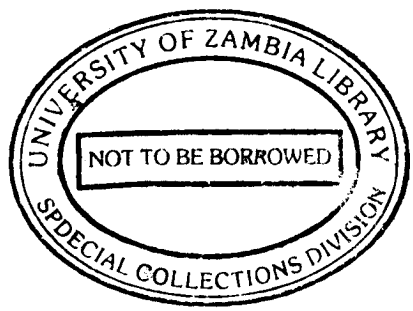
AN ASSESSMENT OF THE FINANCIAL VIABILITY OF INVESTING IN AN ANIMAL DRAWN RIPPER.

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A Thesis

Presented to the Department of Agricultural Economics and Extension Education of the University of Zambia.



By

Choolwe Hankuku.

In partial fulfillment of the requirement for the Degree of Bachelor of Agriculture Sciences

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LIST OF ACRONYMS

ADP	-	Animal Draft Power
GART	-	Golden Valley Agricultural Research Trust
ZNFU	-	Zambia National Farmers Union
CFU	-	Conservation Farming Unit
CF:	-	Conservation Farming
FSRP	-	Food Security Research Project
MACO	-	Ministry of Agriculture and Co-operatives
CSO	-	Central Statistics Office
FAO	-	Food and Agriculture Organization of the United Nations
NPW	-	Net Present Worth

ABSTRACT

AN ASSESSMENT OF THE FINANCIAL VIABILITY OF INVESTING IN AN ANIMAL DRAWN RIPPER

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There are two types of conservation tillage methods commonly used in Zambia- planting basins for hand hoe farmers and ripping for farmers with access to animal draft power and implements. Maize, cotton, soyabean, sunflower and groundnuts are among the major crops grown by the rural households and were hence considered in this study. Ripping requires some investment into the ripper. Purchasing a ripper is an investment in which financial resources are laid out and the resulting benefits flow over the life span of the implement. There is no study that has been done to demonstrate that buying a ripper or plough by smallholder farmers is a profitable investment decision. This study has attempted to carry out an investment analysis to determine if it is financially viable for small holder farmers to buy the ripper or the plough.

The study used secondary data from various sources. These data were analyzed using a mixed interger-programming model that was implemented using a c-plex solver in GAMS. Sensitivity analysis was conducted to determine which tillage method gave the optimal profit maximizing returns under various farmer situations.

The results from the analysis suggested that the ripper is more profitable than the plough. It was found that it is optimal to grow sunflower and cotton using the ripper. The resultant net present worth of cropping enterprises over the estimated 10-year lifespan of the implement is K 12,804,308. (US $3,201) in the base scenario. The results from analysis further suggested that labor in certain months of the year was constraining. Results of the analysis also show that capital is a constraint to increased production.

Since capital is a limiting resource, it is recommended that policy on agricultural credit should be formulated so that viable smallholder farmers can access credit in order to invest in implements like the ripper. It is also recommended that farmers should mechanize there operations with implements like the ripper in order to relax the labor constraint which most of them face.

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

In the early 1990's, Zambia experienced major changes in both the economic and climatic conditions. The economy of Zambia was liberalized and structural adjustment programs were introduced which meant several policies including agricultural policies were changed. Also in the same period, the country coincidentally endured severe droughts while the soil resource suffered from degradation. This threatened food security and the livelihoods of many farm households. One of the major contributors to this trend in soil organic matter loss has been intensive soil preparation with improper tillage implements such as the mould board (disc) plough where 100% of the soil is inverted. Other reasons for continuing soil degradation include deforestation, removal or burning of crop residues and inadequate crop rotations that do not maintain vegetative cover or allow restitution of plant nutrients. These practices leave the soil exposed to climatic hazards such as wind, rain and the sun.

In order to counter the effects of soil degradation caused by unsustainable practices, the ministry of agriculture and cooperatives together with other agricultural stakeholders such as GART, CFU, Dunavant, CLUSA etc have advocated for the use of conservation farming technologies that conserve the soil and at the same time increase yield. Conservation farming can be distinguished from conventional farming on the basis of minimum tillage, permanent soil cover and crop rotation (FAO, 2001).

Minimum tillage is any system of land preparation prior to seeding where the field is disturbed only in areas where the seed would be planted (Keyser and Mwanza, 1996). Animal draft power minimum tillage requires the use of special implements. In view of this, the ministry of agriculture research station in Magoye under Dutch funding developed the ripping equipment, commonly known as the Magoye ripper .The ripper makes rip lines in the soil where seed and other inputs would be placed thereby disturbing the soil as little as possible.

1.2 STATEMENT OF THE PROBLEM

Over the past few years, there has been much debate about conservation farming techniques and their benefits. There are two types of conservation tillage methods commonly used in Zambia – planting basins for hand hoe farmers and ripping for farmers with access to animal draught power and implements. While planting basins can be done with just a hand hoe, ripping requires some investment into ripping implements. Ripping, unlike planting basins, has the advantage of according the farmer the opportunity to increase the scale of operation. It is a form of mechanization.

Chilufya (2003) demonstrated that hiring the ripper is profitable in maize production. However, rippers are not readily available in the rural communities. Haggablade and Tembo (2003) were able to identify only five farmers with rippers out of 40 that they interviewed in central and southern provinces. GART, the promoters of the ripping technology, distributed only about 2000 rippers across the whole country. A more likely option that farmers wishing to rip their fields have is to purchase the implement.

Purchasing a ripper is an investment decisions which requires a financial outlay and whose benefits stretch throughout the life span of the implement. An immediate question is would such an investment be worthwhile for a small holder farmer? There is no study that has been done to demonstrate that buying a ripper by smallholder farmers is a profitable investment decision.

1.3 OBJECTIVES

1.3.1 General Objective

The general objective is to determine the financial viability of investment in the animal drawn ripper in the smallholder farming systems.

1.3.2 Specific Objectives

1. To determine the costs involved in buying and operating the magoye ripper and the plough.

2. To determine the financial viability of the animal drawn ripper relative to the plough.
3. To determine the optimal crop enterprise combination for the typical animal draft power based smallholder farming system.

1.4 HYPOTHESIS

1. Ripper is more profitable than the plough.
2. The optimal crop combination will include use of the ripper.
3. The net present worth of investing in animal drawn land preparation implements is positive in the small holder farming system.

1.5 RATIONALE

Lack of information on the financial viability of investing in the ripper deprives farmers the chance to make informed decisions regarding purchasing the implement and adopting the technology. Also various stakeholders and the promoters of the ripper technology need such information to know if the ripper is financially viable and to give the necessary support to the small holder farmers.

1.6 OGARNISATION OF THESIS

This thesis is composed of five chapters. Chapter one covers a brief overview of minimum tillage in Zambia, the statement of the problem, the purpose of the study and it's significance, the conceptual framework and the organization of the study. Chapter two contains the literature review. It highlights some of the previous studies and findings relevant to this study.

Chapter three consists of the research methodology of the study. It outlines the approach that was used to establish the results of this study that is it gives a description of the data that were collected and specifies the model that was used to analyze the data as well as the assumptions that were made. Chapter four presents the findings of the study and a discussion of the results. Chapter five forms the research summary and conclusion of the study and suggestions (recommendations) that will contribute to sustainable development of the country.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Over the past few years, there has been increased debate over the potential benefits of minimum tillage agriculture and other conservation farming practices. A review of literature on conservation farming practices shows that several authors have carried out quantitative and qualitative studies on conservation farming. This chapter reviews relevant literature on the agronomic and financial and economic benefits of conservation farming. It also reviews the major concepts underlying investment analysis which are used in this study.

2.2 FINANCIAL AND ECONOMIC BENEFITS

Keyser and Mwanza (1996) in their quantitative profitability comparative study showed that whole farm income can improve by between 45% and 65% through the use of minimum tillage and conservation farming techniques compared to full cultivation. However, this study was limited in that it was based on a rapid appraisal of only 28 farmers and it was location specific. Haggblade and Tembo (2003) pointed out that hand hoe conservation farming with basins generates returns per hectare 70% higher than conventional hand hoe cultivation while profitability of dry season ripping surpasses that of conventional ploughing. This indicates that both the ripper and basin variants of CF increase returns to peak season labor when compared to their conventional counterparts. Unfortunately, the study on the ripper had a short fall because only five out of forty farmers had rippers at the time the study was being carried out. Chilufya (2003) carried out a study whose objective was to determine the optimal combination and the profitability of hiring ADP for minimum tillage. The study revealed that it was profitable to grow maize using the ripper.

A comparative study of CF and conventional tillage in Wisconsin (Mueller *et al.*, 1985) found that short-run average costs under CF exceeded long-run average costs by about 7 percent. The short-run average costs per hectare for CFwere greater than for conventional tillage. However, after adjustments to capital, CF costs fell below those of conventional tillage in the long run.

Sorrenson (1997) compared the financial profitability of CA on 18 medium and large-sized farms with conventional practice in two regions of Paraguay over 10 years. He found that by the tenth year net farm income had risen on the CA farms from under US$10 000 to over US$30 000, while on conventional farms net farm income fell and even turned negative. These results were site specific and are liable to fluctuate widely from site to site.

2.3 AGRONOMIC BENEFITS AND OTHER TECHNICAL ASPECTS

The data available on conservation farming suggests that CF improve the yield of the adopters. Haggablade and Tembo (2002) pointed out that maize yield from basins was double that of conventional ploughing and 60% higher for cotton. Langmead (2001) also did a research on the intervention of conservation farming. The main objectives were to find out the impact interventions (sunnhemp, level dunds, vetiver grass, velvet beans, crop rotation improved fallow) had on yield/ha. The findings showed that SCAFE farmers achieved a relative incremental yield per hectare of about 80.37kg per ha. In Paraguay, yields under conventional tillage declined 5-15 percent over a period of ten years, while yields from zero tillage increased 5-20 percent (Sorrenson et al., 1997 and 1998).

Stevens, Samazaka and Wanders (2002) from their survey on the acceptance of the magoye ripper found that the magoye ripper seems to have been well accepted not only according to the number of farmers using it but also on the amount of ripping done. In 2001, 97% of the 58 respondents ripped an average of 2.8 hectares, which is significantly more than 0.25 hectares that the farmers were requested to do at the start of the program.

Chilufya (2003) conducted a profitability study on farmers growing a combination of crops using hired draft power and conservation tillage equipment. The study was made possible by using linear programming to determine the optimal or profitable combination of crops. Banda (2004) also used linear programming to compare the highest total farm income from adopters of weed wipe to that of non adopters and to come up with an optimal crop enterprise when using the weed wipe.

2.4 CONCEPTS UNDERLYING INVESTMENT ANALYSIS

The next section highlights the major concepts underlying investment analysis. It begins by reviewing the theoretical viability of the ripper compared to the plough and further reviews the approaches for assessing viability.

2.4.1 VIABILITY OF THE RIPPER VERSUS THE PLOUGH.

Purchasing a ripper by a smallholder farmer is an investment activity, which requires careful investment appraisal. The use of a ripper will enable the farmers to change from conventional farming practices based on ploughing to conservation farming technologies. For farmers to accept and adopt conservation farming technologies, it is essential to analyze how this new technology will affect their returns.

Unlike ploughing where the whole field is cultivated, ripping involves making rip lines in the soil only in areas where you would place your inputs thereby reducing the amount of labor required to prepare the land. Conservation farming also allows for precision in the placement of inputs because this is done directly in the ripped lines hence input application rate tend to be lower than in conventional ploughing.

It is recommended that ripping should be done in dry soils which enables the farmer to prepare the land early enough thereby allowing the farmer to plant in time. This allows farmers to take advantage of the first rains and to harvest their crops early when prices and demand for the crops are high. Conservation farming is also less vulnerable to drought because the technology allows for water harvesting and retains moisture. Even in times of drought, yields under conservation farming are significantly higher compared to ploughed plots.

However, with conservation farming, weed infestation is relatively higher and this demands more weeding labor to control the weeds, which would reduce yields if they were not managed in time. It has been shown that weed infestation reduces over time if farmers follow the recommended time of weeding. Also weed infestation decreases in subsequent years with repeated use of the plot. Conservation farming has the potential to minimize costs and risks as well as to increase yields.

2.4.2 APPROACHES FOR ASSESSING VIABILITY

Since investment in the ripper is characterized by costs and benefits that extend from the present to the future, there should be careful consideration of the time value of money (Gittinger, 1988). Discounting is the technique by which future benefit and cost streams are adjusted to their present worth. The net present worth which is the present worth of an incremental net benefit can be used as a decision rule. By this criterion, an investment is worthwhile if the NPW is positive.

Mixed interger programming offers a mathematical way of allocating scarce resources among competing activities. It can be employed to optimize the use of resources and thus help in decision making on what combination of farm enterprises to produce. The NPW can be used as an objective function in the optimization model. Gross margins from enterprise budgets are used to evaluate several enterprises.

Purchasing a ripper is an all or nothing phenomenon portrayed by an indivisible input element and is thus a special integer set with two elements zero or everything, that is, 1 if ripper is bought and 0 otherwise. Since some of the variables are continuous and others are discrete, this becomes a mixed integer-programming model. Therefore from the aforesaid, the study hypotheses were tested.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research methodology that was employed in conducting this study. It begins by specifying the model followed by a discussion on data, data sources and the assumptions made in conducting the study. A mixed interger-programming model was developed to analyze data that were collected in Lusaka, Chisamba and Magoye.

3.2 THE MODEL

It was assumed that the farmer's preference to purchase the ripper (plough) can be adequately represented by the net present worth (NPW) of investment, hence the NPW was used as a decision rule. The strength of mixed integer programming lies in its ability to model the decision to "buy" or "not to buy" the ripper as a discrete variable. The mixed integer mathematical programming model was specified as:

$$\text{Max NPW} = \left[\sum_{j=1}^{J}\sum_{k=1}^{K} P_j Q_{jk} X_{jk} - \sum_{i=1}^{n}\sum_{j=1}^{J}\sum_{k=1}^{K} R_i a_{ijk} X_{jk} - \sum_{m=1}^{M} wHLAB_m - \sum_{k=1}^{K} TAFC_k Y_k - RL * RENT - (1+BR) * FUND\right] * PVAF, \quad (1)$$

Subject to

$$\sum_{j=1}^{J} X_{jk} - CAP_k Y_k \le 0, \quad \text{Implement capacity constraints} \quad (2)$$

$$\sum_{j=1}^{J}\sum_{k=1}^{K} a_{ljk} X_{jk}\big|_{l\subset i\mapsto m} - LAB_m - HLAB_m \le 0, \quad \text{Labor constraints} \quad (3)$$

$$\sum_{j=1}^{J}\sum_{k=1}^{K} a_{pjk} X_{jk}\big|_{p=\{Capital\}\subset i} + \sum_{m=1}^{M} wHLAB_m + RL * RENT + \sum_{k=1}^{K} TAFC_k Y_k - CPAV - FUND \le 0, \quad \text{Capital constraint} \quad (4)$$

$$\sum_{j=1}^{J} a_{zjk} X_{jk}\big|_{z=\{Land\}\subset i} - LDAV - RLD \le 0, \quad \text{Land constraint} \quad (5)$$

$$\sum_{mz=1}^{MZ}\sum_{k=1}^{K} X_{mz,k}\big|_{mz=\{Maize\}\subset j} \ge MZLOW, \quad \text{Maize self-sufficiency requirement} \quad (6)$$

$$\sum_{m=1}^{M} HLAB_m \le HLABUP, \quad \text{Upper bound for hired labour} \quad (7)$$

where

NPW	=	the sum of the various Net Present Worth of the activities of an average agricultural season.
P_j	=	the per unit producer price of each commodity j using tillage method k.
Q_{jk}	=	Yield of commodity j using implement k
X_{jk}	=	the quantity of produced commodity j using tillage method k
LAB_m	=	Labor available in each month
$HLAB_m$	=	Quantity of hired labor in each month
w	=	wage rate.
RLD	=	Quantity of land rented
RENT	=	Land rental value
LDAV	=	Land Available.
CPAV	=	Available capital resource in ZMK.
FUND	=	Amount of borrowed money
BR	=	Borrowing interest rate
HLABUP	=	Hired labor upper bound.
MZLOW	=	Maize lower bound
R_i	=	prices of the resources
TAFC	=	Total annual fixed charge amortized over the life span of equipment using tillage method k to produce commodity j.

$$TAFC = AFC + OMA, \quad (8)$$

where

AFC	=	Annual fixed charge amortized over the life span of ripper OMA is the annual operating and maintenance costs.
a_{ijk}	=	quantity of the i^{th} resource such as land, labor and capital required to produce one unit of commodity j using tillage method k.
CAP_k	=	is the capacity of the tillage implement in a given agricultural season.
Y_k	=	is a binary variable, equal to 1 if farmer purchases tillage implements (ripper or plough) and 0 otherwise
PVAF	=	present value of an annuity factor defined as

$$PVAF = \frac{(1+r)^t - 1}{(1+r)^t} \quad (9)$$

The model consists three sets: set j, set k and set i. Set j is a set of crops maize, cotton, sunflower, soyabean and groundnuts. Set k is a set of land preparation implements implements and has two members i.e. the plough and the ripper. The set i is a set of resources- capital, land and labor. In this set, the labor resource is sub-divided by activity such land preparation labor, planting labor, fertilizer labor, spraying labor, weeding labor, harvesting, shelling and packaging labor. Usually more than one activity is performed by the farmers in each month e.g. spraying and weeding could be both done in January. Therefore, these labor activities were mapped onto months. This is shown in the model as: $l \subset i \rightarrow m$ where l is a set of labor which is a subset of the resource set i and is mapped onto the months (m)

Model (1) through (4) was solved using the CPLEX solver in GAMS

3.3 DATA, DATA SOURCES AND ASSUMPTIONS

This study uses secondary data from various institutions such as Food Security Research Project (FSRP), Central Statistical Office (CSO), Golden Valley Agriculture Research Trust (GART), Ministry of Agriculture and Cooperatives (MACO) and Zambia National Farmers Union (ZNFU), supplemented with personal communication with a number knowledgeable individuals. The data that were collected include prices for different crops, the amount of labor (in man days) required for the production of different crops, labor rate as well as the prices and quantities of other inputs such as seed, fertilizers, chemicals etc for different crops. These data were used to create crop budgets. Data were also collected on the quantity of the resource such as labor and capital required to produce one hectare of each commodity (e.g. maize, cotton etc). These technical input-output coefficients, a_{ijk}, were obtained from the Ministry of Agriculture resource guides and from studies carried out by Chilufya (2003), Chilufya (2000), and Mwape et al (2003). The estimates of input-output coefficients from al these sources were averaged to arrive at the input-output coefficient values used in this study.

Data were also collected on the prices and life span of the implements (ripper and plough). The annual maintenance cost of the implements was computed by obtaining the cost of each quick wearing and replaceable component of the implement such as the shear, tine and wheel. The cost was then divided by the life span of the component to get the annual cost of the replaceable component. Also other costs such as sharpening of the tine (shear), and oiling were included. The cost of the implement was amortized over its life span. The average interest rate 5% for an ordinary savings account was used if the farmer uses his equity and 30% interest was used if the farmer borrowed the money from the bank. The value of the cost was amortized in order to avoid charging the entire cost of the implement to a single year but rather distribute the cost of the implement over its useful years.

The amortization formula

$$P = \frac{R\left[1-(1+r)^{-n}\right]}{r}, \tag{9}$$

where

P = the present value of the machine.
r = interest rate.
N = number of useful yrs.
R = amortized value

3.3.1 LABOR

The majority of small-scale farmers depend on family labor to produce food and cash crops. It is assumed, following Mwape 2003 that household members work for about 5.5 days a week. Family members provide the labor in different amounts. On average there are 10 members of the family with a labor force of 5. According to (Mwape, 2003), the household has approximately 2.4 adult equivalent labor days per day. Therefore the household has a total of 52.8 adult equivalent days per month. However 3 household members are assumed to attend boarding school, each representing 0.9 equivalent workdays per day during the times that they are on school holidays.

Therefore, in April, August and December, the household is assumed to have 3.3 adult equivalent labor days per day and a total of 72.6 equivalent days per month.

It was assumed that the farmer could hire labor at an average wage rate of K5000 per man-day (MACO, 2005). The amount of additional labor that the farmer could hire was dependent upon the amount of capital available to the farmer to enable him to get this extra labor.

3.3.2 LAND

According to Mwape (2003), most rural households have adequate access to land to enable them to produce enough food and to provide for other family obligations. The available land for most smallholder farmers was taken to be 20 hectares. According to CSO(2004), a small holder farmer will grow between 0.25 to 20 hectares.

3.3.3 CAPITAL

Capital refers to the amount of money available for investment and purchasing of variable inputs needed to support the production cycle from land preparation to the time the product is sold. Sources of income for small holder farmers include; sale of previous crops, sale of livestock, piecework, gifts from relatives, borrowing from friends and financial institutions. According to the CSO living conditions report 2003/2004 (CSO, 2005), the monthly average expenditure on food by medium scale farmers is K514, 812 and K213400 is spent on non- food items .The capital available to cover expenses for agricultural inputs was assumed to be the money spent on non food items. This was estimated to be 12* K213,400 = K2, 561,316 per annum.

3.3.4 IMPLEMENT CAPACITY.

Two tillage implements were considered that is, the ox-drawn plow used for conventional tillage and the ox-drawn ripper for conservation tillage. It was assumed that the farmer had at least one pair of oxen and that the farmer had the option to use a plow or the ripper or both. For best results, it is recommended that ripping should be done in the dry season. Dry season land preparation extends from April to August. On the other hand the plow is used after the onset of the rainy season. Peak season or wet season land preparation in Zambia is the period from November to early January (Haggblade & Tembo, 2003). A ripper can do 1 hectare in 1 day while a plow tills 1 hectare in 2 days (personal communication, Samazaka, 2005). Therefore the capacity of the ripper for a given season can be estimated to be 150 hectares (150 days * 1hac/day) whereas the capacity of the plow can be estimated to be 45 hectares i.e. (90days * 0.5 ha/day).

According to survey data, the total life span of the implements was taken to be 10 years at which the implements were assumed to have a salvage value of zero.

Oxen are also used in weeding thereby saving weeding labor for other activities (Mwape, 2003) and (personal communication, Peter Aagard;2005). The land preparation and weeding labor components in the budget are based on oxen.

3.3.5 MAJOR CROPS

In Zambia, rural households produce various crops to enable them attain food security and to generate some income for other family needs. In the model five crops were considered i.e. maize, cotton, sunflower, soybeans and groundnuts. According to Mwape, (2003) these are the major crops grown by the rural households Maize is the major staple food of Zambia with 98% of the rural households producing maize for subsistence needs and the surplus is sold as a source of income (Mwape, 2003). Groundnuts are also widely grown among rural households. They are used in relish and for oil extraction, as they are a good source of protein. Most of the smallholder farmers also produce cash crops under various out grower schemes and these include cotton, sunflower and soyabean.

3.3.6 INPUT – OUTPUT COEFFICIENTS

The input-output coefficients used for this model were obtained from the Ministry of Agriculture resource guides and reports such as (Mwape, 2003), (Chilufya, 2000) and (Chilufya, 2003). To arrive at the coefficients, averages were calculated from the data extracted from the aforementioned secondary data sources. The labor coefficients indicate the man-days required producing one hectare of each enterprise. The labor coefficients are sub divided by activity: land preparation labor, planting labor, weeding labor, fertilizer labor, spraying labor, harvesting, shelling and packaging labor. The weeding labor coefficients required if the ripper is used were obtained by talking to key informants in various relevant organizations, such as CFU. According to conservation farming specialists at CFU, the weeding labor for farmers with adequate draft power is about half of the labor required if a hand hoe was used (personal communication, Peter Aagard; 2005). The coefficients for capital show the amount spent on other variable inputs in order to produce one hectare of each crop enterprise. (See Appendix 1).

3.4 DATA LIMITATIONS

The results of this study have some limitations. This is because of the difficulties that were experienced in obtaining data on the labor man-days for various activities. This led to the use of averages from the various data sources. The results are close to the truth because much effort was made to obtain data from several sources in order to come up with averages. These results are only applicable to farmers facing similar situations to the assumptions made in the model. Changes in yields obtained, producer prices and input prices will certainly alter the results. The study assumed that farmers would hire additional labor where family labor was constraining. However little is known about the labor market for rural households. Hence it was assumed that the farmer would hire as much labor as would his capital resources permit at the on going wage rate. These limitations however do not undermine the strength of mixed integer programming as a powerful decision making tool for resource allocation.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 INTRODUCTION

This Chapter presents the main findings of the study. The chapter begins by presenting the costs of the implements, that is, their purchase price and maintenance costs. It goes on to talk about the optimal crop combination and the resulting net present worth in various scenarios as well as the constraining resources.

4.2 PURCHASE AND MAINTENANCE COSTS

Purchasing a ripper or plow is an investment decision that requires careful planning and consideration of the purchasing costs and maintenance costs and returns associated with the implement. The current average price is K500,000 for the ripper and K465,000 for the plow. The maintenance cost per year for the ripper was estimated to be K25,365. This cost covers oiling, sharpening the tine once every season and replacement of the fast wearing parts (tine & wheel). The maintenance cost per year for the plow was estimated to be K45, 765 and this cost is attributed to oiling, sharpening of the shear once a year and replacement of the shear, mould board, and the wheel that wear out within a few years. All these cost components for the two types of implements are summarized in Table 1.

Table 1 Implement Purchase and Maintenance Costs (in Kwacha)

	Ripper	Plough
Purchase price	500 000	465 000
Maintenance cost		
1. Oiling	7 500	7 500
2. Sharpening	1 000	1 000
3. Tine/shear replacement	11 000	12 000
4. Wheel	5 865	5 865
5. Mould board		19 400
Total Maintenance cost	25 365	45 765

Source: Own survey Data.

4.3 BASE SCENARIO

The base scenario represents what is most expected of a typical smallholder farmer when he uses his own available resources. The farmer in this case does not hire any extra labor but rather uses his own family labor and he also does not borrow money from any lending institution or friends. The optimal solution under these assumptions is for the farmer to allocate 0.231 hectares to cotton production and 0.902 hectares of land to sunflower enterprise all prepared by ripping. No hectares of land are to be devoted to maize, soybean or groundnuts. The resultant net present worth of cropping enterprises under this resource allocation pattern over the estimated 10 year lifespan of the implement is K 12,804,308. (US $3201).

In the base Scenario, labor was found to be limiting in certain months of the year; June, July and the last two weeks of the month of January. Cropping activities that are mainly performed in June and July are harvesting, shelling and packaging as well as ripping. In the last two months of January, the major activities are weeding, spraying and fertilizer application. Considering that cotton and sunflower are the crops that come into the basis, it makes sense that labor be limiting in these months. Cotton demands a lot of weeding, spraying and harvesting labor. Sunflower also requires a substantial amount of shelling (winnowing) labor.

Land is not a limiting resource, which is in agreement with other prior studies (Stevens et al, 2002). Of the average assumed average land landholding size of 20 ha, only 1.13 is optimally allocated to crop production. The upper bound for the capacity of the ripper was not binding either hence the implement has excess capacity to enable the farmer to till more land. In his operations, the farmer only uses K414,440 to grow cotton and sunflower hence the farmer has surplus capital of K2 146 876. This capital could have been used to hire extra labor since it's the most limiting resource so that the farmer could increase his operations by using the additional hired labor.

4.3.1 BASE SCENARIO PLUS MAIZE SELF-SUFFICIENCY

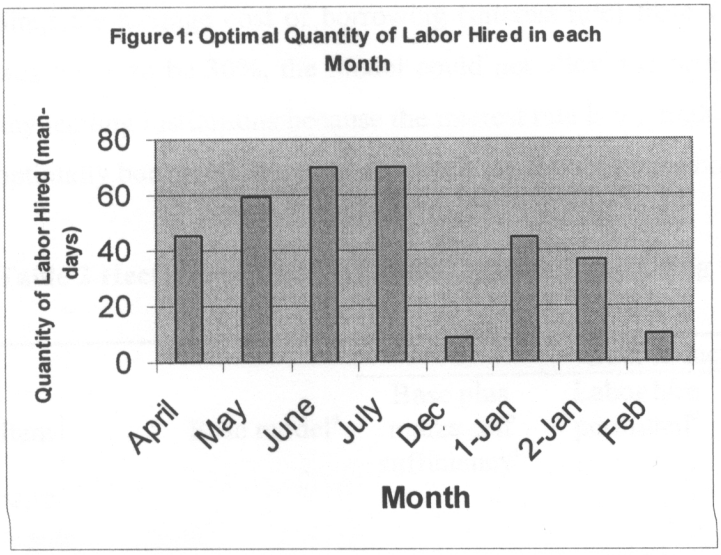
Most rural farmers regard maize self-sufficiency as a priority. To account for this, a maize self-sufficiency objective, a variant of the base model was run that imposed a Lima (0.25 ha) as the minimum land area allocated to maize. Under CF, a lima of maize is argued to be enough to feed a family of 6 for one whole year. With this imposed (equation 6), the resulting crop combination is 0.101 ha. Cotton, 0.818 sunflower and, of course, 0.25 ha. maize. Being a sub-optimal and, otherwise, forced solution, the objective function value drops by 2.7% to K12, 460,567. A total of 1.23 hectares of land and K521, 210 of capital are used up.

4.4 SENSITVITY ANALYSIS

4.4.1 LABOR HIRE PERMITTED

Since labor is the most limiting resource, the farmer is allowed to hire extra labor at the wage rate of K5000 (MACO, 2005). However little is known about the labor market for smallholder farmers. It was assumed that the amount of labor that the farmer can hire depends on the amount of capital available to the farmer for this purpose. From the available capital, the farmer hires 345 man-days and allocates 0.6 hectares of land to cotton and 2.01 ha to sunflower, both using the ripper for land preparation. The farmer hires labor in almost all the critical months of the year as shown in the figure below.

The resulting net present value is K17 644 741. The total amount of land used is 2.61 hectares, hence the farmer still has surplus land. However all the capital (K2 561 343) is used up, hence capital becomes limiting. Hiring additional labor enables the farmer to expand the area of operation. The net present worth increases by 37.8% from K12 804 307 in the base scenario to K17 644 741 when the farmer hires labor.



Note: 1-Jan and 2-Jan stand for first and second week of the month of January.

Source: GAMS output

4.4.2 LABOR HIRE PLUS MAIZE SELF-SUFFICIENCY

Allowing the farmer to be maize self-sufficient by forcing a Lima of maize into the basis and allowing him to hire labor will enable the farmer to devote 0.6 hectares of land to cotton, 1.708 hectares to sunflower and 0.25 hectares to maize. The resulting net present value is K17 336 449.87.This represents a 1.75% reduction, compared to the labor hire scenario. All the capital is used up and 332.7 man-days of labor are hired.

4.4.3 ASSUMING THE FARMER ALREADY OWNS A PLOUGH

There are some farmers who already own a plough. Such farmers could purchase the ripper attachment that costs K183 000, as opposed to purchasing the entire ripper. The optimal solution is to use 0.231 hectares of land on cotton and 0.902 on sunflower. This yields a net present worth of K13 121 307 representing a 2.47 % increase compared to the base scenario. As before labor is still a Limiting resource in June, July and the last two weeks of January. The total amount of capital and land used is K373 390 and 1.133 hectares, respectively. Capital and Land are not limiting.

Since the average cost of borrowing (interest rate) from various lending institutions was found to be 30%, the model could not allow the farmer to borrow capital from any lending institutions because the interest rate is too high. Hence no capital could be optimally borrowed. It would not profit the farmer to use borrowed capital.

Table 2 Hectares of Land Allocated to each Crop Using the Ripper

Item	Base model[a]	Counterfactual scenario			
		Base plus maize self sufficiency[b]	Labor hire permitted[c]	Labor hire plus maize sufficiency[d]	Farmer owns plough[e]
NPW Value K'million	12.800	12.460	17.640	17.340	13.120
% change from base	-	2.700	37.800	35.400	2.470
Crops (optimal)					
Maize	0.000	0.250	0.000	0.250	0.000
Cotton	0.231	0.101	0.600	0.600	0.231
Soya bean	0.000	0.000	0.000	0.000	0.000
Sunflower	0.902	0.878	2.010	1.708	0.902
Groundnut	0.000	0.000	0.000	0.000	0.000
Quantity of labor hired (manday)	0.000	0.000	345.000	333.000	0.000

Source: GAMS out-put

[a]Represents what is most expected of the farmer- no labor hired and no capital borrowed.
[b] farmer in the base scenario with a desire to be self sufficient in maize
[c] farmer can hire labor at the on going wage rate
[d]Farmer permitted to hire labor and to be self sufficient in maize.
[e] Farmer already owns a plough

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the conclusion of the study as well as suggests recommendations drawn from the study.

5.2 CONCLUSIONS

Conservation tillage methods have triggered significant enthusiasm among farmers, extension workers, researchers and policy makers. The two major tillage methods under conservation farming are pot holing and ripping. Ripping requires using a tillage implement (the ripper). Purchasing a riper is an investment decision that requires careful analysis. This study was designed to determine the financial viability of smallholder investment in the magoye ripper relative to the plough. The decision was modeled using the net present worth (NPW). If the NPW is zero or positive, then it is worthwhile to invest in the ripper. In addition if the NPW of the ripper is greater than the NPW of the plough, then it is more worthwhile to invest in the Ripper.

The mixed integer programming model resulted in a crop combination with a positive net present worth in all scenarios therefore it is worthwhile for smallholder farmers to invest in the ripper. If the farmer already owns the plough, the model suggests that it would be worthwhile for farmers to buy the ripper attachment. The fact that the plough does not come into the optimal solution in all scenarios implies that the ripper is more profitable than the plough. Further the model also showed that land is not a limiting resource but rather capital and labor are the limiting resources.

5.3 RECOMMENDATIONS

Since capital is a limiting resource to increased production, policy on agricultural credit should be revised in favor of smallholder farmers. No capital could be optimally borrowed by the farmers because the interest rates from lending institutions are too high.

Farmers should mechanize as much as possible that is farmers should use tools such as the Zamwipe, rippers, cultivators etc so that the labor constraint will be relaxed

A suggestion for future studies is to disaggregate labor by gender. This is because in reality men and women play different roles in agriculture production in the rural areas. This division of labor enhances specialization that could help to relax the labor constraint.

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APPENDICES

APPENDIX 1: INPUT-OUTPUT COEFFICIENT-RIPPER AND THE PLOUGH

Input-Output Coefficient-Ripper

	Maize .Rip	Cotton Rip	Sunflow .Rip	Soyabean .Rip	Groundnut .Rip
Land	1.0	1.0	1.0	1.0	1.0
Labrip	3.0	3.0	3.0	3.0	3.0
Labplow	0.0	0.0	0.0	0.0	0.0
Labplant	5.2	5.0	7.8	8.0	7.0
Labweed	20.0	22.0	18.0	28.0	22.0
Labfert	4.6				
Labspray		22.0			
Labharv	16.2	50.0	11.1	24.0	35.0
Labshell	16.2	00.0	26.0	24.0	57.0
Labpack	2.0	11.2	2.0	2.0	1.0
Capital	596045.0	271850.0	290000.0	646400.0	863040.0

Sources:

1. Rural household models in Zambia 2003
2. Profitability of Hired Animal-drawn Conservation Tillage Among Smallholder Farmers 2003

Input-Output Coefficients- Plough

	Maize plow	Cotton plow	Sunflow .plow	Soyabean .plow	Groundnut .plow
Land	1.0	1.0	1.0	1.0	1.0
Labrip	0.0	0.0	0.0	0.0	0.0
Labplow	8.0	8.0	8.0	8.0	8.0
Labplant	7.0	8.5	9.0	12.0	16.5
Labweed	14.0	16.5	10.0	25.0	20.0
Labfert	4.0				
Labspray		22.0			
Labharv	15.0	50.0	10.0	20.0	35.0
Labshell	15.0	00.0	24.0	20.0	57.0
Labpack	2.0	8.0	1.0	1.0	1.0
Capital	564545.0	268930.0	282000.0	635900.0	899440.0

Sources:

1. MACO Resource guides 1977
2. Rural household models in Zambia 2003
3. Profitability of Hired Animal-drawn Conservation Tillage among Smallholder Farmers 2003
4. Optimizsation of Crop farm Enterprise for Small-scale Farmers in Magoye 2000

APPENDIX: 2: YIELDS OF CROPS AND RETAIL PRICES OF OUTPUTS AND INPUTS

Yields Of Crops in Kg Per Hectare

	Maize	Cotton	sunflower	soyabean	Groundnut
Rip	2486	1905	1700	1543	1440
Plow	1468	1759	1500	1189	1600

Source: 1.MACO Enterprise budgets 2005
2.GART Year Book 2004
3.ZNFU Enterprise Budget 2003.

Retail Prices of Outputs and Inputs Used

Commodity	Unit	Unit price (ZMK)
White maize grain	Kg	720
Groundnuts	Kg	2000
Soya beans	Kg	1300
Cotton	Kg	1400
Sunflower	Kg	950
Maize seed (medium maturing)	Kg	6500
Sunflower seed	Kg	5000
Soya bean seed	Kg	5000
Groundnut seed	Kg	9000
Cotton seed	Kg	1800
Basal fertilizer (D compound)	50 kg	110000
Top dressing (urea)	50 kg	116000
Casual labor	Man-day	5000
Insecticide (thiodan)	Litre	40000
Herbicide (Basogram)	Litre	35000
Packaging	90 kg	3500
Furadan	Litre	40000
Folia fertilzer (solubar)	Kg	35000
Fungicide (Dimethoate)	Kg	11000

Sources: 1.AGRICULTURAL MARKETING INFORMATION CENTER (AMIC)
MACO
2. FARM BUDGETING HAND BOOK; FARM MANAGEMENT SECTION, MACO

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