 Calculation of resource cost ratios 85

6.5 Some implications of the DRC analysis 87

6.6 Sensitivity analysis 87

Chapter

7. CONCLUSIONS 93

7.1 Biological analysis 93

7.2 Financial returns 93

7.3 Food security 94

7.4 Risk 95

7.5 Farmer preferences 95

7.6 Intercropping systems 97

7.7 Government policy 97

7.8 Underestimating intercropping benefits 100

APPENDIX

1. Marginal analysis tables 101

LIST OF REFERENCES 106

LIST OF TABLES

Table Page

1. Lilongwe and Thiwi Lifidzi RDP maize, common beans and and soybeans intercropping trial treatments . . . 33

2. Thiwi Lifidzi 1989 MH12 intercrop statistical analysis (kg/ha) 35

3. Thiwi Lifidzi 1989 local maize intercrop statistical analysis (kg/ha) 36

4. Lilongwe RDP 1989 MH12 intercrop statistical analysis 37

5. Lilongwe RDP 1989 local maize intercrop statistical analysis 38

6. Thiwi Lifidzi and Lilongwe RDP recommendation domains (1989). 42

7. Soil landscape management units by RDP. 43

8. Lilongwe ADD 1989 labor requirement per farm operation (1989). 53

9. Marginal analysis for 10 different sole and intercropping treatments of local maize, Vulgaris beans and soybeans tested in Thiwi Lifidzi RDP . . 55

10. Marginal analysis for 10 different sole and intercropping treatments of local maize, Vulgaris beans and soybeans tested in Thiwi Lifidzi RDP, urban wage rate. 56

11. Minimum returns analysis (1985-1989) for Thiwi Lifidzi RDP. 57

12. Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, Vulgaris beans and soybeans tested in Thiwi Lifidzi RDP . . 59

13. Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, Vulgaris beans and soybeans tested in Thiwi Lifidzi RDP, urban wage rate 60

14. Minimum returns analysis (1985-89) for Thiwi Lifidzi RDP MH12 intercropping trials. 61

15. Marginal analysis for 10 different sole and intercropping treatments of local maize, Vulgaris beans and soybeans tested in LRDP. 63

16. Marginal analysis for 10 different sole and intercropping treatments of local maize, Vulgaris beans and soybeans tested in LRDP, urban wage rate 64

17. Minimum returns analysis (1987-1989) for LRDP local maize trials 65

18. Marginal analysis for 10 different sole intercropping treatments of MH12 maize, Vulgaris beans and soybeans tested in LRDP. 67

19. Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, Vulgaris beans and soybeans tested in Thiwi Lifidzi RDP, urban wage rate 68

20. Minimum returns analysis (1987-1989) for LRDP MH12 intercropping trials 69

21. On-farm import parity price of maize (1989) 75

22. On-farm import parity price of soybeans (1989) 76

23 On-farm export parity price of Vulgaris beans (1989) 77

24. On-farm import parity price of DAP fertilizer (1989). 78

25. On-farm import parity price of urea (1989) 79

26. Social profitability by recommendation domain (MK/ha). 83

27. Net farm margins (MK/ha) by recommendation domain 84

28. Domestic resource cost for each recommendation domain 87

29. Social profitability (MK/ha) sensitivity analysis by recommendation domain (1989) 90

30. Domestic resource cost sensitivity analysis by recommendation domain (1989) 91

CHAPTER 1

INTRODUCTION

1.1 Problem setting and research focus

Malawi is located to the south of the main African Rift valley. The latitude ranges from 9 to 17 degrees south and the altitude ranges from 500 to 3000 meters. Agriculture is the most important sector providing about 40% of the gross domestic product and 89% of the export earnings. About 85% of the people are smallholder farmers who concentrate on food production. The population is 8 million and the growth rate is 3.2% per annum.

Suffering from the neo-Malthusian specter of rapidly increasing population in the face of stagnating food production, Malawi could highly benefit from technical change that raises yields. Technology, in this instance, entails a combination of all the management practices for producing or storing a crop or crop mixture and/or livestock and livestock products. Each practice is defined by timing, amount and types of various technological components such as variety, land preparation, fertilizer application or weeding. A subsistence farmer who purchases no input is, however, using technology (CIMMYT, 1985).

1.1.1 Smallholder development strategies

Within the smallholder sector the Government has emphasized two broad strategies: the transformation and the improvement approaches. The objective of the transformation approach was to provide focal growth points through the introduction of new technical, social and tenure systems in an attempt to modernize and increase smallholder productivity (Mkandawire, 1988). The transformation approach has been mainly associated with four major integrated agricultural projects[1] established in the late 1960s. Agricultural development in the nonproject areas and areas not covered by the settlement schemes or estates[2], has followed the improvement approach. This emphasizes the progressive improvement of methods of crop and animal husbandry among smallholder farmers, to induce them to produce without radically changing their traditional social structure and tenure systems (Mkandawire, 1988). Since 1976/77 period, the Government has attempted to extend the experiences of the transformation approach into areas which

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[1]The Integrated Rural Development Projects were launched in 1966 in order to increase agricultural production and improve the standard of living. Four projects were located in areas with high productive potential. The four projects covered about 20% of the population.

[2]The estate sub-sector produces for export on leasehold land using advanced production technologies. It employs about 60% of the remunerated labor force.

were previously associated with the improvement approach, under the National Rural Development Program[3].

The underlying assumption of these strategies was that through a process of social communication, the relatively better farmers will diffuse innovations to the rest of the farming community, despite differential resources. This justifies a progressive farmer strategy.

The main arguments for pursuing this strategy is that production resources are limited and it is not possible to provide resources to every farmer. Rather improved technology should be directed to farmers who already have above average resources and are willing to make intensive use of them. This strategy thus concentrated on the better off farmers only.

The low income farmers who have small land holding size, experience peak period labor shortage, periodic food shortage, have no access to credit and a host of other constraints, were excluded. A common precaution taken by the low resource farmers is to diversify the crops they grow through intercropping and/or sequential cropping. Until the early 1980s, little or no research was done on these systems because the emphasis was on the larger smallholders who comprise of only 25% of the smallholder farmers. The

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[3]The National Rural Development Program began in 1976/77 with the aim of spreading agricultural development throughout the country. This program covers the whole nation.

strategy adopted contributed to low adoption rate because there was no trickle down effect.

1.2 Objectives

The major objective of this study is to evaluate smallholder farm technology more comprehensively by including financial and economic analysis, rather than relying on statistical analysis only. Financial analysis, which uses market prices, is useful for determining the profitability of proposed changes to the target group, and consequently for assessing how widely recommendations will be adopted.

Financial analysis is distinct from economic analysis (Gittinger, 1984 p. 473). Economic analysis, which uses shadow prices, measures the social profitability at the national level. Economic analysis also measures the comparative advantage of a technology when measured against possibilities of trade. Evaluation of a new technology like soybean intercrop is important because it estimates the cost of domestic currency required to save a unit of foreign currency.

1.3 Research hypothesis

The data used in this study were obtained from the Lilongwe Agricultural Development Division[4] Adaptive

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[4]Malawi has administratively decentralized its agricultural program into eight contiguous areas called Agricultural Development Divisions (ADD). Each ADD has an Adaptive Research Team (ART).

Research trial program. After extensive surveys, it was hypothesized that the farmers would maximize returns to their resources by increasing the density of Vulgaris beans and soybeans in the local maize intercrops. Local maize is grown intercropped with Vulgaris beans and to a lesser extent with soybeans. The government is currently encouraging the growing of soybean in order to reduce imports of soybean products.

It was also hypothesized that intercropping the pulses with hybrid maize would increase financial returns. Hybrid (MH12) is mostly grown in pure stands by a smaller proportion of the farmers. Most hybrid growing farmers get seasonal loans from the government. If pulses increase financial returns, they may help repay loans.

In some recommendation domains vulgaris beans intercropping can perform better than soybean intercropping and vice versa. If it proved profitable to grow soybeans in an intercrop with either local maize or MH12, then soybean can be grown at a larger scale and apart from being consumed at home it could be sold for cash. This would contribute to improving the access of families to basic food requirements through improved home production as well as increased incomes. The country can save on foreign exchange by producing sufficient soybeans and soybean products rather than importing soybean products.

When this experiment was being designed, a big increase in the official price of soybean was being proposed which made ex-ante analysis of the crop attractive. A 55% price increase was achieved in 1988 for the 1988/89 cropping season. An extra 28% increase was achieved in October 1989 for the 1989/90 cropping season (MOA, 1989b).

Since local maize and hybrid maize respond differently to management and are grown by farmers of different categories, they should be tested separately. They are regarded as two different enterprises because hybrids are grown for cash by a small proportion of farmers as sole crops. Local maize is mostly intercropped with pulses. Farmers indicate that they prefer local maize for food because it has superior storage, processing and culinary qualities. Little or no fertilizer is applied to local maize.

Interplant and intraplant competition is known to increase with increasing plant population. It is necessary to increase or maintain the yields of maize because it is the staple food. Intercropping local maize or MH12 with either vulgaris beans or soybeans may reduce the yield of maize and consequently returns to resources used.

1.3 Overview of methodology

On-farm research data is subjected to statistical analysis, financial analysis and economic analysis. Analysis of variance is used to evaluate the mean yields of the intercropping treatments for statistical significance. Marginal returns analysis is used to evaluate the financial returns to variable inputs. Farmer preferences are included in the financial analysis. Analysis of comparative advantage--social profitability and domestic resource cost ratios--is performed for the best technologies.

Organization of thesis

Chapter 1 identifies the problem and discusses the objectives and the hypothesis. The problem is low adoption rates because of a progressive farmer approach to development and of the practice of deriving farmer recommendations based entirely on biological and statistical analysis. The objective is to include financial and economic analysis in deriving recommendations. Chapter 2 discusses Malawian agriculture, emphasizing maize, Vulgaris beans and soybeans intercrops. These are the technologies evaluated in this paper. Chapter 3 dwells on concepts, review of relevant literature and discusses the assumption on which the analysis is based. Chapter 4 discusses the experimental treatments, design and the trend of the results over a period of four years, and the statistical analysis of the final season. Chapter 5 discusses the financial evaluation of the treatments including marginal analysis and farmer preferences. Chapter 6 discusses the economic analysis including social profitability and domestic resource cost ratios. Chapter 7 draws conclusions from the analysis.

Chapter 2

AGRICULTURE AND AGRICULTURAL RESEARCH IN MALAWI

2.1 Cropping systems and role of maize, common beans and soybeans

2.1.1 Maize (Zea mays L.)

Maize is the most important cereal and food crop in Malawi. It is a dietary staple for over 80% of the population, with an average consumption of 225 to 250 kg per capita annually. Ninety percent of the maize is produced primarily by smallholder farmers who generally use few purchased inputs. Approximately 60 to 70% of maize is grown intercropped with various crops. Maize research dates back to 1947 when agricultural research began in Malawi, but until the mid 1980s no research was done on intercropped maize.

Greatest benefits would flow from higher maize yields because maize occupies the majority of the cultivated land. About 63 to 90% of the area is planted to maize (Kangaude, 1988). Much of the balance of the land is given to other food crops including groundnut, pulses[5] and roots. Only

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[5]Pulse is a common name for Vulgaris beans, soybeans and other seeds that grow in pods and are used as food.

3.5% of the total smallholder area is allocated to nonfood cash crops; cotton and tobacco (Carr, 1988). Increased efficiency in maize production for the market is also crucial as this could reduce food prices (Kydd, 1989).

2.1.2 Common beans (Phaseolus vulgaris L.)

Vulgaris beans are the most important food crop in Malawi after maize (World Bank, 1989). Vulgaris beans are used dry, although green shelled seed and immature pods are also consumed as food. Vulgaris beans provide a cheap source of protein for the majority of the people. Vulgaris beans are also high in calcium, magnesium and iron and contain a large amount of vitamin B. Green pods and green shelled seeds are a good source of vitamin A and C. Other than being a food crop, surplus beans are sold to neighboring countries to earn foreign exchange.

Generally, most of the beans are grown in areas between 1,000 and 2,000 meters above sea level, with well-drained soils and rainfall of about 800-1500 millimeters. Lilongwe is one of the major bean-producing areas (Msuku, 1984). Not much research has been done on intercropping although about 99% of the pulses in Malawi are intercropped with maize (Mkandawire et al., 1989).

In Lilongwe Agricultural Development Division (LADD) Vulgaris beans are grown by almost all farmers. But the production is very low in some rural development projects.[6] LADD/ART[7] (1984) survey report indicates figures as low as 133 kgs per hectare in Thiwi Lifidzi RDP. Trial data indicate yields as low as 24 kg per hectare (LADD/ART, 1989).

2.1.3 Soybean (Glycine Max L.)

Soybeans have been grown in Malawi since 1909. Between the early 1940s and mid 1950s about 200 to 900 tons were exported annually mostly to the United Kingdom, Holland and Norway. The soybeans were intercropped with tung in the Southern Region[8] (Sibale, 1989). Soybeans have been grown commercially by the estate sector for a long time but its production in the smallholder sector has been negligible.

In 1981, the Women's Program and the Food and Nutrition section of the Ministry of Agriculture introduced the preparation of soybeans to women extension agents. The Food and Nutrition Program emphasized the crop because the Malawian diet is particularly deficient in fats and to a lesser degree deficient in protein; soybeans contain about 40% fats and 20% protein. The teaching of recipes for

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[6]ADDs are subdivided into Rural Development Projects (RDPs) whose determination conforms to administrative, political and traditional boundaries, population, settlement patterns and environmental characteristics.

[7]Lilongwe Agricultural Development Division Adaptive Research Team conducted the trials analyzed in this study.

[8]Malawi is administratively divided into Southern, Central and Northern regions. Southern region has 3 ADDs, Central region has 3 ADDs and Northern region has 2 ADDs.

preparing soybean milk, porridge, snacks and relish made soybean popular among women in Lilongwe Rural Development Project (Spring, 1986).

Recent studies confirm that whole soybeans are an excellent source of protein and offer a good distribution of amino acids. Soybeans also contain 20% unsaturated fats which are desirable for humans in areas where animal fat is scarce. In addition to providing nutritious weaning foods, soybeans can form an important ingredient in preparation of adult meals. It can be used to enrich porridge or nsima[9].

The anti-nutritional factors associated with soybeans, e.g., trypsin inhibitor, hemagglutinin and phytic acid can be easily removed under village conditions by heating the beans for about twenty minutes (Sibale, 1989). The characteristic off-flavor due to the enzyme lipoxygenase can also be easily removed by boiling the beans in water for twenty minutes. Cooking to achieve a desirable texture according to most Malawians can be done by adding readily available, inexpensive sodium-bicarbonate (Sibale, 1989). It should be noted however, that these are late developments which have not yet spread through the rural population. Most farmers do not regard soybeans as a relish dish because

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[9]Nsima is the staple food made from maize flour. It is eaten together with vegetable, pulse, fish or meat relish dishes.

it does not mash well with nsima (Spring, 1986, and LADD/ART, 1989).

2.1.3.1 Research work on soybeans

In 1984, soybean trials were conducted in Lilongwe ADD by the Women Programs section to determine smallholder farmer soybean husbandry practices. The results were grouped into three usable grain yield sub-categories of high (2,530 to 2,900 Kg/Ha), medium (1,160 to 1,400 Kg/Ha), and low (320 to 660 Kg/Ha). Farmer yields increased with increasing planting densities. The highest yields were obtained at a population of 30 plants per meter (Spring, 1986).

Another survey done by the Women's Program section revealed that 38% of the women who had adopted soybeans were interplanting at a very low planting density: three soybean seeds on one station in between one-meter-spaced maize stations. The farmers were interested in the crop mainly for home consumption. Some farmers used soybeans to feed dairy animals and chickens. Farmers who tried to grow soybean for cash experienced marketing problems.

2.1.3.2 Soybean market

A recently concluded survey undertaken by the Soybean Improvement Project, which visited a number of agro-industries in April 1989, has indicated demand for domestically produced soybeans rising up to 10,000 tons by 1992 (Sibale, 1989). The soybeans will be processed into livestock feed and baby food. The current annual it does not mash well with nsima (Spring, 1986, and LADD/ART, 1989).

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2.1.4 Intercropping systems

Intercropping, a system in which two or more crops are grown in the same field during the same growing season (Mkandawire et al., 1989), is the dominant cropping system for the small scale farmers and will probably remain so for many years to come. Due to the fast rate of population growth and limited land for farm expansion, higher crop productivity per unit area has become necessary. Intercroping Vulgaris beans and maize is known to increase the yield of maize (Reintsma and Lang, 1988). Other advantages are better utilization of land and labor, risk reduction and soil conservation and improvement (Yiwombe, 1988).

2.1.5 Sole cropping system

Since the 1940s, the Ministry of Agriculture has recommended growing crops in pure stands, because improved maize varieties performed best under sole cropping. Current research recommendations are based on sole crops. These are in line with the smallholder development strategy followed until early 1980s (section 1.1.1).

2.1.6 Farmer circumstances

Farmer circumstances are all factors that influence farmer decisions about a technology. These can be divided into natural, social, financial and economic factors (CIMMYT, 1988). The financial, economic and environmental factors influence the types of crops and livestock raised. It is easy to make poor recommendations by ignoring factors that are important to the farmers. Some of these factors may not be very evident.

A good recommendation can be thought of as the practices which farmers would follow, if they had all the information available to the researcher (CIMMYT, 1988). A good recommendation must at least increase net income or in some way relieve a constraint like labor or risk. It will also take into account the existing infrastructure and institutions and other factors that constitute farmer circumstances.

A rapid appraisal survey was carried out in Lilongwe and Thiwi Lifidzi RDPs in 1989, by the author to study some of the farmer circumstances related to the trial programme analyzed in this paper. Some of the survey statistics are discussed below:

1. Most farmers preferred two hills of soybean and two hills of Vulgaris beans in between maize hills[10]. In Lilongwe RDP (LRDP) 50% of the interviewed farmers preferred planting two Vulgaris bean hills in between maize hills due to vigorous vegetative growth and high yields. Vigorous vegetative growth is important because Vulgaris bean leaves are used as relish. Thirty-one and 19% preferred three and one bean hill between maize hills respectively. For soybeans, 68% and 32% preferred two and three hills in between maize hills respectively. In Thiwi Lifidzi, 75% preferred planting two vulgaris bean hills in between maize while 25% preferred one. Similar proportions apply to soybeans.

2. In both locations, most ADMARC[11] buying points are still operating[12] side by side with private traders. Thiwi Lifidzi RDP has 290 while Lilongwe RDP has 127 registered private buyers. At most buying points more than one buyer operates, e.g., there are 29 different buyers at Kupiliatu and 35 different buyers at Gulugulu in Thiwi Lifidzi RDP. In LRDP, Sinyala and Mitundu buying points had 8 buyers

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[10]The intercropping trials were evaluating different densities of pulses in the intercrop by using the number of pulse hills planted in between maize hills (section 4.6)

[11]ADMARC is a statutory agricultural marketing board which sells inputs and buys output at pan-seasonal and pan-territorial prices.

[12]In line with the market liberalization policy ADMARC is supposed to stop most of its operations to give way to private traders and let market forces play a greater role in directing economic activity along efficiency lines.

each. However, there is little information regarding the private buyer prices and quantities. This makes it difficult to use private buyer figures.

3. The net market price of maize during the food shortage period is almost the same as the ADMARC price at harvest. The storage cost of local maize from the time of harvest to the period of peak food shortage is MK0.042 per kg. The local market price at this time is MK0.31 per kg (MOA, 1989c). The net price is MK0.268. ADMARC offers MK0.26 at harvest time. The difference in prices is minimal and not worth using in a sensitivity analysis.

4. Vulgaris bean seed is obtained from the local market and soybean seed is obtained from official marketing channels. All the farmers in LRDP obtained their seed from the local market while 79% of the farmers that grew soybeans obtained the seed from official channels. The analysis will use market price for Vulgaris bean seed and official price for soybean seed. All farmers interviewed sold their Vulgaris beans to the local market and all sold soybeans to ADMARC. The analysis uses local market price for Vulgaris beans and official price for soybeans.

5. Most farmers are aware of the activities of local money lenders. In LRDP, 50% of the farmers admitted knowledge of local lenders. In Thiwi Lifidzi, 75% admitted knowledge of local lenders. All farmers in both RDPs said the interest rate charged over the growing season, an average of 5 months, is 100%. One hundred percent will be

used as the minimum acceptable rate of return in the marginal analysis.

6. Farmers transport their crop by farm carts. The average cost for transporting produce from the field to home is MK1.50 per farm cart trip. An average farm cart carries an equivalent of four 100kg bags. The average cost for carting from home to the market is MK1.77 per 100kg bag. The total transport cost per kg is MK0.02145.

7. The amount of time required to plant depends on the pulse density. Time in minutes was estimated using the stop watch technique and it took farmers 19.38 for planting on the same hill, 23.5 for planting one pulse hill between maize hills, 28.1 for planting two pulse hills, 34.02 and 41.20 respectively for planting three and four pulse hills between maize hills. The net plot size was 4 ridges of 5.4 meters length and the spacing was 0.91 meters between ridges. When converted to a hectare this yields 22.86, 27.81, 33.14, 40.14 and 48.61 hours per hectare, respectively.

2.2 Agricultural Research

Until the late 1970s, agricultural research did not take into account nonbiological factors when developing recommendations for smallholder farmers. Statistical analysis, predominantly analysis of variance to evaluate the statistical significance of biological treatment effects, was the only tool used for analyzing trials (Phiri 1986). Agricultural research has traditionally been organized along biological disciplinary lines without the involvement of social scientists. It has also been conducted on research stations under conditions not representative of the farmer conditions with little or no farmer involvement. This was in line with the transformation and improvement strategies which assumed a trickle down effect regardless of farmer circumstances (section 1.1.1).

2.2.1. Agricultural research with a farming systems perspective

Research with a farming systems perspective has several objectives, the major one being to increase the productivity of a farming system by generating appropriate new technologies. This approach is often divided into:

1. Location specific research which has short-term objectives of developing improved technologies for target farmer groups.

2. Research conducted with a long-term perspective to overcome major, widespread limitations in the farming systems.

Location-specific research is best implemented through on-farm research where farmers are involved in identifying potential technological improvements, which are then tested under their socio-economic and ecological conditions (CIMMYT, 1985)

Direct communication between a multi-disciplinary research team and farmers through surveys and continuous monitoring of participating and non-participating farmers increases the understanding of the farmer's decision-making environment and enables the researcher to identify technological options that are more consistent with the environment. Experiments under farmer conditions lead to estimates of yield and cost changes that better reflect what farmers can expect from using the technological options. Farming systems research also focuses on how policies influence the adoption processes. Marketing is one area of public policy addressed in this paper. The degree of government intervention in the market affects adoption.

CHAPTER 3

CONCEPTUAL FRAMEWORK AND REVIEW OF LITERATURE

3.1 Assumptions about farmer goal orientation

Hansen (1982) defined farming systems in Malawi as a complicated interwoven mesh of resources and factors; agronomic, economic, social, cultural, physical, etc. which are managed to a greater or lesser extent by the farmer. The farmer utilizes some of the technology that is available in an attempt to increase farm household utility within a given context of accepted preferences, aspirations, and socioeconomic conditions. Utility refers to a broad range of satisfactions. For a Malawian farmer, utility includes the production of food and relish for home consumption as well as generation of cash income. These, among other objectives, are the central issues in the farmer's planning. They determine which technology he/she adopts.

The farming systems concept reflects the empirical complexity of the conditions surrounding smallholder agriculture and the complexity of the decisions that the smallholder farmers have to make. Most of their decisions are compromises in which farmers balance what they want to do against limited resources. Other compromises occur because farmer,s goals conflict, e.g., achieving higher incomes versus lower risks. Farmers may fail to adopt an improved technology because they are simultaneously trying to satisfy a range of desires or necessities.

Bearing in mind the complexity of the farmer's situation, this study will assume the farmer's decision is based on the objectives discussed below. The analysis will center around these assumptions.

3.1.1 Food security

Many farmers are primarily concerned with assuring an adequate food supply for their families. They do this by producing most of what their family consumes, e.g., maize and other cereals, root crops, pulses, and vegetables, and by marketing some of their other crops like tobacco, beans, potatoes or vegetables to obtain cash to buy food and other necessities.

3.1.2 Social obligations

The farm family is a part of a wider community toward which it has certain obligations such as to contribute towards festivities and to provide aid such as small gifts of food and money to poorer relations during difficult periods.

3.1.3 Cash-generating activities

The farmers participate in other cash-generating activities like beer-brewing, gin-distilling, baking and selling cakes and other snacks, other rural small-scale industries and off-farm employment for those near the city.

3.1.4 Profit maximization

Although farmers do not necessarily market all their crops, they are interested in the financial returns. Farmers will consider the cost of changing from one technology to another and the financial returns resulting from that change (CIMMYT, 1988). Thus the farmers weigh and assess the difference in net benefits between technologies and other sources of income and/or food.

3.1.5 Risk avoidance

Uncertain markets and climate, since maize intercrops are grown under rainfed conditions, makes risk a big factor in the farmer's decision to adopt a technology. Farmers may prefer a more stable technology, in terms of both physical and financial output, to one with high output but low stability.

3.1.6 Opportunity cost of labor

Labor may be more productive in one farm activity compared to another or compared to nonfarm activities like rural small-scale industries or, if possible, employment in urban industries. Farmers will use their labor in activities that are most productive.

3.1.7 Opportunity cost of capital

Capital availability is of crucial importance. Farmers have low per capita annual incomes which makes capital accumulation difficult. A national sample survey of agriculture in the 1980/81 season indicates a rural per capita cash income range of MK79[13] to MK111 per annum (Reintsma and Lang, 1989). If farmers are asked to make additional investments in their farming operations, they will consider the cost of the money they invest in relation to the expected returns at a later point. Working capital is the value of inputs, whether purchased or owned, allocated to an enterprise with the expectation of a return at one point in time.

The cost of working capital is the benefit given up by the farmer by tying up working capital in an enterprise for a time period (CIMMYT, 1988). This can be a direct cost in the case of someone who borrows money to buy seed and must pay an interest charge on it. Or it may be an opportunity cost, the earnings which are given up by not putting money or an input already owned to its best use (CIMMYT, 1988).

Only 15% of the smallholder farmers utilize formal credit (Carr, 1988). The remaining proportion uses informal credit. Some of the reasons are failure to meet eligibility criteria for the formal credit, fungibility of the informal credit, and ease of re-negotiation. Local money lenders are the most common sources of these loans on which they charge 100% interest rate (section 2.1.6).

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[13] Officially 2.47 Malawi Kwacha is equivalent to US $1.00.

The cost of capital can be used as a benchmark rate of return. Any technology which has a rate of return higher than the cost of capital has a high chance of being adopted. This study will assume the minimum acceptable rate of return of 100% (see section 2.1.6).

3.2 Marginal analysis as a model for evaluating on-farm trials.

Economic models are appropriate for modelling the farm situation assuming farmers roughly and indirectly evaluate technology in terms of benefits and costs. The model used in this study is the marginal benefit-cost analysis which computes the rates of increase in benefits to costs at several incremental treatment levels (CIMMYT, 1988). This analysis compares the farmer's practice with other treatment levels. Marginal benefit-cost analysis considers only the cost of inputs which are variable. For noncash transactions like family labor, opportunity costs are estimated (CIMMYT, 1988).

The researcher arranges treatments in ascending order according to total variable costs. Dominant treatments are selected by comparing benefits and costs of each treatment. Treatments which yield lower benefits but which are more expensive or cost the same as those yielding higher benefits are eliminated. These treatments are dominated and farmers will not adopt them.

Marginal rates of return to variable factors are calculated by dividing the marginal increase in benefit by the marginal increase in costs of adjacent treatments for all nondominated treatments. Experience and empirical evidence have shown that the minimum rate of return acceptable to farmers is between 50 and 100% (CIMMYT, 1988).

This analysis can incorporate risk by including minimum returns analysis which examines the variability of the net benefits. Minimum returns analysis compares the average of the 25% lowest net benefits of the proposed technology with the average of the 25% lowest net benefits of the farmer's practice. If the minimum returns analysis shows that the net benefits of the proposed technology, from individual sites and over a period of time, are above the net benefit of the farmer practice, then the recommendation has a high chance of being adopted (Phiri, 1986). The overall aim of the marginal analysis is to derive recommendations consistent with farmer desired and expected food productivity and income generating goals, avoidance of risk and the best possible use of scarce resources (Dillon and Hardaker, 1980).

3.2.1 Advantages and disadvantages of marginal analysis

The starting point in on-farm research is the assumption that it is much better to consider relatively small improvements in farmer's practice rather than to propose large-scale changes. The idea is to ask what changes can be made in the present system. The focus is on the difference between two treatments. The advantages of marginal analysis include ease of performing the analysis because most of the needed data can be obtained easily from designed trials.

Another advantage is that the method uses only the costs that vary so that only the additional costs and benefits of technologies are needed for the analysis. Marginal analysis, using discrete points can be used for any type of experiment whereas continuous analysis is only applicable to factors that vary continuously such as fertilizer rates or seed rates.

The disadvantage is that certain experiments such as those that look at different varieties or modest changes in seed rate, involve changes in costs that may be very small. If the resulting yield differences are substantial, the resulting marginal rates of return can be very large. A good example is the returns to labor analysis in this study. Moving from technology 4 to technology 5 in Lilongwe RDP MH12 intercropping systems, the returns to labor are MK71.43 per hour (table 5 in the appendix). This is extremely high compared to the assumed opportunity cost of labor of MK0.21 per hour because of the slight differences in additional labor requirements between these two technologies. Such marginal returns are not very useful in comparing treatments (CIMMYT, 1988). While marginal analysis is a powerful tool, it must be seen only as part of a research strategy.

3.2.2 Farmer's opinions

It is important to solicit the farmer's reactions to proposed technologies. Alternatives that seem to be promising both agronomically and financially may have other drawbacks which only farmers can identify. However, it is not easy to get the farmers to make straightforward suggestions in the parts of the world where rural people feel outwardly inferior to urban-based college-educated professionals (Kishindo, 1988). Farmers' opinions are summarized in section 2.1.6.

3.3 Economic analysis

Comparative advantage--expression of the efficiency of using local resources to produce a particular product when measured against the possibility of foreign trade (Morris, 1989a)--is used to estimate the value of soybean and Vulgaris bean intercropping technologies to the nation. Knowledge of comparative advantage is important because potential welfare gains from specialization and trade can be used to foster economic growth. National income can often be increased in the short run through policies that encourage farmers to produce commodities which exploit existing patterns of comparative advantage. Over the long run additional welfare gains can be assured if research resources are used to strengthen comparative advantage. Agricultural policies and research resource allocation should be based, at least in part, on comparative advantage considerations (Morris, 1989b).

During the 1980s, Malawi implemented policy reforms designed to reduce state participation in agriculture, increase productivity, liberalize commodity trade, and free up market forces to play a greater role in directing economic activity along efficiency lines. At the same time increased pressure was put on research administrators to ensure the cost-effectiveness of agricultural research expenditures. These developments are designed to take advantage of comparative advantage.

However, comparative advantage is difficult to determine empirically (Morris, 1989a). Simply comparing shadow production costs between two regions or countries is often inconclusive, because comparative advantage is not directly related to absolute levels of production costs. Even if relative production costs are known, frequently these are distorted by policies or market failure.

CHAPTER 4

THE EXPERIMENTAL PROGRAM

The experimental treatments were selected for testing because an ex-ante analysis showed financially acceptable returns, they are compatible with the farming systems, and they do not present special risk to farmers. The experimental treatments were modified with the acquisition of more information resulting from researchers getting more acquainted with the farmers and the areas.

4.1 Year One

1985/86 season was the first year of the experiment. It had six treatments: a sole crop of maize, maize and beans planted on the same station--the most common farmer practice, one and two vulgaris bean stations between maize stations, and one and two soybean stations planted in between maize stations. The farmer practice was included as one of the treatments in the experiment so that both farmers and researchers could compare the farmer's practice with the alternatives. These treatments showed significant yield differences and increasing financial returns with increasing soybean and Vulgaris bean densities.

4.2 Year Two

In 1986/87, the second year of the experimental program, the number of treatments was increased to allow for higher soybean and Vulgaris bean densities. The soybean and Vulgaris bean stations were increased to three in between maize stations. The seven treatments were a sole crop of maize, maize and Vulgaris beans on the same station, one, two and three Vulgaris bean stations in between maize stations, one, two and three soybean stations in between maize stations. These treatments confirmed an increase in yield and financial returns with increasing densities of both vulgaris beans and soybeans.

4.3 Year Three

In 1987/88 the experiment was further modified to allow for increasing soybean and Vulgaris bean densities. The stations of soybean and Vulgaris beans were increased to four in between maize stations. The treatments with one soybean station in between maize stations and one Vulgaris bean station in between maize station were dropped so that the experiment would examine relatively few factors at a time.

Sole crops of Vulgaris beans and soybeans were introduced. The trend of the results changed. There were no significant differences between different densities of intercropped soybeans and there were no significant differences between different densities of Vulgaris beans.

4.4 Year Four

In 1988/89, the trials were again modified. The pure stands of pulses were dropped and the single stations of Vulgaris and soybeans in between planting stations were reintroduced. The pure stands were dropped because they did not yield significantly better than the Vulgaris beans or soybeans in the intercrop, yet they demanded more labor and seed.

4.5. Trend across years

CIMMYT indicates that marginal analysis for a particular experiment should be done on pooled results from at least several locations over one or more years (CIMMYT, 1988). This analysis uses the final year of the experiment results pooled across locations in each recommendation domain. Ideally, it would be more instructive to analyze the pooled results over the period of four years. This was not possible however, because the trial design had undergone several modifications over the years. Some treatments were dropped and some added over the seasons. The modification of the treatments called for the modification of plot sizes. Farmers are not willing to work with trials that take up most of their land.

Plot sizes were changed from 4 ridges of 0.91 meters by 7.2 meters net in year one to 4 ridges of 0.91 by 6.3 meters in year two. In year three the net plot size was reduced to 2 ridges of 0.91 meters by 5.4 meters to take care of the increased number of treatments. In year four the net plot

size was changed to 4 ridges of 0.91 meters by 5.4 meters. The change in the treatments and plot sizes makes it difficult to do a meaningful across year analysis.
The final year retains all the treatments which are likely to be adopted. The treatments that did not perform well were dropped. The variation in yield over time is taken care of by a minimum returns analysis which compares net benefits for each individual location and all seasons (section 3.2).

4.6 Experimental design

The experiment was laid out using a complete random block design with three replications at each location for all four seasons. The plot size varied with the number of treatments. The ridges were spaced 90 cm apart. Maize was grown 90 cm between plants, three plants per station. The sole crop of dwarf beans was planted on two rows spaced at 30 cm on each ridge or one seed spaced at 10 cm apart along each row. Sole crop of climbing beans was planted on one row, two seeds per station spaced at 15 cm apart. Sole crop of soybeans was planted in two rows per ridge, one seed per station spaced at 5 cm apart. The intercropped Vulgaris beans and soybeans were planted three seeds per station. The treatments, excluding the ones that were dropped are shown in table 1.

Table 1

Lilongwe and Thiwi Lifidzi RDP maize[a], common beans and soybean intercropping trial treatments.

Treatments	Vulgaris beans Hills[b]	Vulgaris beans Plants/ha	Soybeans Plants/ha
1	-[c]	-	-
2	ss[d]	3700	-
3	1	3600	-
4	2	7100	-
5	3	10700	-
6	4	14300	-
7	1	-	3700
8	2	-	7100
9	3	-	10700
10	4	-	14300

a. The population of maize is constant so it is not included in the table.
b. The pulse densities are represented by the numbers of hills in between maize hills. Each hill was planted with three seeds.
c. Not included in the treatment.
d. Maize and Vulgaris beans on the same station.

4.7 Fertilizer application

The recommended levels of fertilizers for maize were applied. MH12 hybrid maize was basal-dressed with 200 kg of 20:20:0 (percentage of nitrogen: phosphorus: potassium). This supplied 40 kg of nitrogen and 40 kg of phosphorus. It was top-dressed with 200 kg calcium ammonium nitrate which contains 26% nitrogen. This supplied 52 kg nitrogen. The total amount of nitrogen supplied was 92 kg. Where high analysis fertilizers[14] were used 80 kg of diammonium sulphate and 175 kg of urea was applied. Local maize received 150 kg of calcium ammonium nitrate as a top dress. This supplies 40 kg nitrogen. Where high analysis fertilizers were used 20 kg of diammonium sulphate and 40 kg urea were applied. Local maize is known to have a poorer response to fertilizers compared to hybrid maize (MOA,1989a).

Fertilizer research in Malawi for intercropping systems has been limited. Consequently there are practically no fertilizer recommendations for intercropping systems. It is important to remember that traditionally these systems used virtually no fertilizers (Mkandawire et al., 1989). Fertilizer use spread with the introduction of improved maize varieties. Even on improved maize varieties, fertilizer is often applied only as a top-dressing at rates considerably lower than recommended (World Bank, 1989 and LADD/ART, 1985). The application of fertilizer levels that are higher than target farmers does not reflect an accurate nonexperimental variable.

The fertilizers were applied at a constant rate to all MH12 trials and at a different but constant rate for local

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[14]High analysis fertilizers have higher concentration of chemicals, per unit weight, than standard fertilizers.

maize. The data from the experiment can be used to determine the performance of intercropping technologies at a given fertility level. However, the technologies may not perform the same under lower fertility levels.

4.8 Statistical inference

There are no significant differences between hybrid maize treatment means in Thiwi Lifidzi (table 2).

Table 2

Thiwi Lifidzi 1989 MH12 intercrop statistical analysis (Kg/ha).

	Maize	V. beans	Soybeans
Treatments			
1. Sole Maize	4204	-	-
2. Maize + V. beans same hill	3457	72	-
3. Maize + 1 V. bean hill	4170	96	-
4. Maize + 2 V. bean hills	4297	99	-
5. Maize + 3 V. bean hills	4163	151	-
6. Maize + 4 V. bean hills	4184	412	-
7. Maize + 1 Soybean hill	4163	-	281
8. Maize + 2 Soybean hills	4348	-	247
9. Maize + 3 Soybean hills	4273	-	342
10. Maize + 4 Soybean hills	4300	-	370
Standard error	241	42	83
Coefficient of variation	10	44	47
Significance	NS[a]	*[b]	**[c]

a. Not significantly different.
b. Significant at 5% level.
c. Significant at 1% level.

Increasing the density of pulses has no significant detrimental effect on hybrid maize. There are highly significant differences between the means of different densities of soybeans. Increasing the density of soybeans increases the yield of soybeans in the intercrop. There are significant differences among the Vulgaris bean treatment means, increasing the density of Vulgaris beans increases the yield of Vulgaris beans.

There are no significant differences between the treatment means of maize (table 3).

Table 3

Thiwi Lifidzi 1898 local maize intercrop statistical analysis (Kg/ha).

	Maize	V. beans	Soybeans
Treatments			
1. Sole Maize	1859	-	-
2. Maize + V. beans same hill	1430	41	-
3. Maize + 1 V. bean hill	1752	-	-
4. Maize + 2 V. bean hills	1567	58	-
5. Maize + 3 V. bean hills	1656	24	-
6. Maize + 4 V. bean hills	1732	41	
7. Maize + 1 soybean hill	1536	-	288
8. Maize + 2 soybean hills	1554	-	460
9. Maize + 3 soybean hills	1341	-	487
10. Maize + 4 soybean hills	1622	-	761
Standard error	183	-	-
Coefficient of variation	20	29	22
Significance	NS[a]	NS	**[b]

a. Not significantly different.
b. Significant at 1% level.

Increasing the densities of pulses has no detrimental effect on the local maize in Thiwi Lifidzi. There are no significant differences among the Vulgaris bean treatment means, increasing the densities of Vulgaris beans does not increase the yield of the beans significantly. The yield of Vulgaris beans are, however, very low (table 2 in the appendix). There are highly significant differences among soybean treatment means, soybean yield increase with increasing densities. There are no significant differences between maize treatments (table 4).

Table 4

Lilongwe RDP 1989 MH12 intercrop statistical analysis (Kg/ha).

	Maize	V. beans	Soybeans
Treatments			
1. Sole Maize	3652	-	-
2. Maize + V. bean same hill	2953	235	-
3. Maize + 1 V. bean hill	2819	274	-
4. Maize + 2 V. bean hills	3529	473	-
5. Maize + 3 V. bean hills	2900	816	-
6. Maize + 4 V. bean hills	2541	864	-
7. Maize + 1 Soybean hill	3704	-	364
8. Maize + 2 Soybean hills	3093	-	360
9. Maize + 3 Soybean hills	3179	-	566
10. Maize + 4 Soybean hills	3107	-	514
Standard error	336	140	116
Coefficient if variation	18	45	45
Significance	NS[a]	*[b]	*

a. Not significantly different.
b. Significant at 5% level.

Increasing the density of pulses has no significant detrimental effect on maize. Vulgaris bean treatment means and soybean treatment means were significantly different from each other, the pulse yield increased with increasing density. There are no significant differences between maize treatment means (table 5).

Table 5

Lilongwe RDP 1989 Local maize intercrop statistical analysis (Kg/ha).

	Maize	V. beans	Soybeans
Treatments			
1. Sole Maize	2960	-	-
2. Maize + V. beans same hill	2702	62	-
3. Maize + 1 V. bean hill	2363	96	-
4. Maize + 2 V. bean hills	2411	178	-
5. Maize + 3 V. bean hills	2140	199	-
6. Maize + 4 V. bean hills	2222	144	-
7. Maize + 1 Soybean hill	2363	-	148
8. Maize + 2 Soybean hills	2925	-	96
9. Maize + 3 Soybean hills	2253	-	144
10. Maize + 4 Soybean hills	2685	-	219
Standard error	237	31	16
Coefficient of variation	17	40	22
Significance	NS[a]	**[b]	**

a. Not significantly different.
b. Significant at 1% level.

Increasing the density of pulses has no significant detrimental effect on maize. Both Vulgaris bean and soybean treatment means are highly significantly different from each other; pulse yields increase with increasing densities.

In general, the data confirms the hypothesis that increasing the densities of pulses would increase the yield of the pulses and have no significant detrimental effect on the maize yield. All recommendation domains show that, except for Thiwi Lifidzi local maize intercrop show that increasing the density of pulses increase the yield. For Thiwi Lifidzi local maize intercrop recommendation domain, only soybean yield increase with increasing density. The Thiwi Lifidzi local maize intercrop Vulgaris bean yields are, however, lower than the lowest average reported by the Thiwi Lifidzi Project Office (section 2.1.2). This may have been a particularly bad season.

CHAPTER 5

FINANCIAL ANALYSIS

5.1 Data

The data used in the analysis were gathered over a period of five years, from 1984, when the LADD/ART started operating at full scale, through 1989 when this study was conducted. Some of the data, especially the background information, dates back further than 1984. Most of these data were gathered through surveys and direct measurements. A rapid appraisal survey (section 2.1.6) was conducted by the author in 1989.

5.1.1 Description of Lilongwe ADD surveys

The surveys were conducted from 1984 to 1986 found that most of the farmers that hold less than a hectare of land do not grow enough food to last for the whole year. Their limited access to various resources set limits to the amount they are able to produce for their families. As a consequence they resort to survival strategies to earn their livelihood. Yet most of the adapted strategies entrench these farmers into the cycle of food deficit. Food shortages occur mostly from December to April. In 1985, 65% of the farmers interviewed in Dedza Hills project run out of food (LADD/ART, 1985). During this time most farmers have no cash with which to purchase food.

Crop diversification through intercropping is a common system employed to try to grow adequate food as well as obtain cash through crop sales. Maize and Vulgaris bean intercrops are the most common. Vulgaris beans can be harvested green and be sold or eaten by February. But Vulgaris beans seem not to be well suited to some RDPs of Lilongwe ADD where they often suffer from diseases. Halo blight and anthracnose are among the most destructive and severe infections can result in heavy reductions of seed and seed quality during the rainy season (Msuku, 1984). Soybeans, which are currently being encouraged, do well in these areas but are mostly grown in pure stands and in small areas. In a few cases, soybeans are intercropped but at low densities.

Based on these survey results an experimental program was initiated in Thiwi Lifidzi and later Lilongwe Rural Development Projects of the Lilongwe ADD. Four recommendation domains[15] were identified. There were two recommendation domains for each location; one for small smallholders and another for large smallholders (table 6).

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[15]A recommendation domain is a group of farmers who have similar circumstances and for whom it is likely that the same recommendation will be suitable.

Table 6

Thiwi Lifidzi and Lilongwe RDP recommendation domains (1989).

Domain	Location (RDP)	Cropping Pattern	Smallholder Category	Smallholder Proportion (%)
1	TL[a]	LM[b] + V. beans or soybeans	Small	95
2	TL	MH12 + V. beans or soybeans	Large[d]	09
3	LL[c]	LM + V. beans or soybeans	Small	87
4	LL	MH12 + V. beans or soybeans	Large	13

a. Thiwi Lifidzi RDP
b. Local maize
c. Lilongwe RDP
d. Large smallholders grow MH12 hybrid in addition to local maize, small smallholders grow local maize only.

It would be more instructive to delineate recommendation domains based on soil type. Lilongwe ADD has abundant information in the form of soil landscape management units. Soil landscape management units (table 7) are areas where specific conditions of elevation, mean annual temperature, mean annual rainfall, landform and soil type occur (Selenje, 1988).

Table 7

Soil landscape management units by RDP.

	Lilongwe		Thiwi Lifidzi	
Soil unit	1	2	3	4
Soil type	Orthic Ferasols	Ferric Luvisols	Ferric Luvisols	Xanthic Ferasols
Elevation	1036-1280	1097-1340	1401-1620	1220-1525
Mean annual Rainfall (mm)	769-1016	765-900	900-1200	900-1000
Mean annual temperature(c)	19-21	18-21	17-20	18-20
Landform	a	b	c	d

a. Gentle to gently undulating plains.
b. Gently undulating broad valleys with gentle slopes.
c. Dissected moderately undulating plains with broad crests and gentle slopes.
d. Dissected gently undulating slopes with high hills and mountains.

For each landscape management unit, it is feasible to apply uniform land use and land management practices. Each unit can, therefore, be used as a basis for delineating a recommendation domain. However, the landscape units in each RDP are almost similar and research funds are limited, hence RDPs were used as a basis for recommendation domain.

5.1.2 Summary of rapid appraisal survey of 1989.

A rapid appraisal survey was conducted by the author in November and December 1989 to update and collect data needed for financial and economic analysis of the trials. Agronomic data explaining how each proposed technology performed were collected from the ADD headquarters. Farmer interviews were conducted to collect data on farmer preferences, markets, knowledge of local money lenders, interest rates charged by local lenders, off-farm job opportunities, land rental, and cost of transportation. Sixteen farmers were interviewed in Lilongwe RDP and 17 were interviewed in Thiwi Lifidzi RDP. Ministry of Agriculture Headquarters provided data on shadow prices of maize, beans, soybeans and fertilizers, opportunity cost of labor and seed, number of private traders operating and number of ADMARC markets operating.

5.1.3. Average yield.

These are the mean yields for the experimental plot converted from kg per plot to kg per hectare. The plots were small, for example 2 ridges of three-meter spacing in between the ridges and 5.4 meters length. The weaknesses related to converting are discussed in the following section.

5.1.3.1 Adjusted yield.

The adjusted yield is the average yield of a treatment adjusted downwards by a certain percentage to reflect the difference between experimental yield and the yield farmers would expect from the same treatment (CIMMYT, 1988). Experimental yields, even from on-farm experiments under representative conditions, are often higher than the yields that the farmers could expect using the same treatments because of the differences in management, plot size and operation precision.

The experiments were farmer-managed but researcher-supervised. The Adaptive Research Team had research assistants located in the experimental vicinity. Their main job was to get cost-route data, but they also reminded the farmer of the expected operations in the experimental plots. Thus the nonexperimental variables were not completely under the farmers' control. The adaptive researchers directly supervised and sometimes got involved in farm operations. The researchers are in general more precise and timely than the farmers in implementing operations such as plant spacing, fertilizer application, weed control and harvesting.

Farmer management probably changed to a higher level due to research supervision. Also the mere fact that a farmer was running research experiments on his field was enough to improve the management because of the reward system. It brings high esteem to work with government agents.

Yields were estimated from small plots. Yields estimated from small plots often overestimate the yield from an entire field because small plots tend to be more uniform than larger fields (CIMMYT, 1988, and Kearl et al., 1976). There is a tendency to overharvest a small plot by gathering produce from plants bordering the crop. When the data is scaled up to a hectare, any such overharvesting is magnified.

A general rule is to reduce experimental yield between 5 and 30% (CIMMYT, 1988). Since this experiment is farmer-managed, but the fertilizer dose does not reflect actual farmer circumstances (see section 4.7), this study will assume an adjustment factor of 15%.

5.2 Methodology

The marginal analysis technique goes through the following steps:

5.2.1 Partial budgets

Partial budgets for each recommendation domain are built using data pooled across locations. Partial budgeting is a method of organizing experimental data and information about the costs and benefits of various alternative treatments. The partial budget indicates the net benefit, which is income remaining after subtracting all the costs that vary, from the gross benefit. The partial budget uses currency as the common denominator. This provides an estimate of the cost of investment measured in a uniform manner without implying that farmers are concerned only with money (CIMMYT, 1988).

5.2.2 Dominance analysis

Dominance analysis is performed on the net benefits and associated total variable costs resulting from the partial budget to eliminate inferior treatments, i.e., treatments with net benefits that are less than or equal to a treatment with lower costs (CIMMYT, 1988). In order to improve farmer income, it is important to pay attention to net benefits rather than just yield. Often the value of increase in yield is not enough to compensate for the increase in cost.

5.2.3 Rate of return analysis

Marginal rates of return are estimated for nondominated treatments. This analysis reflects the additional profit earned by additional capital and labor invested in the treatments. Labor and capital merit attention because they are the resources that the majority of the farmers have some control over (LADD/ART, 1984). The amount of land cultivated by farmers is controlled by traditional authorities.

Marginal rates of return between treatments are calculated, proceeding in step from a lower cost treatment to that of the next higher cost, and comparing those rates of return to the minimum rate of return acceptable to farmers. It is useful both for making recommendations to farmers, where there is sufficient experimental evidence, and for helping select treatments for further experimentation. The minimum acceptable rate of return in this study is 100%, as discussed in section 2.1.6

5.2.4 Returns to labor analysis

Returns to labor are estimated for nondominated treatments by dividing the incremental benefits by the incremental labor time. This gives the amount of money labor can earn per hour and separates the effect of additional labor from other variable factors of production. If changing from one technology to another generates more returns to labor than the assumed opportunity cost, the technology has a high chance of being adopted.

5.2.5 Food security

The relative ability of each of the nondominated technologies to supply an average family with adequate food supply, assuming all food is produced by the farm family, was determined by how much maize and beans the technology can produce. The technology which produces relatively more maize and beans contributes more towards satisfying the food needs. An average person requires 230 kg of maize and 73 kg of Vulgaris beans per year to supply adequate carbohydrates and protein diet (Chipande, 1987, and Barnes-McConnel, 1989). In both RDPs, the average household size is 4 adult-equivalents. Adequate food supply for the family requires 920 kg maize and 292 kg Vulgaris beans assuming these are the only sources of carbohydrates and proteins. A technology which produces more than these amounts of maize and beans is most likely to be adopted. On the other hand, a technology which produces less than these amounts but relatively more than other technologies is likely to be adopted too because it contributes towards household food security.

5.2.6 Minimum returns analysis

Minimum returns analysis is performed on the nondominated treatments to determine how they would perform in the worst possible situations. This tests for the impact of unpredictable weather, especially erratic rainfall and other unpredictable factors that experimental design cannot account for, on the treatments being considered for recommendation. Malawi suffers from early season dry spells in most of the areas, followed by late season excess moisture (MOA, 1989d). This tends to reduce the yields.

5.2.7 Field Crop prices

The field price is defined as the value to the farmer of an additional unit of production in the field, prior to harvest. It is calculated by taking the price that the farmer receives or can receive for a crop when he/she sells it, less all the costs associated with harvesting and selling that are proportional to yield (CIMMYT, 1988). It is convenient to treat these costs separately from other costs that vary because they are incurred at the time of harvesting. The other costs that vary are invested at the beginning of the season. Farmers have to wait at least five months before recovering their invested inputs in maize and soybeans, and at least three months before they can recover their invested inputs from Vulgaris beans (LADD/ART, 1984).

Prices at harvest will be used. Prices at harvest reflect the returns to production while postharvest prices reflect returns to storage (Bernsten, 1989). ADMARC prices for maize and soybean and local market prices for Vulgaris beans will be used because these reflect the amounts that farmers actually receive.

5.2.7.1. Maize prices

Local market prices rise with time as we move away from the harvest time. The consumer market prices for maize falls moderately after reaching a peak in January. This is due to the normal price movement associated with relative scarce supplies late in the growing cycle. Consumer prices fall below ADMARC selling price at harvest (MOA, 1989c).

ADMARC offers the highest prices of maize during the harvesting period. LADD/ART (1986) survey showed that the average price of maize at harvest in the local markets were an average of MK0.09/kg as opposed to MK0.122/kg at ADMARC markets. Price data from agro-economic surveys show a price of MK0.16/kg at the District council market while ADMARC was offering MK0.24/kg (MOA, 1989d). The amount of grain that is sold on the local markets is small compared to the amount that goes through ADMARC at the harvesting time because every farmer has some maize.

Despite the market liberalization program, ADMARC still operates in most areas where private traders prefer not to serve due to high operating costs related to transportation. Private traders lack capacity for purchasing large amounts of grain from surplus areas and transporting to deficit regions. ADMARC has the capacity because it is charged with national food security responsibilities and is supported by the government. Data is readily available from ADMARC but there is very little information concerning the activities of private traders such as the exact amounts they purchase and the prices they offer to farmers (MOA, 1989c).

5.2.7.2. Pulse prices

The price of Vulgaris beans is always higher in the local markets than in ADMARC markets. The majority of the smallholder farmers sell on the local markets (section 2.1.6). The agro-economic survey of 1989 indicates an average market price of MK1.89/kg as opposed to the MK0.50/kg ADMARC price (MOA, 1989d).

The ADMARC soybean price, which is higher than the local market price, will be used. Most farmers sell their soybeans to ADMARC (section 2.1.6) for processing into animal feed. The rest of the beans are processed into food for the family or snacks to sell. The agro-economic survey of 1989 indicates that no soybeans were sold on the local markets surveyed. In 1990 the ADMARC buying Price for soybean is MK0.60/kg (MOA, 1989c).

5.2.8 Produce transportation

The transportation price was estimated assuming the use of a farm cart. The approximate volume of grain the farm cart can carry was converted to weight and the weight was divided by the amount of money paid per trip (section 2.1.6). Farmers hire out their farm carts to other farmers or merchants. The problem is the hiring charge is not dependent on mileage, but vicinity which is a proxy for mileage. The rapid appraisal survey showed that the average total transport cost per kg is MK0.02145 (section 2.1.6.)

5.2.9 Labor time per operation

The labor time required for the treatment operations was recorded using the stop watch technique. The operators were mostly farmers, and in some cases research laborers. The mean recorded time per treatment was then scaled up to a hectare (section 2.1.6). The precision of this variable may be affected by the fact that the people working were aware that they were being timed and may have worked faster or slower. In most cases they were all adults while the real farm labor force includes children. The labor data is reported in the summary of the rapid appraisal survey in section 2.1.6.

5.2.10 Opportunity cost of labor

The most common form of employment for the people living in the area under study, apart from farming their own holdings, is working for estates as laborers. The estates offer the minimum wage stipulated by the Government. This comes to MK0.21 per hour. People also work for other smallholder farmers but only during the peak labor seasons. A few people get employed in the city and get a minimum urban wage rate of MK0.27 per hour. This rate will be used in sensitivity analysis. The labor time required per operation and the total cost of labor for the intercropping technologies are shown in table 8.

Table 8

Lilongwe ADD labor requirements per farm operation (1989)

Farm operation	Labor time (hrs/ha)
Ridging	70
Planting maize	30
Planting Pulses	33
Basal-dressing	42
Top-dressing	42
Weeding	70
Banking	100
Harvesting maize	38
Harvesting pulses	38
Total labor required	463
Total labor cost at rural wage rate	97.23[a]
Total labor cost at urban wage rate	125.01[b]

Sources: Blackie M. J. (1989) and LADD/ART (1986).
a. The rural wage rate is MK0.21 per hour.
b. The urban wage rate is MK0.27 per hour

5.3 Results

The financial analysis was performed using average figures for maize in each recommendation domain and average figures for Vulgaris beans in Thiwi Lifidzi (tables 1 to 5 in the appendix). The mean yields for these crops were not significantly different from each other, implying that whatever differences observed were due to chance

5.3.1 Thiwi Lifidzi local maize intercropping recommendation domain

For Thiwi Lifidzi local maize intercropping recommendation domain, soybean intercropping treatments dominated the Vulgaris beans intercopping treatments. The farmer practice--maize and beans planted on the same station--is dominated (table 9).

Marginal rates of return and marginal returns to labor show that moving to treatment 7--one soybean hill between maize hills--from treatment 1 is worthwhile. The marginal rate of return is higher than the acceptable rate of 100% (section 2.1.6) and the returns to labor are higher than the opportunity cost of labor (section 5.2.4). The farmer would exploit more opportunities for further earning, however, if he/she opted for treatment 8 because this treatment has marginal rate of return that is attractive and is higher than the minimum acceptable rate of return of 100%. Moving from treatment 8 to treatment 9, the marginal rate of return falls below the minimum acceptable rate of return. Treatment 9 is, hence, eliminated from consideration.

Marginal rate of return between treatment 8 and treatment 10 is 699%. This is well above the minimum acceptable rate of return. Financially, treatment 10 is the best treatment (CIMMYT, 1988). Sensitivity analysis (table 10) shows similar results.

Table 9

<u>Marginal analysis for 10 different sole and intercropping treatments of local maize, vulgaris beans and soybeans tested in Thiwi Lifidzi RDP</u>

Treatment	T.V.C[a] (MK/ha)	Net ben[b] (MK/ha)	MRR[c] (%)	MRL[d] (MK/hr)	Food[e] (kg/ha) Maize	beans
1. Sole crop maize	0.00	300.14	-[f]	-	1364	-
7. One soybean hill	11.84	425.38	1058	4.50	1364	-
8. Two soybean hills	18.96	500.14	1050	14.03	1364	-
9. Three soybean hills	26.43	505.52	72	0.77	1364	-
10. Four Soybean hills	34.21	606.74	1310[g]	11.95	1364	-

a. TVC is total variable costs calculated by adding up all costs that vary (table 2 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 2 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. MRR moving from treatment 8 to treatment 10 is (106.60/15.25) = 699%.

Table 10

<u>Marginal analysis for 10 different sole and intercropping treatments of local maize, vulgaris beans and soybeans tested in Thiwi Lifidzi RDP, urban wage rate.</u>

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	286.49	-[f]	-	1364	-
7. One soybean hill	13.51	410.07	915	4.44	1364	-
8. Two soybean hills	20.95	484.50	1000	13.96	1364	-
9. Three soybean hills	28.84	489.47	63	0.71	1364	-
10. Four soybean hills	37.12	603.83	1381[g]	14.42	1364	-

a. TVC is total variable costs calculated by adding up all costs that vary (table 2 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 2 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. MRR moving from treatment 8 to treatment 10 is (119.33/16.17) = 738%.

Treatments 7, 8 and 10 have minimum net benefits that are higher than the farmer's practice (table 11), hence they have a high chance of being adopted.

Table 11

Minimum returns analysis (1985-1989) for Thiwi Lifidzi RDP Local maize intercropping trials.

Season	Site	Treatments 1	7	8	10
1988/89	1	345.92	412.48	490.60	609.92
1988/89	2	273.77	264.07	359.22	343.48
1987/88	1	450.67	-	589.30	696.78
1986/87	1	354.43	496.83	490.53	-
1986/87	2	469.74	499.60	591.77	561.78
1986/87	1	564.74	-	501.41	647.83
1985/86	1	396.44	445.46	548.67	-
Avg 25% lowest net ben[a]		309.85	338.28	424.88	452.63
Avg 25% farmers' practice[b]		326.07			

a. The average of the two lowest net benefits in each treatment (section 3.2).
b. The average of the two lowest net benefits in treatment two--the farmer practice.

The rapid appraisal survey conducted in 1989 revealed that 75% of the farmers in this domain preferred the treatment with two soybeans in between maize hills. This suggests treatment 8, two soybean hills in betweenn maize hills, however, farmers would exploit opportunities for further earning if they adopted treatment 10.

5.3.2 Thiwi Lifidzi MH12 intercopping recommendation domain

In this domain, the farmer practice was dominated (table 12). Moving from treatment 1 to treatment 7 is worthwhile. Marginal rates of return fall below acceptable minimum rate of return if we move from treatment 7 to treatment 9, treatment 9 to treatment 10, and treatment 10 to treatment 5. Treatments 9, 10 and 5 are eliminated from consideration. MRR between treatment 7 and 6 is 425. This is well above the minimum acceptable rate of return.

In the rapid appraisal survey conducted by the author in 1989, most farmers in this domain preferred the treatments with two soybean and/or two Vulgaris beans in between maize hills because of high yields and lower seed costs. However, these treatment is dominated. For low resource farmers--more than 50% of the farmers are categorized as low resource--who cannot afford to invest MK125.41, treatment 7 would be recommended. Adopting treatment 7, however, entails forgoing opportunity for further earning. For large farmers who can afford to invest more than the low resource farmers, treatment 6 would be recommended. Results of sensitivity analysis (table 13) show a similar trend. Minimum returns analysis done on nine locations over a period of four seasons indicates that both treatments 7 and 6 have minimum net benefits that are higher than the farmer's practice (table 14).

Table 12

<u>Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, vulgaris beans and soybeans tested in Thiwi Lifidzi RDP</u>

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (MK/hr)	Food[e] (kg/ha) maize	beans
1. Sole crop maize	0.00	776.99	-	-	3532	-
7. One soybean hill	18.84	898.90	1030	4.38	3532	-
9. Three soybean hills	26.43	913.35	99	g	3532	-
10. Four soybean hills	34.21	918.90	71	g	3532	-
5. Three V. bean hills	94.83	923.45	08	0.30	3532	128
6. Four V. bean hills	125.41	1309.95	1264[h]	46.27	3532	350

a. TVC is total variable costs calculated by adding up all costs that vary (table 3 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 3 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.
h. MRR moving from treatment 7 to treatment 6 is (532.96/125.41) = 425%.

Table 13

Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, vulgaris beans and soybeans tested in Thiwi Lfidzi RDP, urban wage rate.

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[c] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	741.67	-[f]	-	3532	-
7. One soybean hill	13.51	861.91	890	4.32	3532	-
9. Three soybean hills	28.84	875.62	89	g	3532	-
10. Four soybean hills	37.12	880.66	61	g	3532	-
5. Three V. bean hills	97.24	884.44	06	1.83	3532	-
6. Four V. bean hills	128.32	1268.22	1235[h]	45.31	3532	350

a. TVC is total variable costs calculated by adding up all costs that vary (table 4 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 4 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.
h. MRR moving from treatment 7 to treatment 6 is (526.55/128.32) = 410%.

Table 14

Minimum returns analysis (1986-1989) for Thiwi Lifidzi Rural Development Division MH12 maize trials.

		Treatments		
Season	Site	1	7	6
88/89	1	786.15	900.40	1315.38
88/89	2	699.57	731.26	709.78
87/88	1	731.17	-	1058.30
87/88	2	1544.62	-	1801.88
86/87	1	769.32	794.15	-
86/87	3	1254.96	1158.30	-
85/86	1	693.77	697.44	-
85/86	2	877.03	977.39	-
Avg 25%[a] lowest net ben		696.67	714.35	709.78
Avg 25%[b] farmers' practice		551.56		

a. The average of the two lowest net benefits in each treatment (section 3.2) and the lowest net benefit in treatment 6.
b. The average of the two lowest net benefits in treatment two--the farmer practice.

5.3.3 Lilongwe RDP local maize intercropping recommendation domain.

In this domain the farmer practice is among the dominant treatments (table 15). The marginal rates of return fall below the minimum acceptable rates if we move from treatment 7 to treatment 2. Moving from treatment 2 to treatment 10 also results in a marginal rate of return which falls below the acceptable minimum rate of return. Marginal rate of return between treatment 7 and treatment 4 is well above the minimum acceptable rate of return. Moving from treatment 4 to treatment 5, the marginal rate of return again falls below minimum acceptable rate of return. This suggests treatment 4--two Vulgaris bean hills in between maize hills. Sensitivity analysis (table 16) shows similar results. Minimum returns analysis (table 17) shows that treatment 7 has higher net benefits and treatment 4 has slightly higher net benefit than the farmers' practice.

Fifty percent of the farmers in this domain indicated that they preferred two hills of Vulgaris beans and/or two hills of soybean in between maize hills. This coincides with the financial analysis. The best technology in this recommendation domain is treatment 4--two Vulgaris bean hills in between maize hills.

Table 15

<u>Marginal analysis for 10 different sole and intercropping treatments of local maize, vulgaris beans and soybeans tested in Lilongwe Rural Development Project.</u>

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	427.86	-[f]	-	1938	-
7. One soybean hill	11.84	486.46	494	g	1938	-
2. Maize/V. beans same hill	33.66	493.33	32	2.86	1938	-
10. Four soybean hills	34.21	497.89	51	g	1938	-
3. One V.bean hills	34.64	542.62	10402[h]	10.77	1938	82
4. Two V.bean hills	64.65	647.74	505	18.79	1938	151
5. Three V.bean hills	94.83	651.03	08	0.47	1938	169

a. TVC is total variable costs calculated by adding up all costs that vary (table 4 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 4 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.
h. MRR moving from treatment 7 to treatment 3 is (56.16/22.8) = 246%.

Table 16

Marginal analysis for 10 different sole and intercropping treatments of local maize, vulgaris beans and soybeans tested in LRDP, urban wage rate.

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	406.98	-[f]	-	1938	-
7. One soybean hill	13.51	463.92	421	g	1938	-
2. Maize/V. beans same hill	34.97	471.98	31	2.78	1938	-
3. One V.bean hills	36.31	532.26	4499[h]	10.65	1938	82
4. Two V.bean hills	66.55	646.75	128	18.78	1938	151
5. Three V.bean hills	97.24	626.05	09	0.38	1938	169

a. TVC is total variable costs calculated by adding up all costs that vary (table 4 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 4 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.
h. MRR moving from treatment 7 to treatment 3 is (68.34/22.80) = 300%.

Table 17
Minimum returns analysis (1987-1989) for LRDP local maize intercropping trials.

		Treatments			
Season	Site	1	7	4	5
1988/89	1	553.32	605.58	670.74	332.64
1988/89	2	400.52	414.12	348.97	583.59
1987/88	1	723.69	-	1867.93	1555.87
Avg 33% lowest net ben[a]		400.52	414.12	348.97	332.64
avg 33% farmers practice[b]		347.07			

a. The lowest of the three net benefits.
b. The lowest of the three net benefits in treatment two--the farmer's practice.

5.3.4 Lilongwe RDP MH12 intercropping recommendation domain

In this domain the farmers' practice is among the dominant treatments (table 18). However, moving from the farmers' practice to treatments 3, 4, 5 and 6--one, two, three and four Vulgaris bean hills in between maize hills, respectively--will offer opportunities for further earning. The marginal rates of return for all these treatments are above the minimum acceptable rate of 100%. Sensitivity analysis (table 19) showed similar results.

Table 18

Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, vulgaris beans and soybeans tested in LRDP.

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	588.62	-[f]	-	2675	-
7. One soybean hill	11.84	750.10	1364	g	2675	-
9. Three soybean hills	26.43	831.66	559	g	2675	-
2. Maize/V.beans same hill	33.60	935.40	1447	15.20	2675	202
3. One V.bean hill	34.64	991.82	5432	11.30	2675	233
4. Two V.bean hills	65.64	1278.97	960	54.05	2675	402
5. Three V.bean hills	94.84	1779.97	1657	71.47	2675	693
6. Four V.bean hills	125.41	1843.94	209	8	2675	743

a. TVC is total variable costs calculated by adding up all costs that vary (table 5 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 5 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.

Table 19

<u>Marginal analysis for 10 different sole and intercropping treatments of MH12 maize, vulgaris beans and soybeans tested in LRDP, urban wage rate.</u>

Treatments	T.V.C[a] (Mk/ha)	Net Ben[b] (Mk/ha)	MRR[c] (%)	MRL[d] (Mk/hr)	Food[e] (Kg/ha) Maize	Beans
1. Sole crop maize	0.00	561.92	-	-	2675	-
7. One soybean hill	13.51	721.67	1183	g	2675	-
9. Three soybean hills	25.24	802.50	527	g	2675	-
2. Maize/V.beans same hill	34.79	905.25	1676	15.01	2675	202
3. One V.bean hill	36.31	961.13	4817	11.29	2675	233
4. Two V.bean hills	66.55	1247.70	940	53.67	2675	403
5. Three V.bean hills	97.24	1761.71	1676	73.50	2675	694
6. Four V.bean hills	128.32	1806.92	145	5.34	2675	734

a. TVC is total variable costs calculated by adding up all costs that vary (table 5 in the appendix).
b. Net benefit is calculated by subtracting TVC from the gross benefits (table 5 in the appendix).
c. MRR is calculated as discussed in section 5.2.3
d. MRL is calculated as discussed in section 5.2.4
e. Food supply is calculated as discussed in section 5.2.5
f. Not relevant
g. Treatment is dominated because it requires more labor but has lower net benefit than the preceding treatment.

Table 20

Minimum returns analysis (1987-1989) for LRDP MH12 intercropping trials.

	Seasons				
	1987/88		1988/89		
Treatments	Site1	Site2	Site3	Site4	lowest[a] net ben
1	460.02	985.49	682.92	400.18	400.18
7	-	-	854.07	432.28	432.28
9	527.97	1286.17	777.39	551.43	551.43
2	895.62	1779.62	899.93	1233.19	895.62
3	-	-	930.30	937.33	930.30
4	929.38	1705.82	1315.22	1267.53	929.38
5	844.08	1632.17	1751.44	1095.31	844.08
6	1672.55	1929.40	1157.07	1511.01	1511.01

a. Ideally, this analysis takes an average 25% of the lowest net benefits. In this case the lowest figures are used because the data is only for a short period. The farmers' lowest net benefit--the lowest net benefit from treatment 2--is MK895.62.

A minimum returns analysis over two seasons indicates that only treatments 3, 4 and 6 have net benefits that are higher than the farmer practice (table 20). In the rapid appraisal survey conducted in 1989, farmers in this domain indicated they preferred either two soybean hills in between maize hills or two Vulgaris bean hills in between maize hills (section 2.1.6). Since treatment 8 is dominated, treatment 4, which represents two Vulgaris bean hill in between maize hills, would therefore be recommended.

5.3.5 Food

On a per hectare basis, all the nondominated treatments produce more quantities of maize than is required to supply adequate carbohydrates to an average family of four adult equivalents per annum (section 5.2.5). Only the Vulgaris beans intercropped with MH12 hybrid are able to supply adequate protein to an average family. Two, three and four Vulgaris bean hills in between MH12 hybrid maize hills are able to satisfy adequate protein in Lilongwe RDP and only four Vulgaris bean hills in between MH12 hybrid maize hills can supply adequate protein in Thiwi Lifidzi (section 5.2.5).

However, 50% of the farming families in Thiwi Lifidzi RDP and 40% of the farming families in Lilongwe RDP hold less than one hectare. The smallest holding size category is 0.5 hectares and less. Seventeen percent of the farmers in Thiwi Lifidzi and 15% of the farmers in Lilongwe RDP fall under this category (LADD/ART, 1989).

MH12 hybrid maize intercrops in both ecological zones are able to provide adequate carbohydrates to farm families with hectarages as low as 0.5. In Lilongwe RDP, local maize intercrops are able provide adequate carbohydrates to farm families with hectarages as low as 0.5. Thiwi Lifidzi RDP local maize intercrops are, however, not able to provide adequate carbohydrates to an average family. Only Lilongwe RDP MH12 intercropping recommendation domain can provide adequate protein for an average family with 0.5 hectares if four Vulgaris bean hills in between MH12 hybrid maize hills is adopted. However, the financial analysis shows that two Vulgaris bean hills in between maize hills is the best technology in recommendation domain.

CHAPTER 6

ECONOMIC ANALYSIS

6.1. Social profitability and domestic resource costs

"Comparative advantage depends on technology, which determines production possibilities and influences rates of product transformation, on resource endowment, which determines the value of domestic resources, and on international prices, which determine the value of all inputs and outputs" (Morris 1989a).

Domestic resource costs analysis can generate several measures of the relative economic efficiency of production alternatives. One of these measures, net social profitability, indicates the contribution of each production alternative to national income, measured in terms of net social returns to land. A second measure, the resource cost ratio (R.C.R), indicates the efficiency of each production alternative in using domestic resources to earn or save foreign exchange.

To determine domestic resource costs (DRC), all inputs must be classified into primary factors or tradable inputs. Primary factors are defined as goods that are not normally traded internationally, including land, labor and capital. Tradables are traded internationally or potentially could be traded internationally. Shadow or social prices are used to reflect the true economic value of goods and services in the absence of taxes, subsidies, import tariffs, quotas, price controls and other government policies. Tradables are valued at their world price equivalent adjusted for transport costs and exchange rate anomalies (Morris, 1989a). Primary factors are valued at their returns in the most profitable alternative use expressed in world price equivalents.

Social prices can differ substantially from market prices, as when farmers pay less than the full import cost of fertilizer because of government subsidy, or when they receive less than the full value of their output because the official producer price is set below the world price equivalent. When significant discrepancies exist between market and social prices, the interest of the farmers and the nation can diverge. A crop can be profitable to farmers because of high producer prices or subsidies on inputs even though its production does not represent an efficient use of resources from the point of view of the nation's resources.

Conversely, a crop can be unprofitable to farmers because of low producer prices or taxes on inputs, even though its production represents an efficient use of the nation's resources. Comparing private profitability with social profitability thus provides important insights into the impacts of government policies on producer incentives (Morris 1989a).

One critical aspect of the calculation of comparative advantage is the valuation of inputs and outputs. It is necessary to adjust market prices to eliminate the effects of policy-induced distortions or market failure. This adjustment is accomplished by assigning all inputs and outputs shadow prices reflecting their true value in the economy.

6.2 Calculating social profitability

The social profitability of local maize and MH12 hybrid intercrops was calculated for Thiwi Lifidzi and Lilongwe RDPs. The financial analysis indicated that soybean intercropping technologies were the best in Thiwi Lifidzi RDP recommendation domains and Vulgaris bean intercropping were the best in Lilongwe RDP recommendation domains. Two Vulgaris bean hills in between maize hills was the best bet for Thiwi Lifidzi Local maize intercropping recommendation domain. One soybean hill in between maize hills was the best bet technology for Thiwi Lifidzi MH12 intercropping recommendation domain. Two Vulgaris bean hills in between maize hills was the best bet for Lilongwe RDP local maize intercropping recommendation domain and Lilongwe RDP, MH12 intercropping recommendation domain. The comparative advantage analysis is based on these technologies. The assumptions underlying these calculations are:

1. Gross social returns are calculated by multiplying the world reference price of a commodity by the quantities of the commodity produced. The world reference prices per kg are MK1.01 for soybeans, MK0.91 for Vulgaris beans and MK0.94 for both local and hybrid maize (tables 21, 22 and 23).

Table 21

On-farm import parity price of maize[a] (1989)

	Exchange rate[b]	
	Official (Mk/t)	Market (Mk/t)
World Price White Maize, C.I.F Rotterdam[c]	249.96	372.41
ADD: Freight Rotterdam to Durban	148.20	220.80
Port Charges	35.00	35.00
Road/Rail Durban[d] to Limbe	156.00	232.43
ADMARC Costs	53.10	79.10
On-farm import parity	642.26	939.74

Source: MOA (1989[b]) and IMF (1989).

a. Malawi generally imports maize, sometimes exporting small quantities.

b. The official exchange rate is MK2.47 per US$1.00, the market rate is MK3.68 per US$1.00.

c. The starting point in the calculation of the parity prices is Rotterdam because there were no data available from neighboring countries. This, however, does not reflect the actual trade pattern.

d. Half the transport cost is nontraded and half is traded. This also applies to ADMARC costs.

Table 22

On-farm import price of soybeans[a] (1989)

	Exchange rate[b]	
	Official (Mk/t)	Market (Mk/t)
World price soybeans C.I.F Rotterdam[c]	299.36	446.02
ADD:		
Freight Rotterdam to Durban	148.20	220.80
Port charges	35.00	35.00
Rail or road Durban[d] to Limbe	156.00	232.43
ADD:		
ADMARC costs	153.10	79.10
On-farm import parity	791.66	1013.35

Source: MOA (1989c) and IMF (1989).

a. Malawi imports soybean products.

b. The official exchange rate is MK2.47 per US$1.00, the market rate is MK3.68 per US$1.00.

c. The starting point in the calculation of the parity prices is Rotterdam because there were no data available from neighboring countries. This, however, does not reflect the actual trade pattern.

d. Half the transport cost is nontraded and half is traded. This also applies to ADMARC costs.

Table 23

On-farm export parity price of Vulgaris beans[a] (1989)

	Exchange rate[b]	
	Official (Mk/t)	Market (Mk/t)
ADMARC export price FOB Limbe	763.75	1137.89
ADMARC buying, selling and administrative costs[c]	148.74	221.60
On farm export parity price	651.01	912.29

Source: MOA (1989c)
a. Malawi exports Vulgaris beans.
b. The official exchange rate is MK2.47 per US$1.00, the market rate is MK3.68 per US$1.00.
c. ADMARC handling includes both traded and non-traded components; 50% is assumed traded.

2. Cost of seed is calculated by multiplying the shadow price of soybean seed, maize seed and Vulgaris bean seed by the quantities of seed required. The shadow prices of seed and produce are assumed to be the same (tables 21, 22 and 23). The quantities are shown in tables 1 to 5 in the appendix.

3. Fertilizer cost is calculated by multiplying the import parity price of diammonium sulphate and urea with the various levels of fertilizer required per technology. Using the market exchange rate, the import parity price of

diammonium sulphate is MK1.84 per kg and urea is MK1.69 per kg (tables 24 and 25).

Table 24

On-farm import parity price of DAP fertilizer (1989)

	Exchange rate[a]	
	Official (Mk/t)	Market (Mk/t)
World Price Durban[b]	1000.00	1489.00
Add:		
Port Charges	35.00	35.00
Rail/ Road Durban to Lilongwe	156.00	232.43
ADMARC costs[c]	53.10	79.10
On farm import parity price	1244.10	1835.53

Source: Lele (1988) and MOA (1989c).

a. The official exchange rate is MK2.47 per US$1.00, the market rate is MK3.68 per US$1.00.

b. Malawi imports all its chemical fertilizers through the port of Durban. DAP is diammonium sulphate.

c. ADMARC handling includes both traded and non-traded components; 50% is assumed traded.

Local maize requires 20 kg diammonium sulphate and 40 kg urea. MH12 requires 80 kg diammonium sulphate and 175 kg urea.

Table 25

On-farm import parity price of urea fertilizer (1989)

	Exchange rate[a] Official (MK/t)	Market (MK/t)
World Price Durban	900.00	1340.89
Add:		
Port Charges	35.00	35.00
Rail/Road Durban[b] to Lilongwe	156.00	232.43
ADMARC costs[c]	53.10	79.10
On-farm import parity price	1144.10	1687.42

Source: MOA (1989c) and Lele (1988).

a. The official exchange rate is MK2.47 per US$1.00, the market rate is MK3.68 per US$1.00.

b. Malawi imports all its chemical fertilizers through the port of Durban. DAP is diammonium sulphate.

c. ADMARC handling includes both traded and non-traded components; 50% is assumed traded.

The calculation of shadow prices included Government controlled foreign exchange rate of MK2.47 per US$1.00 and the market exchange rate of MK3.68 per US $1.00. The shadow price of MK3.68 is used in the analysis. Slow growth in Malawian agricultural exports along with depressed world prices have reduced the nation's export earnings and precipitated a foreign exchange shortage. The government has responded to this by instituting a set of foreign exchange controls, including a system of rationing foreign exchange to essential industries. One effect of this policy is allow the government to maintain an overvalued currency (Morris, 1989a). The official exchange rate does not fully reflect the real value of a unit of foreign currency to the Malawian economy. Using the shadow exchange rate takes care of overvaluation of the domestic currency.

The overvaluation of domestic currency is important in comparative advantage analysis because it affects the market price of tradables. Imported goods become cheaper in domestic currency because they can be purchased with fewer units of overvalued domestic currency. Exports become more expensive for foreign buyers because more units of undervalued foreign currency are required to pay for them. Consequently, if adjustments are not made to correct for overvaluation, efficiency analysis will be biased in favor of import intensive activities (Morris, 1989a).

4. Transport is an indirectly traded input comprising both a tradable component and a primary factor component. Such composite goods are decomposed into the tradable component and the primary component (Morris 1989a). Trucks, trains, fuel and spare parts are the tradable component, and labor is a primary input. The analysis assumes that half the transport cost is tradable. The within country transport cost is calculated assuming that the furthest market is 8 km away from the furthest village. The average cost per kg for transporting from the farm to home and from home to market is MK0.01245 (section 2.1.6).

5. Labor costs are calculated in table 8.

6. Interest on capital is based on the local lending rate of 100% (section 2.1.6). "Capital" excludes labor costs because the labor is supplied by the farmers themselves.

7. In the sensitivity analysis (section 6.7) average low yields and average high yields in each recommendation domain are used. The average low and average high yields used in the sensitivity analysis were obtained from project reports for the respective rural development project. These figures are estimated by the respective project offices. Even the figures for average high yields are lower than the figures generated by the research program under study. This may be due to differences in fertility and managerial levels; the farmers apply less fertilizer and are poorer managers than the researchers. The average high yield for local maize is 1300 kg per hectare in Thiwi Lifidzi and 1200 kg per hectare in Lilongwe RDP. The average low local maize yield is 880 kg per hectare in Thiwi Lifidzi and 1000 kg per hectare in Lilongwe RDP. The average low soybean yield is 400 kg per hectare in Thiwi Lifidzi. The average low yield of vulgaris beans 125 kg per hectare in local maize intercrops and 300 in hybrid intercrops. The average high yield of MH12 in both Thiwi Lifidzi and Lilongwe RDP is 3000 kg per hectare and the low yield is 2000 kg per hectare. The average high yield of Vulgaris beans is 500 kg per hectare.

6.3 Social profitability implications

The social profitability--returns to management and land--is higher in MH12 intercropping than the local maize intercropping technologies in both Thiwi Lifidzi and Lilongwe RDPs (table 26). One of the shadow costs that stands out in this analysis is the fertilizer cost of MH12 production, which is 4.24 times higher than for local maize intercrops. Despite the high shadow cost of fertilizer, MH12 intercrops dominate the local maize intercrops due to the high yields of hybrid maize.

Since social prices reflect the true economic scarcity value of inputs and outputs, MH12 intercrops represent the most profitable production alternative in terms of contributing to national income. Because social prices for primary factors are set equal to their alternative use values, the higher net social profitability of MH12 intercrops indicates that MH12 intercrops are relatively more efficient than local maize intercrops (Morris, 1989a).

Table 26

Social profitability by recommendation domain (Mk/ha).

	Thiwi Lifidzi		Lilongwe	
	Local maize	MH12	Local maize	MH12
Gross social returns[a]	1687.30	3561.08	1939.49	2881.53
Variable costs:				
Seed[b]	67.86	59.78	79.00	79.00
Fertilizer	104.10	442.95	104.10	442.95
Transport	21.85	46.93	25.74	38.32
Labor	97.23	97.23	97.23	97.23
Interest	193.81	549.66	208.84	560.27
Total variable costs	484.85	1196.55	514.91	1217.77
Total costs	484.85	1196.55	514.91	1217.77
Social profitability	1202.45	2364.53	1424.58	1663.76

a. All the terms used in this table are discussed in section 6.2.

b. The seed cost is higher for Thiwi Lifidzi local maize intercrop and Lilongwe RDP MH12 intercrop because the best technologies for these recommendation domains have two soybean and two Vulgaris bean hills in between maize hills. The best technologies for the other recommendation domains are one soybean hill between maize hills (section 6.2).

Farmer net margins are significantly lower than the net social profit for both local maize and MH12 technologies in both RDPs (table 27).

Table 27

Net margins (MK/ha) by recommendation domain (1989)

	Thiwi Lifidzi		Lilongwe	
	Local maize	MH12	Local maize	MH12
Net benefit[a]	500.14	898.90	647.74	991.82
Less:				
labor[b]	97.23	97.23	97.23	97.23
Fert[c]	46.20	195.90	46.20	195.90
	356.71	605.77	504.31	698.69

a. Best bet technology net benefits (tables 9, 12 and 15)
b. Total labor cost at rural wage rate (table 8)
c. Total cost of fertilizer using ADMARC prices. Diammonium phosphate costs MK0.83/kg and urea costs MK0.74/kg. The required quantities are reported in 4.7.

Local maize net margins are very low in Thiwi Lifidzi because of low yields of maize and very low yields of Vulgaris beans. The difference between farm net margins and social profitability can be attributed to agricultural policies that tax a large portion of social profits away from the farmers.

To date, ADMARC buys most of the farmer produce despite market liberalization (section 5.2.7.1). ADMARC is charged with making a financial contribution to the Governments' development strategies. The contribution comes mostly from maintaining a difference between produce prices and international prices (Christiansen and Southworth, 1988), thus taxing the farmers. Such taxes can provide disincentive to smallholder farmers.

However, the calculation of the shadow prices used in the net social profitability assumes that the starting point is Rotterdam. This does not reflect the true trade pattern. Malawi trades with neighboring countries. If the starting point was a neighboring country, the transport costs would most likely be less. This would reduce the net social profitability and the difference between farm net margins and social profitability.

6.4. Calculating resource cost ratios

The data used in the calculation of social profitability was rearranged to determine the resource cost ratios of the various technologies. The following formula was used.

$$RCR = \frac{\Sigma\ Wp\ Fp}{\Sigma\ PoTo - \Sigma\ PiTi}$$

Where:

RCR = Resource cost ratio for a specific technology.

WpFp = Shadow cost of land, labor, 0.5* transport and the interest on working capital.

PoTo = Shadow value of maize and vulgaris beans in Lilongwe RDP intercropping recommendation domains and shadow value of maize and soybeans in Thiwi Lifidzi recommendation domains (section 6.2).

PiTi = Shadow cost of seed and fertilizer per technology and 0.5* transport costs.

RCR for Thiwi Lifidzi RDP Local maize intercrops =

$(123.5^{a}+97.23^{b}+10.98^{c}+232.43^{d}+232.43^{e}+125.46^{f})/(1687.30^{g}-67.86^{h}-104.10^{i}-232.43^{j}) = 0.640759$

a. Opportunity cost of land (section 6.6)
b. Opportunity cost of labor (section 6.2)
c. Half of within the country transport (section 6.2)
d. Half maize transport Durban to Lilongwe (section 6.2)
e. Half soybean transport Durban to Lilongwe (section 6.2)
f. Interest on working capital--12.5% per annum on items a to h except for b and g.
g. Shadow value of maize and soybeans (section 6.2)
h. Shadow cost of seed (section 6.2)
i. Shadow cost of fertilizer (section 6.2)
j. Half fertilizer transport (section 6.2)

Resource cost ratios calculated for each recommendation domain using similar equations (table 28) showed that all the technologies have comparative advantage.

Table 28

Domestic resource cost ratios for each recommendation domain (1989)

	Thiwi Lifidzi		Lilongwe	
Term*	Local maize	MH12	Local Maize	MH12
a	123.50	123.50	123.50	123.50
b	97.23	97.23	97.23	97.23
c	10.98	23.47	12.89	19.16
d	232.43	232.43	232.43	232.43
e	232.43	232.43	232.43	232.43
f	125.46	168.37	124.70	170.24
Sub-total(1)	822.03	877.46	823.18	874.99
g	1687.30	3561.08	1939.49	2881.53
h	- 67.86	- 59.78	- 79.00	- 79.00
i	-104.10	-442.95	-104.10	-442.95
j	-232.43	-232.43	-232.43	-232.43
Sub-total(2)	1282.91	2825.92	1523.96	2127.15
DRC(1/2)	0.640759	0.310494	0.540158	0.411344

* The terms are discussed in the Thiwi Lifidzi resource cost ratio equation on the previous page.

6.5. Some implications of the R.C.R. analysis

All the technologies have comparative advantage indicating that the value of domestic resources used in the production is less than the value of foreign exchange earned or saved. Malawi should encourage the production of these intercrops. It should be borne in mind, however, that the trial data used in the analysis received high dosage of fertilizers. The results may be different at lower dosages.

6.6 Sensitivity analysis

Technical coefficients used in the construction of enterprise budgets are often calculated from a range of observed values and the prices used in calculating social profitability are often estimated or projected prices. Sensitivity analysis can reveal whether comparative advantage rankings calculated using mean values, estimated values, or projected values for technical coefficients and social prices are likely to change if technical coefficients or social prices eventually differ from expectations (Morris, 1989a).

Social profitability and resource cost ratios frequently are sensitive to the following parameters:

1. World reference prices of outputs - A change in the world reference price of an output will have a greater effect on the social profitability and resource cost ratio of an enterprise than a change of similar magnitude in any other parameter. This analysis assumes an arbitrary 10% increase and 10% decrease in the world reference prices.

2. Yields - Comparative advantage tends to be highly sensitive to the level of yield assumed for any fixed quantity of inputs. Improved management can succeed in raising mean yields above current levels and enterprises that appear socially unprofitable at present could become profitable. Average yields experienced over several seasons

as reported by the project office, both low averages and high averages, are used in the sensitivity analysis.

3. Wage rate - Conducting sensitivity analysis on wage rates guards against estimation error for shadow wage rate. The sensitivity with respect to wage rate depends upon the labor intensity of the enterprises being compared. The urban wage rate is used in the sensitivity analysis instead of the rural wage rate.

4. Opportunity cost of land is calculated based on the going rate for land rental. Land can be rented at Mk50.00 per acre per season. This gives MK123.50 per hectare. This is a low figure. It would be instructive to base the opportunity cost of land on the returns to land in its most socially profitable alternative use (Morris 1989a), but such data are not available. The land rental will be doubled to see the effect of a higher opportunity cost of land on the comparative advantage.

5. The shadow price of maize is based on Rotterdam freight prices. This does not accurately reflect the trade patterns. Malawi trades with neighboring countries, but the data is unavailable to the author. Maize prices are halved to see the effect of low shadow prices on the resource cost ratios.

When the shadow price of maize is halved (table 29), the net social profitability is still higher than the net farm margins (table 27) for all recommendation domains except for Lilongwe RDP MH12 recommendation domain. The

MH12 hybrid maize yields in this recommendation domain are not as high as the yields for Thiwi Lifidzi. This is an important point because the shadow prices used in this study assume the starting point is Rotterdam. The assumption, which is not consistent with the trade pattern increases the shadow costs because of high freight costs.

Table 29

Social profitability (MK/ha) sensitivity analysis by recommendation domain (1989).

	Thiwi Lifidzi		Lilongwe	
	Local maize	MH12	Local maize	MH12
World reference prices increased by 10%	1365.46	2728.64	1656.91	1951.63
World reference prices decreased by 10%	1029.22	2008.42	1230.61	1375.60
Urban wage rate	1174.64	2336.75	1435.18	1635.98
High average yield	1141.15	2027.45	924.47	2088.75
Low average yield	746.35	1087.45	577.22	996.75
Maize price halved	551.14	704.76	548.91	406.13

NB: All the variables reported in this table are discussed in items 1 to 5 of section 6.6 and in section 6.2.

An important implication of the social profitability analysis is that existing agricultural policies on soybean and Vulgaris bean intercropping technology provide a disincentive to farmers because the farm net margins are consistently lower than the social profitability, with the exception of the Lilongwe MH12 intercrop.

When average high yields, which assumes a lower dosage of fertilizer and poorer management compared to the treatment levels are used, the technologies still exhibit comparative advantage (table 30).

Table 30

Domestic resource cost sensitivity analysis by recommendation domain (1989)

	Thiwi Lifidzi		Lilongwe	
	Local maize	MH12	Local maize	MH12
World reference prices increased by 10%	0.5685	0.2757	0.4791	0.3622
World reference prices decreased by 10%	0.7407	0.3552	0.6189	0.4757
Urban wage rate	0.6624	0.3203	0.5687	0.4244
High average yield	0.6729	0.3525	0.6729	0.3471
Low average yield	1.0163	0.5665	1.2898	0.6124
Maize price halved	1.3015	0.7525	1.3496	1.0063

NB: All the variables reported in this table are discussed in items 1 to 5 of section 6.6 and in section 6.2.

This indicates that even at the current lower levels of fertilizer the country has a comparative advantage in using these technologies. Only local maize intercrops loses comparative advantage when the average low yields are used. Three recommendation domains lose comparative advantage when the shadow price of maize is assumed to be half the calculated shadow price. If shadow prices were calculated based on neighboring countries, the transport cost is likely to be lower and hence the shadow prices would be lower. Malawi could then lose comparative advantage.

Chapter 7

CONCLUSIONS

7.1 Biological analysis

This study has shown that it is important to do comprehensive analysis of on-farm trial technologies in order to come up with farmer recommendations that are more likely to be adopted. The biological analysis is necessary but not sufficient. Some treatments that give highest biological yield are financially less profitable than some treatments with lower yield levels. Farmers did not indicate preference for any of the highest yielding pulse treatments, although some of them earned high financial returns to investment. This suggests that there are more factors that influence farmer decisions than just yield.

7.2 Financial returns

Financial returns analysis indicates that farmers in the Thiwi Lifidzi RDP local maize intercropping and the MH12 intercropping recommendation domains earn higher financial returns from soybean intercropping than from Vulgaris bean intercropping. In contrast, farmers in the Lilongwe RDP local maize intercropping and MH12 intercropping domains earn higher financial returns from Vulgaris bean intercrops than from soybean intercrops. In Thiwi Lifidzi, MH12 intercrops have higher net benefits than the local maize intercrops. This is mostly due to the differences in the yield of the maize type because soybeans seem to do better in the local maize intercrops. Similarly, in Lilongwe RDP, MH12 intercrops have higher net benefits than local maize intercrops and yield of Vulgaris beans is higher in the MH12 intercrops than in the local maize intercrops. Farmers who can afford to invest in hybrid maize can realize higher financial returns than farmers that invest in local maize intercrops.

7.3 Food Security

In both locations, MH12 hybrid maize intercrops give higher maize yields than local maize intercrops. Similarly, in both locations MH12 hybrid intercrops give higher yields of Vulgaris beans than local maize intercrops. Assuming most of the maize and Vulgaris beans produced are consumed by the farmers, MH12 hybrid intercrops offer more household food security than local maize intercrops (section 5.2.5). Farmers prefer local maize to MH12 hybrid for food because local maize has better storage and culinary qualities, but in the absence of local maize farmers eat hybrid maize. Most of the maize that farmers buy from ADMARC for food is hybrid maize. It is necessary for the Ministry of Agriculture to emphasize research on factors that will encourage the growing and consumption of hybrid MH12 and other high yielding varieties. Storage and culinary qualities, among other things, should be improved.

7.4 Risk

There is more annual variability in MH12 intercrop net benefits than in local maize intercrops (11, 14, 17 and 20). This is a disadvantage of growing MH12 intercrops. Farmers prefer more stable technologies which have lower profitability to technologies with high profitability and variability.

MH12 hybrid maize intercrops is a more risky undertaking than local maize intercrops (tables 11, 14, 17 and 20). Local maize is known to tolerate mid-season droughts more than MH12 hybrid maize. Local maize is also known to tolerate late season showers more than MH12 hybrid maize. It is necessary for maize breeders to incorporate mid-season drought and late season showers tolerance in MH12 hybrid maize to reduce yield variability. If the variability can be reduced while maintaining its high yield potential, MH12 can become very attractive. Many farmers including the small smallholders, who are more risk averse, would grow it. This would contribute to household and national food security.

7.5 Farmer Preferences

It is important to include farmer preferences in the derivation of recommendations. This is one important criterion that should be used to supplement marginal analysis because it incorporates factors which marginal analysis cannot capture. It is evident in this study that farmer preferences do not always coincide with marginal analysis and it is up to the researcher to decide which factor to give more weight. Some of the farmer preferences may not be evident to the researcher.

Farmers in both locations preferred two soybean and two Vulgaris bean hills in between maize hills (section 2.1.6). In Thiwi Lifidzi MH12 intercropping recommendation domain, two soybean hills in between maize hills were dominated. This suggests some underestimation of the benefits from these treatments by researchers. The possible underestimations are discussed in section 7.8. On the other hand, some treatments that earn high financial returns are not preferred by farmers. In Thiwi Lifidzi local maize intercropping recommendation domain, treatment 10 gave the highest financial returns. In Thiwi Lifidzi MH12 intercoppping recommendation domain, treatment 6 gave the highest financial returns. These treatments represent four pulse hills in between maize hills. None of these treatments were preferred by the farmers. Low cost and lack of seed were some of the reasons the farmers indicated for preferring two pulse hills in between maize hills. This suggests that the farmers' preferences are related to their circumstance. Improvement in institutions serving the farmers will change the farmers' preferences. An increase in the farmers' cash earnings and capital accumulation and seed availability will enable the farmers to invest in highpaying technologies. More research needs to be done in the area of rural cash income and capital accumulation. More efficient seed markets should be encouraged.

7.6 Intercropping systems

It is evident that intercropping systems earn higher financial returns than sole cropping systems. In all the recommendation domains there are no statistical significant differences between sole and intercropped maize. Statistically the maize yields are the same. The intercropped treatments, however, have additional yields from the pulses. The net benefits realized from the intercrops are thus higher than those of the sole crop.

In order to improve the small farmers' incomes, it is important to place greater emphasis on intercropping systems than on sole cropping. Apart from the financial returns intercropping has other benefits like producing both main and relish dishes in the same field, maintaining soil fertility, etc. (section 2.1.4).

7.7 Government policy

Malawi's policy is to maintain self-sufficiency in the staple food--maize--and other foodstuffs including Vulgaris beans (MOA, 1989a). Malawi's policy also includes reducing imports of commodities, like soybeans, in which it has comparative advantage.

Most of the maize that contributes to self-sufficiency is hybrid maize which is grown by large smallholders using subsidized inputs and government loans. Between 1985 and 1988, the production of hybrid maize declined sharply because the government embarked on a fertilizer subsidy removal program while maintaining taxes on the produce sold to ADMARC (Christiansen, R.E., and Southworth, V.R., 1988).

To maintain self-sufficiency, Malawi needs to encourage the production of MH12 intercrops. One way of achieving this goal is to remove both taxes on produce and subsidies on fertilizer simultaneously so that the prices of these commodities will come close to reflecting their true values. The social profitability analysis, assuming the starting point for calculating shadow prices is Rotterdam, shows that if the input and output prices of the maize intercrops were closer to the shadow prices, the technologies could be more attractive to the farmers because social profitability is higher than net farm margins. However, this process should be done gradually and cautiously. Transport costs should be given special attention.

Transport costs are high and contribute to high import and low export parity prices. This may change because in the late 1989, the Nacala rail route which passes through Mozambique was re-opened. The Nacala route was closed because of the war in Mozambique. All inputs and outputs had to be routed through Durban. This raised the external transportation costs by an equivalent $50 million which was close to 20% of the value of exports and 3% of the GDP by 1984 (Lele, 1989).

The re-opening of the Nacala route is likely to reduce the transportation costs. Production costs for crops will most likely decrease because imported inputs would become less expensive. At the same time the value of export commodities would increase due to reduced costs of getting them to the market. The social profitability will most likely increase. If the prices of inputs and outputs come close to reflecting true values, the net farm margins will increase and the technologies will become more attractive.

Policy makers can shape comparative advantage. Comparative advantage is not static, although heavily influenced by parameters that can be considered fixed in the short run such as primary factor endowments and technology (Morris 1989b). Comparative advantage is likely to change as these factors change. Technology for example can be subject to deliberate manipulation, e.g., currently, the maize commodity team of the Department of Agricultural Research is screening varieties under lower than recommended rates of fertilizer to identify varieties that could suit low resource farmer circumstances. This is likely to increase the social profitability of maize. Policy makers can thus take an active role in shaping future patterns of comparative advantage by influencing the direction and nature of technological change (Morris, 1989a).

It is important to encourage the production of MH12 hybrid maize and other high yielding hybrids. The MH12 hybrid intercropping are more efficient in terms of net social profitability (section 6.3) than local maize intercrops. While both local maize and MH12 are sold to ADMARC or private traders, hybrid is sold most. MH12 hybrid intercropping production can be encouraged by adopting policies that are designed to take advantage of comparative advantage.

7.8 Underestimating intercropping benefits

It is difficult to include all the benefits of intercropping technologies in an analysis like this one because some benefits, like improving soil fertility, do not have immediate impact. Some benefits, like relish dishes made from Vulgaris bean leaves, can not be easily measured.

The financial profitability of the intercropping technologies is based on the grain yield only. While the grain is the most important part of the yield, there are some benefits of intercropping which have not been built into the analysis, e.g., the Vulgaris bean leaf is continuously harvested and used as a relish dish or sometimes the main dish during the food shortage period without significantly affecting the yield of beans (LADD/ART, 1989). The Vulgaris bean leaf is also sold on local markets. If the value of the leaf that can be harvested without affecting maize yields can be determined, it could be included in the analysis.

Intercropping maize with pulses has soil-enriching effects because pulses are nitrogen fixers. If the amount of nitrogen fixed and consequently utilized by the maize crop was determined, then the reduction in the amount of nitrogen fertilizers required to maintain the same level of fertility would be included in the analysis. This cannot be easily done.

The financial analysis assumes that all the beans are harvested at the end of the season. Vulgaris beans can be harvested green and either be consumed or sold as a horticultural crop. The value of the green Vulgaris beans is higher than the dried Vulgaris beans. Using the dried bean prices underestimates the value of the Vulgaris bean intercrop. This value could be incorporated by determining approximately how much of the Vulgaris beans are sold green and how much are sold or consumed dry. The weighted average price could reflect the Vulgaris bean value more closely. If the mentioned benefits among others were included, the analysis would yield different results. Vulgaris bean intercrops may perform better than soybeans in Thiwi Lifidzi.

APPENDIX

Table 1

Partial budgets for ten different sole cropping and intercropping treatments of local maize, hybrid maize, vulgaris beans and soybeans tested in Thiwi Lifidzi and Lilongwe RDPs.

DATA

PRICES		
Market Prices		
Maize	MK per Kg	0.26
Vulgaris beans	MK per Kg	1.92
Soybeans	MK per Kg	0.60
Grain transport to markets	MK per Kg	0.02
Field Price (Market prices less harvesting and processing labor, and transportation)		
Maize	MK per kg	0.21
Vulgaris beans	MK per kg	1.88
Soybeans	MK per kg	0.56
Soybean Seed	MK per kg	0.75
SEED RATE		
(Pulse seed rate assuming one hill between maize hills)		
Vulgaris beans	Kg per ha	15.00
Soybeans	Kg per ha	8.00
OPPORTUNITY COSTS		
Labour for planting pulses		
On the same station	Hrs per ha	22.86
One hill between maize stations	Hrs per ha	27.81
Two hills between maize stations	Hrs per ha	33.14
Three hills between maize stations	Hrs per ha	40.14
Four hills between maize stations	Hrs per ha	48.61
Bean harvesting and processing	Hrs per kg	0.10
Maize harvesting and processing	Hrs per Kg	0.10
Labor	MK per ha	0.21
Yield adjustment	Percent	15.00

Table 2

THIWI LIFIDZI RDP LOCAL MAIZE INTERCROPPING TRIAL

TREATMENTS	M1 Pure Maize	M2 Maize/V beans same hill	M3 Maize/1 V. bean hill	M4 Maize/2 V. bean hills	M5 Maize/3 V. bean hills	M6 Maize/4 V. bean hills	M7 Maize/1 soybean hill	M8 Maize/2 Soybean hills	M9 Maize/3 Soybean hills	M10 Maize/4 Soybean hills
AVERAGE FIELD YIELD (kg/ha)										
Average maize yields	1605.00	1605.00	1605.00	1605.00	1605.00	1605.00	1605.00	1605.00	1605.00	1605.00
Average vulgaris bean yield	m	41.00	0.00	41.00	41.00	41.00	m	m	m	m
Average soybean yields	m	m	m	m	m	m	288.00	460.00	487.00	716.00
ADJUSTED YIELD (kg/ha)										
Average maize yields	1364.25	1364.25	1364.25	1364.25	1364.25	1364.25	1364.25	1364.25	1364.25	1364.25
Average vulgaris bean yields	0.00	34.85	0.00	34.85	34.85	34.85	0.00	0.00	0.00	0.00
Average soybean yields	0.00	0.00	0.00	0.00	0.00	0.00	244.80	391.00	413.95	608.60
GROSS FIELD BENEFIT BY CROP (MK/ha)										
Maize	300.14	300.14	300.14	300.14	300.14	300.14	300.14	300.14	300.14	300.14
Vulgaris beans	0.00	65.52	0.00	65.52	65.52	65.52	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	137.09	218.96	231.81	340.82
TOTAL GROSS FIELD BENEFITS (MK/ha)	300.14	365.65	300.14	365.65	365.65	365.65	437.22	519.10	531.95	640.95
COSTS THAT VARY BY OPERATION(MK/ha)										
Vulgaris bean seed	0.00	28.80	28.80	57.60	86.40	115.20	0.00	0.00	0.00	0.00
Soybean seed	0.00	0.00	0.00	0.00	0.00	0.00	6.00	12.00	18.00	24.00
Vulgaris bean planting labor	0.00	4.80	5.84	6.96	8.43	10.21	0.00	0.00	0.00	0.00
Soybean planting labor	0.00	0.00	0.00	0.00	0.00	0.00	5.84	6.96	8.43	10.21
TOTAL VARIABLE COSTS	0.00	33.60	34.64	64.56	94.83	125.41	11.84	18.96	26.43	34.21
NET BENEFITS	300.14	332.05	265.49	301.09	270.82	240.24	425.38	500.14	505.52	606.74
DOMINANCE ANALYSIS										
Treatments	1	7	8	9	2	10	3	4	5	6
Net benefits (MK/ha)	300.14	425.38	500.14	505.52	332.05	606.74	265.49	301.09	270.82	240.42
Total variable costs (MK/ha)	0.00	11.84	18.96	26.43	33.60	34.21	34.64	64.65	94.83	125.41
Status (D=dominated and ND=nondominated)		ND	ND	ND	D	ND	D	D	D	D
MARGINAL RATE OF RETURNS ANALYSIS										
Treatments	1	7	8	9	10					
Net benefits	300.14	425.38	500.14	505.52	606.74					
Total variable costs	0.00	11.84	18.96	26.43	34.21					
Marginal rate of return		1057.77	1050.00	72.02	1300.86					
RETURNS TO LABOR ANALYSIS										
Treatments	1	7	8	9	10					
Net benefits (MK/ha)	300.14	425.38	500.14	505.52	606.74					
Variable labor time (hrs/ha)	0.00	27.81	33.14	40.14	48.61					
Marginal returns to labor (MK/hr)		4.50	14.03	0.77	11.95					
ABILITY TO FEED AN AVERAGE FAMILY (Assuming the family needs 920 kg maize and 292 kg Vulgaris beans)										
Treatments	1	7	8	9	10					
Maize yield (kg/ha)	1605.00	1605.00	1605.00	1605.00	1605.00					
Bean yield (kg/ha)	0.00	0.00	0.00	0.00						

NB: Treatment 2 is the farmers' practice.
m = Not included in the treatment.

Table 3

THIWI LIFIDZI MH12 INTERCROPPING TRIAL

TREATMENTS	M1 Pure Maize	M2 Maize/ V. beans same hill	M3 Maize/1 V. bean hill	M4 Maize/2 V. bean hills	M5 Maize/3 V.bean hills	M6 Maize/4 V.bean hills	M7 Maize/1 soybean hill	M8 Maize/2 Soybean hills	M9 Maize/3 Soybean hills	M10 Maize/4 Soybean hills
AVERAGE FIELD YIELD (KG/ha)										
Average maize yields	4155.00	4155.00	4155.00	4155.00	4155.00	4155.00	4155.00	4155.00	4155.00	4155.00
Average vulgaris bean yield	m	72.00	96.00	99.00	151.00	412.00	m	m	m	m
Average soybean yields	m	m	m	m	m	m	281.00	247.00	342.00	370.00
ADJUSTED YIELD (KG/ha)										
Average maize yields	3531.75	3531.75	3531.75	3531.75	3531.75	3531.75	3531.75	3531.75	3531.75	3531.75
Average vulgaris bean yields	0.00	61.20	81.60	84.15	128.35	350.20	0.00	0.00	0.00	0.00
Average soybean yields	0.00	0.00	0.00	0.00	0.00	0.00	238.85	209.95	290.70	314.50
GROSS FIELD BENEFIT BY CROP (MK/ha)										
Maize	776.99	776.99	776.99	776.99	776.99	776.99	776.99	776.99	776.99	776.99
Vulgaris beans	0.00	115.06	153.41	158.20	241.30	658.38	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	133.76	117.57	162.79	176.12
TOTAL GROSS FIELD BENEFITS (MK/ha)	776.99	892.04	930.39	935.19	1018.28	1435.36	910.74	894.56	939.78	953.11
COSTS THAT VARY BY OPERATION(MK/ha)										
Vulgaris bean seed	0.00	28.80	28.80	57.60	86.40	115.20	0.00	0.00	0.00	0.00
Soybean seed	0.00	0.00	0.00	0.00	0.00	0.00	6.00	12.00	18.00	24.00
Vulgaris bean planting labor	0.00	4.80	5.84	6.98	8.43	10.21	0.00	0.00	0.00	0.00
Soybean planting labor	0.00	0.00	0.00	0.00	0.00	0.00	5.84	6.98	8.43	10.21
TOTAL VARIABLE COSTS	0.00	33.60	34.64	64.58	94.83	125.41	11.84	18.98	26.43	34.21
NET BENEFITS	776.99	858.44	895.75	870.63	923.45	1309.95	898.90	875.60	913.35	918.90
DOMINANCE ANALYSIS										
Treatments	1	7	8	9	2	10	3	4	5	6
Net benefits (MK/ha)	776.99	898.90	875.60	913.35	858.44	918.90	895.75	870.63	923.45	1309.95
Total variable costs (MK/ha)	0.00	11.84	18.98	26.43	33.60	34.21	34.64	64.65	94.83	125.41
Status (D=dominated and ND=nondominated)		ND	D	ND	D	ND	D	D	ND	ND
MARGINAL RATE OF RETURNS ANALYSIS										
Treatments	1	7	9	10	5	6				
Net benefits	776.99	898.90	913.35	918.90	923.45	1309.95				
Total variable costs	0.00	11.84	26.43	34.21	94.83	125.41				
Marginal rate of return		1029.65	99.04	71.34	7.51	1283.90				
RETURNS TO LABOR ANALYSIS										
Treatments	1	7	5	6						
Net benefits (MK/ha)	776.99	898.90	923.45	1315.38						
Variable labor time (hrs/ha)	0.00	27.81	40.14	48.61						
Marginal returns to labor (MK/hr)		4.38	1.99	46.27						
ABILITY TO FEED AN AVERAGE FAMILY (Assuming the family needs 920 kg maize and 292 kg vulgaris beans)										
Treatments	1	7	5	6						
Maize yield (kg/ha)	4155.00	4155.00	4155.00	4155.00						
Bean yield (kg/ha)	0.00	0.00	0.00	0.00						

NB: Treatment 2 is the farmers'practice.
Treatments 9 and 10 are dominated in the marginal returns to labor analysis.
m=not included in the treatment.

Table 4

LILONGWE RDP LOCAL MAIZE INTERCROPPING TRIAL

TREATMENTS	M1 Pure Maize	M2 Maize/ beans same hill	M3 Maize/1 V. bean hill	M4 Maize/2 V. bean hills	M5 Maize/3 V. bean hills	M6 Maize/4 V. bean hills	M7 Maize/1 soybean hill	M8 Maize/2 Soybean hills	M9 Maize/3 Soybean hills	M10 Maize/4 Soybean hills
AVERAGE FIELD YIELD (kg/ha)										
Average maize yields	2288.00	2288.00	2288.00	2288.00	2288.00	2288.00	2288.00	2288.00	2288.00	2288.00
Average vulgaris bean yield	m	62.00	96.00	178.00	199.00	144.00	m	m	m	m
Average soybean yields	m	m	m	m	m	m	148.00	96.00	144.00	219.00
ADJUSTED YIELD (kg/ha)										
Average maize yields	1944.80	1944.80	1944.80	1944.80	1944.80	1944.80	1944.80	1944.80	1944.80	1944.80
Average vulgaris bean yields	0.00	52.70	81.60	151.30	169.15	122.40	0.00	0.00	0.00	0.00
Average soybean yields	0.00	0.00	0.00	0.00	0.00	0.00	125.80	81.60	122.40	186.15
GROSS FIELD BENEFIT BY CROP (MK/ha)										
Maize	427.86	427.86	427.86	427.86	427.86	427.86	427.86	427.86	427.86	427.86
Vulgaris beans	0.00	99.06	153.41	284.44	318.00	230.11	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	70.45	45.70	68.54	104.24
TOTAL GROSS FIELD BENEFITS (MK/ha)	427.86	526.93	581.26	712.30	745.86	657.97	498.30	473.55	498.40	532.10
COSTS THAT VARY BY OPERATION(MK/ha)										
Vulgaris bean seed	0.00	28.80	28.80	57.60	86.40	115.20	0.00	0.00	0.00	0.00
Soybean seed	0.00	0.00	0.00	0.00	0.00	0.00	6.00	12.00	18.00	24.00
Vulgaris bean planting labor	0.00	4.80	5.84	6.96	8.43	10.21	0.00	0.00	0.00	0.00
Soybean planting labor	0.00	0.00	0.00	0.00	0.00	0.00	5.84	6.96	8.43	10.21
TOTAL VARIABLE COSTS	0.00	33.60	34.64	64.56	94.83	125.41	11.84	18.96	28.43	34.21
NET BENEFITS	427.86	493.33	546.62	647.74	651.03	532.56	486.46	454.59	469.97	497.89
DOMINANCE ANALYSIS										
Treatments	1	7	8	9	2	10	3	4	5	6
Net benefits (MK/ha)	427.86	486.46	454.59	469.97	493.33	497.89	546.62	647.74	651.03	532.56
Total variable costs (MK/ha)	0.00	11.84	18.96	28.43	33.60	34.21	34.64	64.65	94.83	125.41
Status (D=dominated and ND=nondominated)		ND	D	D	ND	ND	ND	ND	ND	D
MARGINAL RATE OF RETURNS ANALYSIS										
Treatments	1	7	2	10	3	4	5			
Net benefits	427.86	486.46	493.33	497.89	546.62	647.74	651.03			
Total variable costs	0.00	11.84	33.60	34.21	34.64	54.65	94.83			
Marginal rate of return		494.93	31.57	747.54	11332.56	505.36	8.19			
RETURNS TO LABOR ANALYSIS										
Treatments	1	2	3	4	5					
Net benefits (MK/ha)	427.86	493.33	546.62	647.74	651.03					
Variable labor time (hrs/ha)	0.00	22.88	27.81	33.14	40.14					
Marginal returns to labor (MK/hr)		2.86	10.77	18.97	0.47					
ABILITY TO FEED AN AVERAGE FAMILY (Assuming the family needs 920 kg maize and 292 kg vulgaris beans)										
Treatments	1	2	3	4	5					
Maize yield (kg/ha)	2288.00	2288.00	2288.00	2288.00	2288.00					
Bean yield (kg/ha)	0.00	53.00	82.00	151.00	169.00					

NB: Treatment 2 is the farmers' practice.
Treatments 7 and 10 are dominated in the marginal returns to labor analysis.
m= not included in the treatment.

Table 5

ULONGWE RDP MH12 INTERCROPPING TRIAL

TREATMENTS	M1 Pure Maize	M2 Maize/ beans same hill	M3 Maize/1 V. bean hill	M4 Maize/2 V. bean hills	M5 Maize/3 V. bean hills	M6 Maize/4 V. bean hills	M7 Maize/1 soybean hill	M8 Maize/2 Soybean hills	M9 Maize/3 Soybean hills	M10 Maize/4 Soybean hills
AVERAGE FIELD YIELD (kg/ha)										
Average maize yields	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00	3148.00
Average vulgaris bean yield	m	238.00	274.00	473.00	816.00	864.00	m	m	m	m
Average soybean yields	m	m	m	m	m	m	364.00	360.00	566.00	514.00
ADJUSTED YIELD (kg/ha)										
Average maize yields	2675.80	2675.80	2675.80	2675.80	2675.80	2675.80	2675.80	2675.80	2675.80	2675.80
Average vulgaris bean yields	0.00	202.30	232.90	402.05	693.60	734.40	0.00	0.00	0.00	0.00
Average soybean yields	0.00	0.00	0.00	0.00	0.00	0.00	309.40	306.00	481.10	436.90
GROSS FIELD BENEFIT BY CROP (MK/ha)										
Maize	588.68	588.68	588.68	588.68	588.68	588.68	588.68	588.68	588.68	588.68
Vulgaris beans	0.00	380.32	437.85	755.85	1303.97	1380.67	0.00	0.00	0.00	0.00
Soybeans	0.00	0.00	0.00	0.00	0.00	0.00	173.26	171.36	269.42	244.66
TOTAL GROSS FIELD BENEFITS (MK/ha)	588.68	969.00	1026.53	1344.53	1892.64	1969.35	761.94	760.04	858.09	833.34
COSTS THAT VARY BY OPERATION(MK/ha)										
Vulgaris bean seed	0.00	28.80	28.80	57.60	86.40	115.20	0.00	0.00	0.00	0.00
Soybean seed	0.00	0.00	0.00	0.00	0.00	0.00	6.00	12.00	18.00	24.00
Vulgaris bean planting labor	0.00	4.80	5.84	6.98	8.43	10.21	0.00	0.00	0.00	0.00
Soybean planting labor	0.00	0.00	0.00	0.00	0.00	0.00	5.84	6.98	8.43	10.21
TOTAL VARIABLE COSTS	0.00	33.60	34.64	64.58	94.83	125.41	11.84	18.98	26.43	34.21
NET BENEFITS	588.68	935.40	991.89	1279.97	1797.81	1843.94	750.10	741.06	831.66	799.13
DOMINANCE ANALYSIS										
Treatments	1	7	8	9	2	10	3	4	5	6
Net benefits (MK/ha)	588.62	750.10	741.06	831.66	935.40	799.13	991.89	1279.97	1779.97	1843.94
Total variable costs (MK/ha)	0.00	11.84	18.98	26.43	33.60	34.21	34.64	64.65	94.83	125.41
Status (D=dominated and ND=nondominated)		ND	D	ND	ND	D	ND	ND	ND	ND
MARGINAL RATE OF RETURNS ANALYSIS										
Treatments	1	7	9	2	3	4	5	6		
Net benefits	588.62	750.10	831.66	935.40	991.89	1279.97	1779.97	1843.94		
Total variable costs	0.00	11.84	26.43	33.60	34.64	64.65	94.83	125.41		
Marginal rate of return		1363.86	559.01	1446.86	5431.73	959.96	1656.73	209.19		
RETURNS TO LABOR ANALYSIS										
Treatments	1	2	3	4	5	6				
Net benefits (MK/ha)	588.62	935.40	991.89	1279.97	1779.97	1843.94				
Variable labor time (hrs/ha)	0.00	22.81	27.81	33.14	40.14	48.61				
Marginal returns to labor (MK/hr)		15.20	11.30	54.06	71.43	7.55				
ABILITY TO FEED AN AVERAGE FAMILY (Assuming the family needs 920 kg maize and 292 kg vulgaris beans)										
Treatments	1	7	2	3	4	5				
Maize yield (kg/ha)	3104.20	3148.40	2510.06	2398.15	2999.66	2466.00				
Bean yield (kg/ha)	0.00	0.00	202.30	232.90	402.05	743.00				

NB: treatment 2 is the farmers' practice.
Treatment 7 and 9 are dominated in the malginal marginal returns to labor analysis.
m=not included in the treatment.

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