This is to certify that the
thesis entitled

FACTORS AFFECTING SMALLHOLDER FARMERS'
ADOPTION OF SOIL AND WATER CONSERVATION
PRACTICES IN ZAMBIA

presented by

GEOFFREY NDAWA CHOMBA

has been accepted towards fulfillment
of the requirements for the

MASTER OF SCIENCE degree in Agricultural Economics

Major Professor's Signature

December 17, 2004

Date

FACTORS AFFECTING SMALLHOLDER FARMERS' ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES IN ZAMBIA

By

GEOFFREY NDAWA CHOMBA

A THESIS

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

MASTER OF SCIENCE

Department of Agricultural Economics

2004

ABSTRACT

FACTORS AFFECTING SMALLHOLDER FARMERS' ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES IN ZAMBIA

By

GEOFFREY NDAWA CHOMBA

Land and water for agriculture are scarce natural resources hence the promotion of good land management has taken center stage in Zambia. This study attempts to measure the factors that could be associated with the adoption of conservation farming practices considering that farmers have multiple practices to choose from and may adopt a given technology package in pieces.

Based on a 1999/2000 national representative sample, the study suggests that farmers may be using intercropping to manage risk in low rainfall areas whereas pot holing does not yet appear to be considered as a risk reduction option. The thrust of this study is that policy makers should strive to build human capital, while at the same time retain skilled farmers through reduced adult mortalities. Provision of extension services should concentrate in areas with relevant physiographical factors while infrastructure should be improved to minimize costs of delivering extension services and agricultural inputs.

DEDICATION

This thesis is dedicated to my wife Doreen and my little daughter Chomba. The patience they showed and the support they provided during the time I was studying up to the very end of writing this thesis was wonderful.

ACKNOWLEDGEMENTS

Many thanks and appreciation goes to the following institutions and individuals whom without their help and support, the successful completion of my study would not have been possible:

The Government of Zambia, particularly the Ministry of Agriculture and Cooperatives, for allowing me to study outside my country whilst keeping my job. The United States Agency for International Development (USAID) for the financial support they gave me for the whole period of my study. Without this help it would not have been possible for me to come all the way from Zambia (Africa) to come and study at Michigan State University (MSU). I also thank the Agency for facilitating in bringing my family over to the United States of America.

The Department of Agricultural Economics at Michigan State University (MSU), for offering me an opportunity to study in this country. I thank the Department especially for granting me assistantship through Food Security Research Project. This gave me an opportunity to meet and make new friends. More importantly, the knowledge I gained during my study will surely be beneficial to my country.

I would like to sincerely thank Cynthia Donovan who was my major professor during the write up of this thesis. I am so grateful for the advice and timely help she offered. I owe so much for the knowledge I gained and for her tireless effort in shaping this work. Many thanks go to John Kerr and Scott Swinton my committee members for the guidance and encouragement I received. Their guidance availed me an opportunity to widen my academic knowledge. The useful suggestions given are highly appreciated.

I extend my thanks to all the lecturers and students in the Department of Agricultural Economics, and all those individuals who supported me as pursued my studies.

Finally, I thank God for his wonderful mercies to enable me complete my study successfully.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BOZ	Bank of Zambia
CSA	Census Standard Area
CSO	Central Statistical Office
CIMMYT	International Maize and Wheat Improvement Center
CLUSA	Cooperatives League of United States of America
DAPP	Development Aid from People to People
EEOA	Economic Expansion in Outlying Areas
MACO	Ministry of Agriculture and Cooperatives
NGO	Non Governmental Organization
ORGUT	ORGUT Consulting AB
PHS	Post Harvest Survey
SCAFE	Soil Conservation and Fertility
SEA	Standard Enumeration Area
ZMK	Zambian Kwacha
ZNFU	Zambia National Farmers Union

CHAPTER 1

INTRODUCTION

1.0 Background of the Study and Problem Statement

Livelihoods of most of the rural households in Zambia are dependent on land. The smallholder[1] households comprise about 88% of the farming population of Zambia. The small householder farmers could further be classified into small-scale farmers and medium scale farmers. The former cultivate land area less than five hectares and comprise about 85% of the agricultural households whilst the latter group cultivate land area between five and twenty hectares and are about 13% of the agricultural households. Both these smallholder households largely use land for agricultural purposes, with an ultimate contribution of 60% to the value of national agricultural output (Saasa 2003). The land resource has been employed in varied proportions to meet both subsistence needs and/or cash needs. Principally the endowment related to soil types and the prevailing rainfall has had a bearing on the way the resource has been used. Farmers that live in high rainfall areas, where the soils are acidic, have generally tended to practice shifting cultivation while those that live in medium rainfall zone of the country have tended to practice semi-permanent hoe and ox plough farming systems. In addition, water shortage concerns in low rainfall areas have tended to lead farmers to water harvesting or moisture conservation methods.

---

[1] Smallholder farmers as used in this study covers both small-scale and medium-scale farmers of Zambia. See Chapter two for the definition of small and medium scale farmer.

Farmers have long recognized that land cannot be used without limit. They have before experienced a decline in land productivity necessitating some action on their part.

Traditionally the redemptive action has been through land-fallow practices or clearing new land areas (using a system commonly referred to as chitemene) or crop rotation (though in a limited sense of the word). However, with increasing land constraints in most areas, fallow periods have drastically declined from a range of 15-20 years to an average of 3 years (Kwesiga et al. 2003). The traditional farming systems that farmers have previously employed to sustain their productivity cannot any longer effectively work due to population pressure. It is now evident that in provinces such as Central and Southern Provinces where yield for maize used to be around 2.4 metric tones per hectare in 1981, the typical yield now is about 1.5 metric tones per hectare (Mulenga 2003).

Farmers have perceived a decline in soil productivity, and continued water shortages in low rainfall areas. They consider these problems to be a natural course, which cannot be avoided (Siachinji-Musiwa 1999). The effects of soil degradation and water shortages on crop productivity have induced researchers to introduce some innovative practices such as mulching, bunding, contour ridging, ripping, minimum tillage and others to check the downward spiral in agricultural production. Varied soil and water conservation practices requiring varied farmer inputs have been promoted among farmers for over a decade now (Chelemu and Nindi 1999; Haggblade and Tembo 2003 a; Mulenga 2003). In the early 1980s the emphasis by the Ministry of Agriculture and Cooperatives (MACO) and collaborating partners was on physical control measures such as soil bunds and contour ridges. Thereafter, the focus was on a combination of physical and biological measures (e.g. vetiver grass, improved fallow and bunds). During the latter part of the 1990s the focus shifted to land management and conservation farming.

According to studies on livelihood strategies, the rural poor when faced with limited resources adapt to environmental degradation by mitigating its effects or by rehabilitating degraded resources (Scherr 2000). With deterioration in land productivity due to soil degradation and erratic rainfall, which is also evident to farmers themselves, one would expect most farmers should have embraced the practices by now. Nevertheless, studies that have attempted to look at farmer participation in soil and water conservation practices[2] give mixed results ranging from 8% (Haggblade and Tembo 2003 a) to 48 % (Kwesiga et al. 2003).

The study conducted by Luputa and Malesu (1999) on utilization of water conservation practices indicate that less than 10 % of farmers had adopted rainwater-harvesting practices. The study on prevalence of conservation tillage practices, based on 1999/2000 post-harvest survey reported that 7.8 % small-scale farmers and 13% medium scale farmers were using planting basins (Haggblade and Tembo 2003 b). In the same year the study that looked at adoption of improved fallow in Eastern Province of Zambia found that 60,000 farmers, (approximately 48%) were following the practice (Kwesiga et al. 2003).

The percentage of farmers using the soil and water conservation practices is still low, especially when one considers that these studies have simply reported

[2] Some of the soil and water conservation practices that have been promoted in Zambia are improved fallow, planting basins, pot holing, planting of vetiver grass, ripping, soil bunds and terraces. A more detailed account of these and other practices not mentioned here is given in Chapter two.

elements of the total recommended packages. Faced with such low levels, one may be tempted to conclude that soil and water conservation practices are not profitable. Such doubts would be in direct conflict with the emerging evidence in the country, which demonstrates the benefits of soil water conservation. The appraisal study by Keyser and Mwanza (1996) conducted in Mumbwa noted differential income to the user of conservation farming techniques in the order of 45-60% over and above the users of conventional farming. Haggblade and Tembo (2003 b) stated that water basins were responsible for yield increments on average of 460 Kg per hectare among cotton growers in Mumbwa district and an incremental yield averaging about one metric tonne among maize growers in the same district. The returns to labor per hectare for the practice of minimum tillage were US $9.00 above the practice of conventional cultivation among maize farmers. The paper reviews of adoption of conservation technologies in Sub-Saharan Africa undertaken by Haggblade et al. (2004) also recognize the likely potential in financial incentives of soil conservation practices.

The foregoing situation where there is low adoption despite potential financial returns makes it necessary to further understand factors germane to adoption of soil and water conservation practices. Previous studies on adoption of soil and water conservation practices in Zambia have simply highlighted the proportion of farmers participating in conservation practices while those that have looked at factors influencing farmers have largely addressed the adoption issues as a binary choice and have largely concentrated on farmers participating in out-grower schemes or individual project-supported areas rather than an extensive area of the country. For now no known study has attempted to measure the factors that influence the adoption of soil and water conservation practices against the background that farmers have a multiple choice of practices.

1.2 Objectives, Rationale of Study and Key Questions

The overall objective of this study is to assess the adoption of soil and water conservation practices among small to medium scale farmers in Zambia from a perspective that farmers combine practices though they may not necessarily use all the practices in a given package. The specific objectives are:

1. To determine the factors which significantly influenced the use of soil and water conservation practices in 1999/2000 cropping season;
2. To assess whether farmers maintained the same soil and water conservation practices in 2000/2001 from the previous agricultural season.

The smallholder farmers have been experiencing declining yields due to land degradation. Their participation in maintaining and improving land resources require identifying some factors that could act as incentives. The farmer incentives have generally revolved around marketing related factors. It would be worthwhile to determine whether the incentives entailed by proximity to market, input and output prices can also have any effect on farmer decision to adopt conservation practices in Zambia. Moreover, farming systems have been determined by location. It is important therefore, that some insight is gained into what role location factors would play on farmer's choice of conservation practices. Equally important is the realization that farmers are always trying technologies. This being the case, it is important to understand potential changes in farmer use of conservation practices.

Appropriate improvement and corrective measures in promoting soil and water conservation can only be made when there is a way of determining critical factors for any given practice. Anything less than this may lead into unnecessary financial expenditures that could otherwise be avoidable. A better understanding of the factors that will condition adoption and possibly restrict the adoption of soil and water conservation practices would allow the formulation of well-tailored interventions that could result in rationalizing the scarce physical, financial and human resources that the nation most requires for use in other sectors of the economy. A better understanding could further facilitate close monitoring of conservation activities. Moreover, future related efforts in other areas with similar characteristics may be targeted with less difficulty and it would allow for prediction of the speed at which adoption of the practice to be introduced would likely take place.

The key questions that this study attempts to address are:

- What factors have been critical for adoption of individual and multiple soil and water conservation practices?
  - ✓ Do output and input prices act as incentives for the use of soil conservation practices in Zambia?
  - ✓ Does proximity to market matter for farmer's adoption of soil conservation practices?
  - ✓ Are farmers in the low rainfall areas more likely to use potholing and mixed cropping practices as a risk reduction strategy than other areas?
- Was there a significant change in farmers' use of individual soil and water conservation practices between 1999/2000 and 2000/01 agricultural season? What

factors could be associated with those who did not maintain the individual practices the following agricultural season?

1.3 Overview of the Thesis

This study is structured into eight chapters. The first chapter has given a brief overview of the problem this study is pursuing, and what it expects to achieve by the end of its discourse. The chapter that follows expands on the background of the study. It shows the importance of agriculture in Zambia and to the livelihoods of its rural population. It further discusses the relevance of soil and water conservation and how it has been induced by policy (market and others), and climatic changes. The chapter concludes by highlighting the type of practices that have been promoted and which research area this study focuses on. It is worth noting that this study refers to land management and agronomic practices that have a direct impact on ameliorating soil degradation as soil and water conservation practices.

Chapter three provides a behavioral model based on literature and economic theory. As much as is possible the discussion in this chapter specifically looks at practices focused on by this study. The chapter highlights the selection of the analytical framework to guide the selection of arguments to include in the analytical model for this study. It then explains the categories of theoretical variables and for each one it shows the empirical variables relevant to this research situation. It also gives a synopsis of the contribution of previous studies and literature on disadoption of soil and water conservation technologies among farmers and then closes up with a discussion on appropriate estimation models for this study. The fourth chapter follows on to discuss the data this study used and the empirical methods for this study's analysis.

Chapter five and Chapter six present results of the study interposed with very limited comments or observations. Chapter seven discusses the results and their implications and the last chapter makes some inferences based on the results and discussion of this study and it suggests future research efforts and makes policy recommendations aimed at enhancing conservation activities among small and medium scale farmers in Zambia.

CHAPTER 2

AGRICULTURE, SOIL AND WATER CONSERVATION IN ZAMBIA

2.1 Location

Zambia is a landlocked country located in the southern part of Africa. It is situated between latitudes 8 and 18 degrees South of the equator and between longitudes 22 and 36 degrees East. It has a land area of about 752,000 square meters.

2.2 Geographical Features and Climate

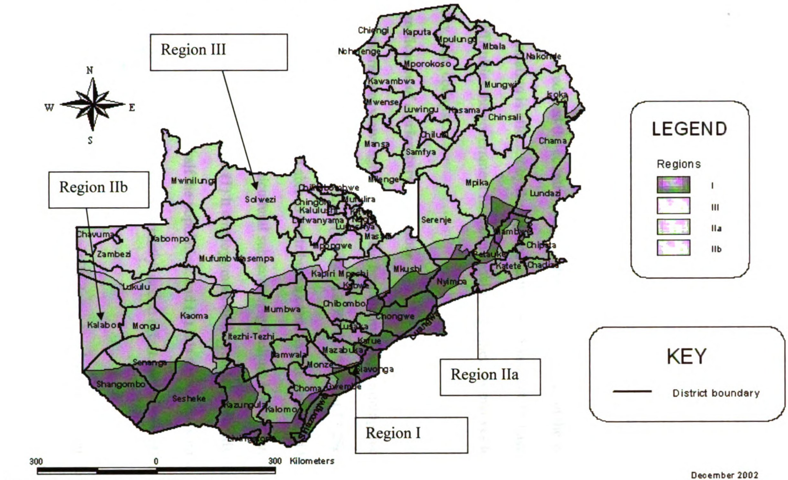
The country has three main topographical features namely (1) mountains with an altitude of at least 1500 meters above sea level; (2) plateau area with an altitude ranging from 900 to 1500 meters; and (3) low lands with an altitude of between 400 and 900 meters. There are three distinct seasons and these are:

- Cool and dry season from May to August;
- Hot and dry season from September to November; and
- Warm and wet season from December to April.

2.3 Rainfall and Vegetation

Zambia is divided into three major ecological zones. Zone 1 receives rainfall below 800 millimeters; Zone 2 receives rainfall between 800 and 1000 millimeters whilst Zone 3 receives rainfall above 1000 millimeters (Refer to Figure 1 for location of zones). The vegetation of the country is mainly savannah woodlands in high rainfall regions of the country and tropical grassland in low rainfall regions.

Figure 1: A Map Showing Agro-ecological Zones in Zambia



Source : Soil Survey, Mt. Makulu Chilanga

2.4 The Economy of Zambia

Zambia has been experiencing sluggish economic growth since the early 1980s. The mediocre performance of the economy has been attributed to the long dependence of the country on copper exports. Since the time copper prices failed to measure up to expectation at the London Metal Exchange, in the latter half of the 1970s, the government has been facing difficulties to cover its budget deficits. The recent closures of most of the manufacturing industries, the poor operational state of the mines and the escalating inflation rate have reduced the country to one of the poorest countries in the world. About 70% of the population is affected by the high poverty level (Saasa 2003). Faced with such economic difficulties the government has been looking for other alternatives to redeem the economy from collapse.

2.5 Significance of Agriculture in Zambia

The government views agriculture as the best alternative to mining due to its contribution to the gross domestic product (GDP) – 18.5% in 1995 and 17.2% in 2000 (BOZ 2003). The sector has been able to contribute a considerable amount of foreign exchange earnings through the horticultural subsector. Agriculture is important in Zambia because of the following reasons: (1) It employs most of the rural households and it is the primary source of food for half the population; and (2) It is a potential source of foreign exchange for the country, which is partly used to offset the balance of payments deficit.

The smallholder farmers in Zambia heavily depend on land and rainfall for their agricultural activities. This land is held in trust for the nation by the president, and people get it on lease for a period of ninety-nine years through the Ministry of Lands. Only very few smallholder farmers have land with title deeds while the majority of the people have customary use rights. They access land through the customary tenure system after getting approval of traditional rulers such as chiefs and headmen. Arable land covers 47% of the country's total land but only 15% of this land, which is approximately 7% of total land, is under cultivation (BOZ 2003). Most land lying in opened up areas is occupied but unexploited agricultural land, which generally is far from where minimal infrastructure is developed, still remains unoccupied. This has resulted in great pressure on cleared arable land by the fast growing population, which currently stands at 3.2%. Farmers are now constrained in their traditional practice of shifting cultivation (the fertility management methods are fully explained below) from the previous average period of 15-20 years to 3-4 years now. This period is not long enough for farmers to sustain their agricultural production.

The agricultural sector is composed of three categories of farmers. These are large-scale farmers, medium-scale farmers and small-scale farmers. According to the classification of Ministry of Agriculture and Co-operatives large-scale farmers comprising about 2% of the farmer population cultivate more than 20 hectares. They are generally characterized by high mechanization and have a well organized farmer network, which facilitates the acquisition of inputs. Medium-scale farmers, comprising about 13% of the farmer population, by definition cultivate a land area between 5 and 20 hectares. In the case of small-scale farmers (85% of farmer population), they cultivate land area that is less than 5 hectares.

There are five major farming systems that have been identified in Zambia. These are shifting cultivation, semi-permanent hoe system, semi permanent hoe and ox plough system, semi commercial cultivation and commercial systems (Saasa 2003). The smallholder households are mainly associated with the first four farming systems whilst the large-scale farmers are largely associated with the latter farming system.

- Shifting Cultivation System: This system has traditionally been practiced in Region[1] III (Zone III) where *chitemene* system (slash and burn) has been used (Refer to Figure 1). It has also been practiced in some medium rainfall regions where fallowing system has been used. The fallowing system involves leaving completely cleared and destumped fields unused for a period of 15 to 20 years (Kwesiga et al. 2003). The dominant crops have been maize, cassava, millet, groundnuts and beans. This system is unsuitable in the long run because of inadequate land to allow long fallow periods. The practice has seen some level of decline with the fertilizer subsidy support system that the Government introduced. The usage of fertilizer took the place of the burning of leaves previously used to improve soil fertility. The switch to fertilizer use, more especially ammonium nitrate exacerbated the acidic levels in the soils.
- Traditional system: This system is practiced in the lowest rainfall bracket of the country known as Region I hereafter referred to as Zone I (See Figure 1). The weather is generally unsuitable for crop production and it is prone to droughts or spurts of rainfall that cause floods and crop destruction. The dominant crops grown are sorghum and maize but the crop output in this region in most cases is low.

---

[1] In much of the later texts Regions I, II and III will simply be referred to as Zones I, II and III.

- The Semi-Permanent Hoe and Ox plough: This farming system is prevalent in Region II (Zone II) where rainfall ranges from 800mm to 1000 mm (See Figure 1). The dominant crops grown are finger millets, maize, cassava, groundnuts and beans. Livestock has been the major source of draught power though this has recently declined due to disease and droughts. The soil structure is generally good though the long usage of the same pieces of land have resulted in soil exhaustion. The farmers under this system are not able to counteract the effect of soil acidification due to various reasons some of which are unavailability of lime, or where lime is available, farmers lack knowledge or they do not have the finances to purchase it.
- Semi-Commercial Hole and Ox Plough System: The farmers falling in this category are mainly found in region II (See figure 3). The dominant crops grown are maize, groundnuts, cotton and beans. Livestock is the major asset for the farming activities and the farmers have equally been affected by the pestilence that attacked the animals. The farmers in this category have equally been dependent on fertilizer at the expense of other practices aimed at improving soil quality.
- The Commercial Farming System: This is characterized by well-developed agronomic management practices and intensive usage of mechanized farm equipment. The farmers implementing this system tend to mitigate the effects of soil acidification through lime application.

2.6 Relevance of Soil and Water Conservation

The need to promote soil and water conservation was induced by both economic and physical factors that became a common experience of the farmers. The late 1970s and early 1980s saw the heavy promotion of high yielding input practices such as fertilizer and hybrid seeds. Packaged inputs designed to cater for a quarter of a hectare were advanced to the farmers by the government. For enhanced results the recommendations discouraged mixing crops in the same field. With time farmers got used to subsidized inputs and guaranteed markets for outputs that offered pan-territorial, pan-seasonal prices. In recent years, the steady withdrawal of subsidies made fertilizer unaffordable to most of the farmers, and there is only a limited guaranteed market for maize grain.

Secondly farmers that in the past tended to rely on animal draught power experienced loss of animals in the early 1990s due to plague. Thirdly, compounding the problem of disease was the steady decline in the length of the rain season in Southern half of Zambia from an average period of 120 to 140 days, to less than 110 days, and the amount of rainfall in some seasons has been reported to be 30% to 40% below normal (Banda 2002). The country experienced severe droughts that affected the crop output in 1992/93, 1998/99, and 2001/02 seasons (see figure 1 below for the 2001/02 rainfall performance). The impact of these droughts has not only been felt in rainfall deficit provinces but also at national level as reflected by the pattern of the growth rate of GDP of agriculture and other related sub sectors (see Figure 2). The real growth rate of GDP for agriculture and related subsectors was poor during the years of severe droughts.

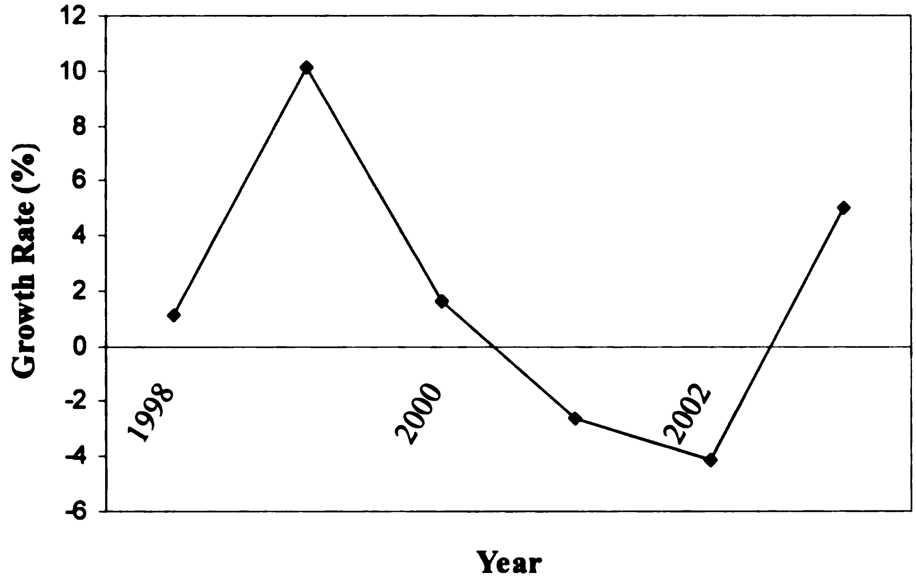
Figure 2: Rainfall Performance in Zambia in 2000/01

Source: Meteorological Department, Zambia; 2002[2]

---

[2] The Department presented this map to the National Early Warning Committee in Lusaka

Figure 3: Trend of Growth Rate of Real GDP (1994 Prices) of Agriculture, Forestry and Fisheries



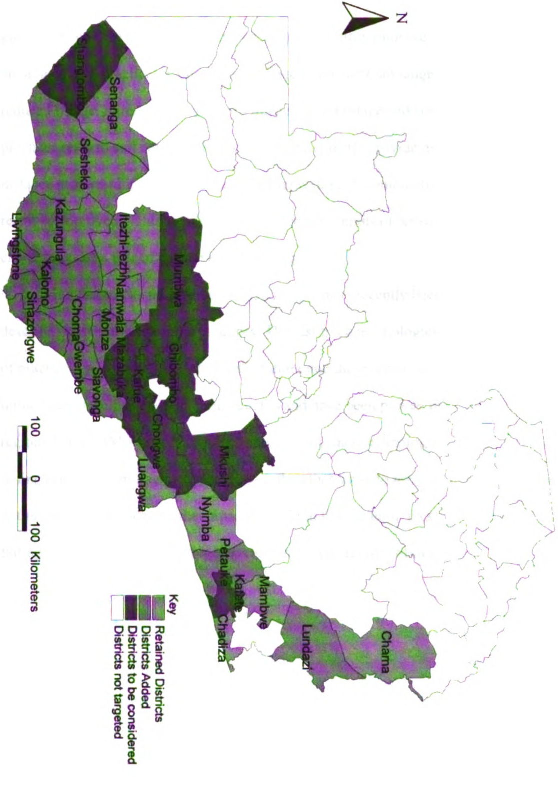
Source: Central Statistical Office, Ministry of Finance & National Planning; 2003 Lusaka.

Due to the above problems, agricultural development agents' interest in addressing the quality of soil through soil conservation practices was rekindled. The small household farming left unaided appeared to be the most vulnerable to the above problems whilst the large-scale farmers had recourse to some problems such as purchased inputs. In recent years the food situation has even been more worrying because Eastern, Southern and Central Provinces, which for a long time have been known to be surplus regions in field crops such as maize have now become targets for food distribution in disaster years. A primary example is shown in Figure 4 below for the fiscal year of 2002. After the regions were hit by the severe drought during the 2001/2002 rainfall season, almost all the districts from these provinces became targets of emergency food aid. According to the World Food Program report given to the

National Early Warning Committee in Zambia in July 2002, between April and July 2002, districts in Eastern Province received a total food tonnage of 5,390 while districts in Southern Province received a total food tonnage of 4,599. Mumbwa, Mkushi and Chibombo districts of Central Province were under consideration for food relief. Evidently the farmers have become increasingly vulnerable to the harsh environment surrounding them.

Against the background given above, land management and conservation farming activities have occupied a center stage in Zambian agriculture. Considerable assurances for policy support have even been provided to the agricultural sector to ensure that there is food security, and enough revenue is earned through exports. The government has reiterated that in its policy goals of agriculture it will ensure the resource base is maintained through sustainable practices by providing extension support services.

Figure 4: Targeted Districts for Extended WFP Emergency Food Distribution as of July 2002



2.7 Soil and Water Conservation Practices Promoted

There are many soil and water conservation practices that have been promoted by MACO and collaborating partners among farmers and they can be categorized into three groups: (1) conservation tillage practices, (2) soil fertility improvement practices, and (3) erosion control practices. Conservation tillage covers a broad range of practices such as reduced tillage, minimum tillage, zero tillage, mulch tillage and strip tillage. Soil fertility practices refer to soil conservation practices that directly provide nutrients to the soil, for instance crop residue through organic decomposition. A combination of practices that result in improved yields or reliability with reduced inputs of fertilizer or labor are captured under a title of conservation farming.

The fast track and medium track concepts have recently been employed to describe conservation farming practices. The fast track technologies refer to a sequence of practices, which must be done by the farmer and these recommendations give immediate as well as medium term benefits and have been proven in agro-ecological regions I and II (Mulenga 2003). Examples of fast track technologies are ripping and pot holing. The medium track technologies on the other hand do not give immediate response within the growing season; the impact is medium to long term. Examples of technologies falling in this category are cover crops and improved fallow (Mulenga 2003).

The practices that have been promoted in the country are summarized in Table 1 below.

Table 1: Soil and Water Conservation Categories Promoted Among Farmers

Soil Fertility Practices	Tillage Practices	Erosion Control Practices
Leave crop residue in field after harvest	Pot holing / planting basins	Level bunds / contour ridges
Crop rotation	Ripping	Terracing
Improved fallow	Zero Tillage	
Mulching		
Mixing crops in same field		

Source: Compiled based on Land Management and Conservation Farming: 1999-2002 Completion Report; MACO & ORGUT, 2003.

Physical control measures characterized by terracing, soil bunding and contour ridging began to be promoted by the early 1980s. A farmer would follow some of the practices depending on the topography of his/her farm. The following is a short description of the practices mentioned above:

- Soil bunding: This practice is where an embankment of earth is constructed across a slope to prevent soil erosion across the field. Contour ridging is technically the same as contour or soil bunding. Soil bunding helps in soil and water conservation on moderately sloped fields.
- Terracing: This is a practice of leveling land into layers to reduce runoff on a steep slope area. Terracing is commonly practiced on hilly places with a beneficial outcome of reduced water erosion of soil.

The above practices were largely promoted by MACO through a number of projects. In the early 1995/96, the Zambia National Farmers Union (ZNFU) began to promote land management and conservation practices (tillage and fertility enhancement practices listed in Table 1 with an exception of mulching) expanded on below. These practices were adopted by MACO as a priority practice in late 1999. The practices MACO promoted to start with in 1999 were based on the tillage practices of inverting the soil (MACO, 2003). This study will specifically focus on practices/ technology package adopted and promoted by ZNFU and MACO. It will analyze the practices as a technology package under the title of conservation farming, and also as sets of practices[3]. The latter refers to a situation where a farmer implements pieces of the technology package.

The three key elements (techniques) of the technology package of land management and conservation practices, also referred to as conservation farming, are crop rotation, minimum tillage (e.g. pot holing or ripping), and leaving crop residue in the field. These have to be combined with agronomic recommendations such as tilling land before the onset of the rains, establishment of precise and permanent planting stations or furrows or contour ridges and planting the seeds with the first rains. A brief description of these practices together with other related practices is given below:

- Leaving crop residue in field after harvest: This is the practice where farmers are encouraged not to burn the crop residues after harvest, with an exception of cotton and tobacco. Cotton and tobacco stalks are subject to the Rattoon Crop Agricultural Act, which is aimed at preventing breeding and pest build up. The rationale for leaving the residues is that the crop nutrients locked-up in the residue

[3] Conservation farming may be implemented in pieces. Each combination of the pieces is considered as a set.

should get back into the soil. The residue at the same time acts as a physical barrier to sun exposure of the soil. The residue also shields land from wind erosion, which ultimately reduces soil loss.

- Pot holing: This is a practice where a crop is planted in planting holes or basins, largely for the purpose of harvesting water. The practice also rationalizes the use of fertilizer, as there is proper targeting in the application of the input. This practice does not use conventional plowing and disturbs only a small percentage of the topsoil area of fields.
- Crop rotation: This is a practice of alternating crops of different families every year in a field in order to reduce incidences of crop diseases and pest attacks as well as contribute to improved soil composition. The crops alternated should make different demands on soil requirements. Farmers are in most cases encouraged to plant legumes after cereals for the purpose of nitrogen fixation in the soil.
- Mixing crops in one field: This is a practice of planting different crops in one field in the same row or ridge. This practice also referred to as intercropping may be used, depending on planting density and other inputs, for land-use intensification thereby confining land degradation and wearing effects to a less extensive area. It can also be useful to fix nitrogen into the soil when a legume is planted together with a cereal crop.
- Improved fallow: This is a practice of planting leguminous plants such as *Sesbania sesban* or *Leucana leucocephela* in a field for the purpose of restoring soil fertility. These plants help in the fixation of nitrogen in the soil.

- Only animal traction (Ripping): This is a management practice of breaking up a compact horizon that resists root penetration. This is done to a depth of 45 – 75 cm (18-30 in) with a special implement known as ripper. This practice avoids full soil inversion characterized by digging with hoe, ridging, plowing, disking and harrowing.

2.8 Study Area

The study area covers part of Zone I and Zone IIa. These are the districts where the conservation practices have been promoted as summarized in Table 2 with their respective agro-ecological zones indicated in brackets. They are the same districts that have particularly been experiencing declining levels of rainfall. Some districts such as Chongwe have an overlap of zones within the confinements of the district and hence the indication of both zones in brackets.

Table 2: Districts and Zones in Research Area[4] Where Soil and Water Conservation Technologies Have Been Promoted

Central / Lusaka Province	Eastern Province	Southern Province
Chibombo (IIa)	Chadiza (IIa)	Choma (IIa)
Kabwe (IIa)	Chama (IIa/III)	Gwembe (I/IIa)
Mumbwa (IIa)	Chipata (IIa)	Kalomo (IIa)
Kapiri Mposhi (IIa /III)	Katete (IIa)	Kalomo (IIa)
Chongwe [5](I/IIa)	Lundazi (IIa)	Livingstone (I/IIa)
	Mambwe (I/IIa)	Kazungula (I/IIa)
	Nyimba (I/IIa)	Mazabuka (IIa)
	Petauke (IIa)	Monze (IIa)

[4] Chongwe District and Gwembe District were incorporated in 1997

[5] Chongwe is the only district from Lusaka Province

CHAPTER 3
CONCEPTUAL FRAMEWORK

3.1 Behavioral Model of Adoption

Adoption of agricultural practices is one of the subject areas that have been heavily researched globally. However, as Ervin and Ervin (1982) and Feder et al. (1985) note, most of the studies related to adoption of conservation practices have simply used farm and farmer characteristics without providing the rationale for their inclusion based on theory. Some studies such as Swinton and Quiroz (2003 a; 2003 b), Marra (2001), McConnell (1983), Ellison and Fundenberg (1993) and Norris and Batie (1987) have attempted to highlight the economic theory underlying farmer behavior in decision-making over conservation practices. McConnell (1983) used production theory where a farmer has an objective to maximize profit; Ellison and Fundenberg (1993) employed a version of innovation diffusion whereas studies such as Swinton and Quiroz (2003 a; 2003 b) Marra et al. (2001), and Norris and Batie (1987) used household model based on utility maximization.

In order to adequately determine factors that influence farmers to adopt soil and water conservation technologies, the focus of the adoption analysis needs to go beyond the characteristics of farmers and plots of land (CIMMYT 1993). A farmer should be regarded as both a producer and a consumer (Sadoulet and de Janvry 1995). This implies that a farmer takes into consideration "current consumption and production ends" (Reardon and Vosti 1997a; Clay et al. 2002), and also policy and physical effects (CIMMYT 1993; FAO 2001 a). The consumption needs are satisfied through own production though at times they are met through food purchases. Farmers make purchases using cash from crop sales or off-farm earnings. The need for cash is not only for food but also for other household requirements such as health and education.

A farmer may react in a number of ways towards declining production or/and variability in production that undermine consumption needs. Existing practices may be modified or new ones may altogether be adopted (FAO 2001 b). A farmer may here depend on information diffusion from external parties to learn about a new technology (Shaw 1985; Ellison and Fudenberg 1993; Knox et al. 1998; Marra et al. 2001). Before investing in a soil / water conservation practice brought to a farmer's attention, he/she looks at the monetary incentives, whether the capacity is there to implement the practice, and what constraints he/she is facing (Ervin and Ervin 1982; Reardon and Vosti 1995; Clay et al. 2002).

One of the major concerns of a farmer is how long he/she has to wait before getting the benefits of soil and water conservation investment (Reardon and Vosti 1997 a; Field 2001). Soil and water conservation practices have different wait periods hence the perceived returns may be slower than the immediate impact of inputs like fertilizer (Barlowe 1978; Reardon and Vosti 1997 a). Most farmers in developing countries have high preference rates whereby today's consumption of resources is more valuable than the future's consumption (Field 2001). As the challenge for developing countries concerns farmers' potential for mining out the soil vitality to attain short-term gains (Field 2001), farmers in Zambia are likely to have great preference for conservation practices that yield benefits in the shortest time possible. This desire for short term benefits also implies that land use rights that do not give a sense of permanency may promote conservation practices that yield benefits in short term (Shiferaw and Holden 2000; Gebremedhin and Swinton 2003).

More still, farmers tend to be conscious about uncertainties that may arise from both the physical environment and a new technology (Knox et al. 1998). Farmers in such a situation may feel more comfortable to continue with current practices despite noticing a decline in soil productivity (Reardon and Vosti 1997 b; Siachinji-Musiwa 1999). They regard such behavior as risk reduction strategies.

In view of the above discussion, the study's approach about the decision-making behavior of Zambian farmers in adoption of practices under consideration are made based on the following assumptions:

- The farmer's primary objective is to be food secure;
- The farmer wants to generate farm revenues to meet household cash obligations;
- The farmers are risk averse hence farmers living in geographical areas with erratic rains want to reduce risk as much as possible and thus those soil and water conservation practices that have a quick effect on productivity and reduce yield variability are more appealing to them;
- The farmers are discouraged to engage in land management practices due to input and output price variations, poor accessibility to output and input market, and poor flow of information (e.g. on technologies, markets and cropping practices) brought about by poor infrastructure;
- The farmers face constrained resources in land, labor, management skills and capital hence activities and practices that ameliorate the pressure on these resources are more appealing to farmers. It is specifically assumed that the most critical resource

constraints among Zambian farmers are management skills and capital.

This study considers farmer behavior in the adoption of conservation farming or any piece of the technology package within the analytical framework discussed above and the incentive and capacity paradigm employed by Clay et al. (2002), and Reardon and Vosti (1997 a). A farmer is regarded as a consumer and an investor hence an investment model that yields utility over time to a farm household is employed. The conceptual model for investment in conservation farming or any piece of the technology package highlights that the farmer pursues consumption and production ends conditional on expected investment returns and other conditioning variables and thus the model is specified as:

$$\text{Max } E_0\left[\int_t U.dt\right] = E_0\left[\sum_{t=0}^{T}\frac{1}{(1+r)^t}\pi_t\right];\Theta \quad \text{..(i)}$$

s.t. $\pi_t = P_t^e Y_t - w_t X_t - FC - i_t$

$$Y_t = f(X_t; Z_t)$$

Where E_0 = Expectation at time 0;

P_t^e = Expected output price at a future time t;

X = a vector variable of inputs;

w = price of inputs;

FC = fixed costs;

i = investment efforts in soil and water conservation;

r = time preference rate for investment;

Θ = farmer risk perceptions about technology;

$f(X_t;Z_t)$ = production function of crop output, which is conditional on soil quality among others. The quality of soil is itself affected by investment efforts in soil conservation; and

Z = a vector of conditioning variables.

The first order condition, FOC: $$P_t^e \frac{\partial f(X_t;Z_t)}{\partial X_t} - w_t = 0$$

The factor demand function reflecting the financial and physical incentives and other capacity factors could generally be stated as:

$$X = X^*(P_t^e, w_t; Z_t) \quad \text{(ii)}$$

The demand for a factor of production is dependent on the expected price, the price of inputs and the conditioning variables.

Going by the same logic depicted in equation (ii) to derive the demand function for a factor of production, and bearing in mind the time horizon for investment, the decision rule guiding the conservation investment effort a farmer would undertake is described by the following function:

$$i = i(P_t^e, P_{t+1}^e, \ldots\ldots P_{t+n}, w_t; Z_t) \quad \text{(iii)}$$

The function states that farmer decision to invest in a given set of soil and water conservation practices is dependent on the future expected output prices at time t, t_{+1}, t_{+2}, ….,t_{+n}, input prices and conditioning variables (e.g. physical constraints, and capacity factors).

3.2 Factors Included in the Model and Expected Effects

In order to explain the factors included in the conceptual model and particularly the expected effects on the outcome, guidance from literature was sought. According to available literature the decision to adopt pot holing as a conservation tillage practice in Zambia was positively associated with the distributor that practiced pot holing (Haggblade and Tembo 2003 b). Empirical studies of conservation tillage in other areas have indicated mixed results with some showing a positive correlation between farm size and conservation tillage while others have shown a negative correlation (FAO 2001 b).

Although there is no known study that has been conducted to explain the adoption behavior of farmers regarding the practice of intercropping in Zambia, the empirical studies elsewhere were used to predict the likely behavior of farmers with respect to this practice. The works of Reardon and Vosti (1997 b), Jalloh (2001) and also Knox et al. (1998) state that the practice of intercropping is likely to be followed by those who are risk averse. Moreover, according to the study of Rajasekharan and Veeraputhran (2002) in Kerala, India, the decision-making behavior of farmers in adoption of this practice was significantly and positively influenced by the availability of family labor and the perception of the profitability of intercropping.

In the case of conservation farming or pieces of this technology package, there seems to be very little known about their use in Zambia. The light shed elsewhere on these practices by Sayre et al. (2001) indicate lack of information on the practices, and demand for crop residue as fodder are cited as greatly influencing the joint adoption of tillage, crop rotation and crop residue management among farmers of Altiplano of Central Mexico.

The specific broad categories of factors used in this study are explained below based on other experiences other than Zambia.

Incentives

The factors associated with monetary incentives are output prices, input prices, and access to markets (Reardon and Vosti 1997 a; Malla 1999; Sanders and Cahill 1999; Bekele 2003). The literature review of Shiferaw and Holden (2000) indicates that the impact of the increase or decrease in commodity prices is unclear. This study however anticipates increase in output prices would enhance the practice of monocropping due to farmers' desire for short-term gains (Table 3). Output prices are expected to positively influence farmer's use of pot holing, as a conservation tillage practice, in line with Bekele's (2003) findings among farmers in Ethiopia. It is here assumed that a farmer would only make an effort to go for all the practices if the package is anticipated to "increase the profitability of farming through higher prices" (Shiferaw and Holden 2000).

Increase in input prices such as fertilizer would positively influence farmers to use intercropping it being a fertility enhancement technology. Increase in fertilizer prices is also expected to negatively influence farmer's choice for pot holing or conservation farming in line with Shiferaw and Holden (2000) findings.

Easy access to the market creates an enabling environment for timely acquisition of inputs, and reduced market transactions. Price effects arising from reduced market transaction costs are expected to negatively affect intercropping. In the case of pot holing and conservation farming practices easy access to market is expected to have a positive influence on the farmer's choice of the practice (Sayre et al. 2001).

Physical Constraints

The factors associated with physical constraints are physiographical factors of the farm parcel, and climatic factors such as rainfall (Ervin and Ervin 1982; FAO 2001 a; Clay et al. 2002). The physical constraints are expected to have varying effect on conservation practices being studied. Pot holing is expected to be positively associated with low rainfall during the previous season and locations that generally experience low rainfall (Haggblade and Tembo 2003 b; Mulenga 2003). Along the same logic indicated by Reardon and Vosti (1997 b), this study considers intercropping as a risk reduction strategy and as such low rainfall the previous season is expected to positively influence farmer's choice of intercropping. Similarly, all locations associated with low rainfall are expected to have a positive impact on farmers' choice of intercropping. In the case of conservation farming, low rainfall in the previous season is expected to have a positive influence whereas those zones with low rainfall are expected to have either positive or negative influence on farmer's choice of the practices. The effect may be negative if the farmer places a high opportunity cost on crop residue as fodder (Sayre et al. 2001).

Capacity Factors

The conditioning variables that give a farmer the capacity to act are assets related to human, natural and cultural capitals (Bebbington 1999), which are simply referred to as household resources and management ability in this study. Management ability improves with experience, level of education and farmer training (Manyong et al. 1999; FAO 2001 b; Clay et al. 2002; Place et al. 2002; Haggblade and Tembo 2003 b). Farmer experience is expected to have a positive relationship with intercropping being a traditional practice but a negative relationship with pot holing or minimum tillage or conservation farming, which are non traditional practices (Clearfield and Osgood 1986). Farmer training and increase in farmer education are expected to improve farmer adoption of conservation farming. On the other hand, more educated farmers are less likely to adopt intercropping since the practice had in the recent past been less preferred for pure crop stands by crop researchers (Jalloh 2001).

Household resources such as labor inputs are negatively associated with reduced tillage (FAO 2001 b; MACO and ORGUT 2003). Nevertheless, the dynamics of the practice of pot holing with respect to labor is a bit complex. The labor requirements during the establishment stage of pot holing could be double the labor requirements during later stages on the same piece of land (Haggblade and Tembo 2003 b). This being the case, the relationship between the practice of pot holing and labor is expected to be positive or negative depending on the stage of establishment (Table 4). The same relationship is expected with conservation farming as pot holing or reduced tillage is one of the elements of the technology package.

The household resources pertaining to land ownership, farm size, off-farm income and livestock or farm implements have varying capacity effect on farmers. A sense of temporal use rights is expected to be positively associated with the use of pot holing which is considered as a fast track technology. Large farm size gives a farmer the capacity to use land intensive conservation practices (elements) such as improved fallow and crop rotation (Thangata et al. 2002) hence the farm size may be positively associated with conservation farming (Table 4). It may also be positively associated with the use of intercropping at household level as farmers may simply engage marginal land to maintain the initial plant population before engaging into intercropping.

The expected average effects of adopting intercropping, pot holing or conservation farming compared with pre-adoption levels on input needs and output levels are summarized in Table 3 and Table 4, respectively. The effect of intercropping on labor would be positive or negative depending on type of crops that are intercropped. If one of the crops is a cover crop, the growth of weeds may be restricted resulting in decreased labor requirements during weeding. In some other cases crops may have different maturity periods. This may demand household labor at different periods of time, which may sometimes be cumbersome. The effect on land is likely to be positive assuming that the farmer's desire is to maintain the plant population equivalent to pre-adoption level.

Table 3: Effects Expected From Switch to Intercropping Practice

Item	Expected Effect [a]
Inputs:	
• Labor	-/+
• Land	+
• Fertilizer use	-
• Tillage equipment use	0
Output Production (Total)[6]:	
• Maize	-
• Other crop	-

a/ + = Increase; 0 = no change; - = decrease

The effect on fertilizer use is negative since intercropping is considered as one of the fertility enhancing practices. This implies that if the price of fertilizer goes up, farmers may likely implement intercropping. Maize output or any other crop would go down because of reduced plant population (Table 3). This implies that if maize price goes up, a farmer may be inclined to implement monocropping, which increases plant population.

The expected effect on land may be either positive or negative depending on size of the farm. With use of pot holing, it may be possible to cultivate big land area but the adverse effect of weeding may make it laborious to implement the practice. So more land

[6] It is assumed that land area is fixed before and after adoption of the practice

is expected to be demanded depending on stage of implementation. The expected effect on labor as presented in Table 4 has already been discussed.

Table 4: Effects Expected From Switch to Pot holing or Conservation Farming

Item	Expected Effect [a]
Inputs:	
• Labor	-/+
• Land	-/+
• Fertilizer use	-
Output Production (Total)[7]:	
• Maize	+
• Other crop	+

a/ + = Increase; 0 = no change; - = decrease

Hypotheses

Based on key questions raised in the first chapter of this study, the assumptions made about adoption behavior of smallholding farmers and the discussion made in this section, the following hypotheses are made:

1. Farmers living in more arid areas are more likely to use intercropping and potholing as risk reduction strategies than farmers living in higher rainfall areas;
2. Fast track soil and water conservation practices such as pot holing are more attractive to farmers who do not own land;

[7] It is assumed that land area is fixed before and after adoption of the practice

3. Increased prices of maize output act as an incentive to farmers to use conservation farming practices (except intercropping) so that they could continue to reap the benefits of farming;
4. The closer the farmer is to district town the more likely the farmer implements soil and water conservation practices due to anticipated cash benefits, and easy contact with agricultural development activities including credit and extension dissemination programs;

3.3 Behavioral Model of Technology Disadoption

It is a common experience that at times farmers try some conservation practices and abandon them to try others or simply revert to old practices (CIMMYT 1993; Fernandez-Cornejo et al. 2002; Haggblade and Tembo 2003 b; Kwesiga et al. 2003). There are also cases where farmers modify the practices, which in a sense may be abandonment (CIMMYT 1993; Mulenga 2003). For now, there appears to be little literature that covers the study of disadoption of soil and water conservation practices to guide on the underlying behavior of farmers. Highlights from Marra et.al (2001) on disadoption of Bt cotton based on farmer practices in one season and the farmer's planned practices in the coming season seem to suggest production losses or financial losses, may lead into abandonment of a given practice.

In spite of the paucity of studies that pinpoint specific factors that lead farmers to abandon soil and water conservation technologies, suggested key factors affecting retention of conservation practices are withdrawal of subsidies designed to support conservation efforts (Pagiola 1999), forcing unwanted technologies on farmers, tying incentives such as credit services to technologies farmers have previously not adopted and creating an environment where farmer contribution to a conservation technology is insignificant (Kerr et al. 1999). Other literature has pointed out that good land management practices are likely to last only in places where incentives created are accompanied by good general conditions such as improved marketing opportunities and increased non-agricultural employment opportunities (Nibbering 1999).

This study considers that farmers may experiment with a new practice on a small scale while still carrying on with the old practice on a larger scale (CIMMYT 1993; Haggblade and Tembo 2003 b; Kwesiga et al. 2003) form the basis for comparison between the old and new technology. When the farmer perceives that utility derived from the new practice denoted as *Un* is lower than the old practice, denoted as *Uc,* the farmer abandons the new practice (Fernandez-Cornejo et al. 2002). Since utility is unobservable to the analyst due to unobserved alternative attributes, unobserved individual attributes, measurement errors and proxy variables, the utility associated with alternative *n*, for individual *i* is modeled as a random variable:

$$U_{ni} = V_{ni} + e_{ni} \qquad \text{(iv)}$$

where V_{ni} is the deterministic component and e_{ni} is the random component of utility U_{ni}.

Given two alternatives c and n, the probability that alternative n is abandoned is:

$$\begin{aligned} \text{Prob (n = 1)} &= \text{Prob}[Un \leq Uc] \\ &= \text{Prob}[V_{ni} + e_{ni} \leq V_{ci} + e_{ci}] \\ &= \text{Prob}[V_{ni} - V_{ci} \leq e_{ci} - e_{ni}] \end{aligned}$$

The observer simply sees whether a farmer continues a given practice or not. In this study it is assumed that the error terms follow a logistic distribution.

The estimator models employed to understand factors influencing the adoption of conservation farming practices and related pieces, and disadoption of technologies in Zambia are discussed in the chapter that follows.

CHAPTER 4

EMPIRICAL METHODS AND DATA

4.1 Data

The data were obtained through countrywide household post harvest surveys (PHS) in Zambia during the years 1998/1999[8], and 1999/2000. In addition, the data from 1999/2000 Supplemental Survey (SS), which followed up all the respondents, who had been interviewed during the 1999 /00 PHS, have been used. The 1998/99 PHS and 1999/2000 were conducted as cross-section surveys between August and September in 1999 and 2000, respectively conducted by the Central Statistical Office (CSO) in conjunction with the then Ministry of Agriculture, Food and Fisheries (now called MACO). The 1999/2000 Supplemental survey was conducted by CSO in collaboration with Ministry of Agriculture and Cooperative, and Food Security Research Project of the Agricultural Economics Department, Michigan State University in 2001 between June and August.

To select the households, a sample of 407 Standard Enumeration Areas (SEAs) was drawn using probability proportional to size sampling scheme. The number of households located within each SEA determined the measure of size of the SEAs. The area-sampling frame employed was as per the 1990 Census of Population, Housing and Agriculture. Each sampled SEA had a list of households from where farming holdings were selected. The selection of farming holdings took into consideration categories of

---

[8] This dataset was only used to extract the crop output price

farmers based on land area and livestock. The surveys' sample sizes with their respective response rates are indicated in the Table 5.

Table 5: Sample size of Household Surveyed

Year	Sample Size	Response	Response rate
99/00	7859	7699	98%
SS 99/00	7700	6922	90%

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

For the purpose of this study, Chipata, Katete, Lundazi, Petauke, Chadiza, Mabwe, Nyimba, Chama (all from Eastern Province), Chongwe (Lusaka Province), Choma, Gwembe, Mazabuka, Monze, Kalomo, Livingstone/Kazungula (all from Southern Province), Kabwe, Kapiri Mposhi, Mumbwa and Chibombo (all from Central Province) just as also indicated in Table 2, were used to analyze the conservation practices ZNFU and MACO have been promoting. The sample size and response rate from the districts this study focused on are as shown in Table 6 below.

Table 6: Sample size of Household Surveyed in Selected Districts

Year	Sample Size	Response	Response rate
99/00	2844	2825	99%
SS 99/00	2826	2581	91%

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The effective sample size that this study finally worked with after dropping out some cases that had incomplete responses to some variables of key interest was 2524 households of which 2,068 were small farms and 456 were medium farms.

The questionnaires were used as instruments to collect data, with a single visit. Farmers were asked whether they practiced a given soil / water conservation practice to which a yes or no answer was given. The questions soliciting farmer practices about soil and water conservation practices were closed as there was no room for farmers to say anything more than the prescribed yes/no answers. The soil and water conservation practices covered during the 1999/2000 supplemental survey (SS) were mixing of crops in one field; improved fallow; pot holing / planting holes; crop rotation; leaving crop residues; and other minimum tillage. The main focus for this survey was on conservation farming practices.

With the return visit in 2001, the supplemental survey attempted to determine soil and water conservation practices followed by each individual farmer in 1999/2000 and in 2000/2001. This was a single survey in which each farmer was asked if a given practice was used in 1999/2000, and if the farmer used the same practice in 2000/2001. This dataset is considered as a form of panel data and thus useful to track the changes that occurred in the use of the soil and water conservation practices between two years.

4.1.1 Operational definitions of Variables

The empirical variables employed under each of the broad categories discussed in the previous chapter were quantified from the survey instruments as follows:

Management ability

Age of the household head was measured in years. The level of education was quantified as the number of years of schooling of the household head while farmer contact with agricultural support programs was used as a dummy variable to measure if a farmer had any contact with agricultural developmental programs. The variable was one if a farmer had contact or received any agricultural related service from the following: Soil Conservation and Fertility (SCAFE) Project, Lonhro/Dunavant, Clark Cotton, Amaka, other outgrower schemes, Cooperative League of the United States of America (CLUSA) group, ZNFU, Care International, World Vision, Economic Expansion Outlying Areas (EEOA) Project and other Non Governmental Organizations (NGOs).

Household resources

Household labor was quantified based on the number of household members above twelve years. In Zambia, household members with at least twelve years of age are actively involved in farming activities. As for tenure status, it was captured as a dummy variable with one indicating that a farmer had land of his/her own either with title deeds or on bequest. Those who indicated that they were using borrowed or rented land were considered as not owning land.

Farm size was quantified in the survey instrument as a continuous variable based on total hectares of fields used by a farmer. Land area cultivated was used as a proxy measurement of farm size for cases where farm size was not declared. The supplemental survey instrument was used to quantify all the above-mentioned variables.

Number of Ploughs and number of harrows were quantified as discrete continuous variables using the 1999/2000 PHS. Using the same survey instrument, number of livestock owned was determined based on big animals such as cattle, goats, sheep, and pigs. This quantification determined implements and livestock owned by the household as at October 1999, respectively.

Source of off farm income was quantified as a dummy variable based on the 1999/2000 PHS instrument. The variable was one if a farmer indicated that s(he) had a source of off-farm income. This was a proxy variable to measure the farmer's alternative income sources. This variable could not adequately measure the level of off farm income but it was incorporated as a way of taking note which farmer had other alternative sources of income.

Incentives

The study uses the premise that farmers in Zambia plan for production based on current prices. They do not have access to skilled forecasting services (Sadoulet and de Janvry 1995). Maize price was, therefore, estimated from the 1998/99-survey instrument where households that sold maize grain in 1999 marketing season declared the selling price. The prices were aggregated at district level to represent even those households that did not manage to sell the commodity. The prices were quantified based on a Kg unit. There was no household in the sample that had sold maize in Chama district at the time of the survey. To fill up this gap an annual average price was computed based on the monthly prices for Chama district reported by CSO. The computed price was not expected to introduce noise in the dataset as the CSO prices were comparable to those prices reported by farmers in other districts from the survey instrument.

Fertilizer price was quantified on a per Kg basis using the 1999/2000 PHS survey instrument in which farmers reported the price at which they bought fertilizer during the 1999/2000 agricultural season. The prices were aggregated at district level to represent even those farmers who did not report any price. Kazungula and Nyimba districts did not have information on prices for fertilizer. To fill up the gaps the prices for the nearest towns were used. For Nyimba, Petauke district was used whilst for Kazungula, Livingstone prices were used. Not much noise is expected as a result of this because generally the people who live in Kazungula do most of their shopping from Livingstone. In fact, it used to be part of Livingstone but it was turned into another political district. The little noise may arise from the Nyimba / Petauke price data but this is also not supposed to affect the results as the prices of fertilizer in Zambia do not vary very much from their neighboring districts.

The market access variables related to distance to main road, distance to the feeder road in kilometer, distance to the town center, all in kilometers (Km) were measured from the SEA center. These variables were used in aggregate terms hence there could have been some households that were closer than the computed values. Distance here simply looks at the physical dimension without any due attention to the quality aspects of the road.

Physical constraints

The rainfall variable was used to measure the amount of water experienced by a farmer the previous season. The rainfall data were from the Meteorological Department of Zambia. The amount of rainfall measured in millimeters was collected at the district centers during the 1998/99 agricultural season hence it is just a proxy of the amount of water received by farmers in the district.

To quantify the physiographical factors for the household farms, agroecological zones were used as proxy variables. Consequently, some noise in the data is expected as the farm physiographical factors can vary within a short distance. The criteria employed by the Ministry of Agriculture to classify agro ecological zones were used. Zone 1 was a dummy variable to represent all areas that fall within agro ecological zone 1 while Zone 2 was used as dummy variable to represent all areas that fall within agro ecological Zone 2. Similarly Zone3 was a dummy variable representing all areas falling within agro ecological zone 3. In order to distinguish physiographical factors prevailing in one province from another, provinces were used as geographical dummy variables. The use of this variable is expected to introduce some bit of noise as it may collect along with it other factors such as culture that vary from province to province.

Statistical Summary of Empirical Variables

The characteristics of farmers in the study area together with their associated conditioning variables are summarized in Tables 7 and 8. The average age of farmers was 45 years of age and had an average land area of 3.21 hectares. The factors associated with the farm characteristics indicate that 12% percent of the farm holdings fell in the least rainfall zone (zone 1).

4.1.2 Limitations of the Data

The data collected on the practice of soil and water conservation practices are at household level rather than plot level; hence it is not feasible to know the area over which conservation was practiced and it is not possible to know which crop lands household particularly used the conservation practices. The data collected did not cover the biophysical factors of household farms related to soil texture and slope of land. The other limitation regarding the conservation practices was that they were farmer declared, and not observed by an enumerator hence it is not possible to establish if the farmers were implementing the practices as per recommendation.

No information about agronomic recommendations relating to tilling land before onset of rain and whether a household planted in permanent grids was collected. Hence it was not possible to determine who was using conservation farming according to the specifications of promoters such as ZNFU. Moreover, lack of information pertaining to costs of soil and water conservation operations and the accompanying returns posed a challenge in ordering the conservation practices.

The lack of different observations about households corresponding to each of the two years makes it difficult to undertake an expanded econometric analysis about disadoption. It is basically not appropriate to use the values that influenced the adoption of a given technology in the earlier year to analyze the disadoption the following period. Understanding the dynamic nature of practices such as pot holing requires data observations over a number of years so as to understand or the number of years a farmer has been using the practice; this information was not available and worse still the inconsistence in the conservation practices measured across data sets would not allow construction of a form panel data.

4.1.3 General Environment

It is important here to highlight some climatic and general conditions prevailing in the years preceding the two surveys. As noted in Chapter two, the amount of rainfall received in 1998/99 was inadequate. The drought experienced during this year created some anxiety in the nation because of the looming critical food shortages. In late 1999 MACO officially adopted the conservation and land management practices as relevant for promotions among farmers. The year that followed was characterized by calls from the farming community for government's intervention in agricultural marketing and particularly the need to establish agricultural cooperatives in strategic areas of the districts e.g. poling stations. These were to be particularly used for fertilizer distribution. This could have influenced the use of fertilizer among some farmers thereby affecting the adoption of fertility enhancing conservation practices.

Table 7: Summary Statistics of Farmer and Farm Characteristics: Continuous Factors

Variable	Mean	Standard deviation	Minimum	Maximum	Median
Age (years)	45.3	15.0	18.0	92.0	43.0
Farm size (hectares)	3.2	6.2	0.1	240.9	2.0
Fertilizer price (ZMK per Kg)	691.4	59.9	540.0	800.0	697.7
Maize price in (ZMK per Kg)	270.8	31.2	227.5	333.3	270.4
Adult labor (Family members 12 years and above)	3.8	2.3	1.0	23.0	3.0
Level of education (Years of schooling)	5.3	3.9	0	18.0	6.0
Number of livestock	6.5	13.7	0	168.0	0
Number of plough	0.5	0.9	0	7.0	0
Number of harrows	0.1	0.4	0	5.0	0
Distance of SEA center to nearest main road (Km)	29.4	42.2	0	188.9	14.2
Distance of SEA center to nearest district town (Km)	29.9	17.9	2.7	100.5	27.4
Distance of SEA center to feeder road (Km)	2.5	2.1	0.2	17.9	2.1
1998-99 Mean rainfall (mm)	926.1	122.9	580.0	1100.0	940.0

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

US$ 1.00 = ZMK 2,400 for 1999 and US$1.00 = 1878 for 1998

Table 8: Summary Statistics of Farmer and Farm Characteristics: Dichotomous Factors

Variable	Proportion
Farm holdings with program contact	.20
Off-farm income source indicated	.42
Farmers that own land (Tenure status)	.95
Agro ecological Zone 1	.42
Agro ecological Zone 2	.50
Agro ecological Zone 3	.08
Central Province	.19
Eastern Province	.52
Lusaka Province	.04
Southern Province	.25

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

4.2 Empirical Methods

4.2.1 Adoption Estimation Model for Intercropping and Pot holing

To understand adoption behavior logit and probit models are commonly employed as two related multifactorial analytical practices. The two models can take on one or two values – adopt or don't adopt (CIMMYT 1993). This study employed logit model to understand the binary choices for intercropping and pot holing.

4.2.1.1 Logit Model and Analysis

The logit model is based on the logit regression, which may be specified as

$$L = X'\beta + \varepsilon$$

Under a logistic distribution, the cumulative distribution function of the random variable X is $\Pr(X \leq x) = G(x) = \exp(x)/[1+\exp(x)] = 1/(1+\exp(-x))$

The logit has a general form of:

$$\Pr(Y_i = 1) = G(X'\beta) = 1/[1 + \exp(X'\beta)$$

Where;

βs are coefficients to be estimated; and

X are predictors.

The coefficients in logit analysis are estimated using maximum likelihood. The interpretation of the coefficients is not as straight forward as in ordinary least square regression analysis. The coefficients on their own do not tell much but the coefficients can be used to compute the marginal effects, which are useful in interpreting the effect of predictors on the change of probability. Also the signs of the coefficients can be used to indicate the direction of the change of the predicted probability arising from a change in the predictor.

Marginal Effects

The main interest for any analyst is to know what the effect of a change in a given predictor would be on the outcome. The marginal effect on the probability for an average individual due to a small change in variable X_k under a logistic distribution is

$$\frac{\partial pr(Y_i = 1)}{\partial X_k} = \frac{1}{1 + \exp(X'\beta)}\left[1 - \frac{1}{1 + \exp(X'\beta)}\right]\beta_k$$

The above expression cannot be used to evaluate the incremental effects of a dummy variable. The effect of a dummy variable has to be analyzed by comparing the effect of the variable when the value is one to when the value is zero. The difference of the effects on the probabilities between the two values, holding other variables constant, is the incremental effect for a dummy variable. As much as the marginal effects can be computed on an individual case by case, the general practice is to compute the marginal effects at the sample's mean values.

Odds Ratio

The odds ratio is a statistical measure defined as the ratio of the odds of an event occurring in one group to an event occurring in another group; for instance, a dichotomous classification. It is a summary measure of the relationship between two variables or dichotomous classification and it tells us how better the odds are for the occurrence of a certain event. The odds ratios are particularly useful when dealing with dummy variables to answer some policy questions such as how likely is it for a farmer owning land to practice a given soil and water conservation practice compared to a farmer who does not own land? Or how likely would it be for a farmer living in a more arid area to use pot holing or intercropping as a risk reduction strategy?

Mathematically the odds ratio may be expressed as follows:

Assume the odds for group one = odds1 = $\frac{p}{1-p}$ and the odds for group two = odds2 $= \frac{q}{1-q}$; where p and q are probabilities for group one and two, respectively.

Odds ratio = odds1 / odds2, but considering that $\ln\left[\frac{p}{1-p}\right]$ = logit (p) and $\ln\left[\frac{q}{1-q}\right]$ = logit (q), it follows that the log odds ratio = logit (p) - logit (q). Therefore, the odds ratio may be taken as the antilogarithm of [logit (p) - logit (q)] or alternatively as the antilogarithm of the slope of the logit regression, one unit apart of two different values of the predictor (Mukherjee et al. 1998).

Goodness of fit

The likelihood ratio test is used to see if the model including regressors provides extra explanatory power over the model with only an intercept. The likelihood ratio statistic is computed based on the premise that there are two models. Assuming that the unrestricted model has the log-likelihood function denoted as L_1 and the restricted model has the log-likelihood function denoted as L_2, the likelihood ratio test of the hypothesis of dropping all regressors is defined as $2(L_1 - L_2)$. The degree of freedom is equal to the number of the estimated coefficients less one (i.e. the intercept is excluded). The computed likelihood ratio statistic has an asymptotic chi-square distribution. Therefore, the computed statistic is compared with the critical value in the chi-square table. If the estimated statistic is greater than the table chi-square value, then the variables in the estimated model jointly explain the response effect. It means the hypothesis to drop all variables apart from the constant term is rejected by data.

Like the likelihood ratio test, the pseudo R-Squared is based on comparing a model with regressors to a model with only a constant intercept. It can be used to determine the goodness of fit in a limited sense. A pseudo R-Squared of one indicates a perfect fit whilst zero means that all the coefficients are zero hence regressors do not contribute to any variation of the dependent variable. The values of pseudo R-Squared between zero and one do not have any natural interpretation (Mukherjee et al. 1998).

4.2.1.2 Regression Specification for Intercropping

The model to estimate the practice of intercropping is specified as follows:

hsoilf = f(management ability, household resources, incentives, physical constraints)

Where hsoilf = 1 if farmer practiced intercropping in 1999/2000, 0 otherwise.

To avoid the problem of collinearity in the zone and province dummy variables, zone3 and prov1 were respectively, dropped from the model. This implies that each parameter estimate will have to be compared to the dummy variable dropped out as the base. For instance, the parameter for zone 1 indicates the differential effect above Zone 3 arising from Zone 1.

4.2.1.3 Regression Specification for Pot holing

The model used to estimate the practice of intercropping was modified to suit pot holing by dropping out the variables that are directly related to tillage such as harrows and ploughs. To eliminate the tillage effect of livestock on the practice but yet capture its importance as part of wealth, livestock variable has been adjusted by dropping out draft animals. Thus the model is specified as follows:

hsoilp = f(management ability, household resources Less tillage implements and oxen, incentives, physical constraints).

Where hsoilp = 1 if farmer practiced pot holing in 1999/2000, 0 otherwise.

4.2.2 Econometric Specification for Conservation Farming Practice and Other Sets of Practices

In this study ordered logit model is employed to allow for multiple outcomes and scaling of multiple responses (Borooah 2001; Wooldridge 2001; Greene 2003). In estimating the adoption of conservation farming practices, it was felt that the multiple selections that the farm household faced are inherently ordered (MACO and ORGUT 2003). For this reason count models or any non-ordered model such as poisson regression and multinomial logit, respectively cannot adequately estimate the adoption of many choices as the information conveyed by the ordered nature is ignored resulting in loss of efficiency (Borooah 2001).

4.2.2.1 Ordered Logit Model

The ordered logit is built around the latent regression:

$Y^* = X'\beta + \varepsilon$; where Y^* is unobservable. We only see

Y = 0 if $Y^* \leq 0$

= 1 if $0 < Y^* \leq \delta_1$

= 2 if $\mu_1 < Y^* \leq \delta_2$

.

.

= j if $\delta_{j-1} \leq Y^*$

Under a logistic distribution, the cumulative distribution function of the random variable X is $\Pr(X \leq x) = G(x) = \exp(x)/[1+\exp(x)] = 1/(1+\exp(-x))$

The ordered logit has a general form of:

$\Pr(Y_i = 1) = G(\delta_1 - X'\beta) = 1/[1+\exp(X'\beta - \delta_1)$

$\Pr(Y_i = 2) = G(\delta_2 - X'\beta) - G(\delta_1 - X'\beta)$

.

.

$\Pr(Y_i = j) = 1 - G(\delta_{j-1} - X'\beta)$

Where,

βs are coefficients to be estimated;

X are predictors;

δs are cutoff points, where applicable;

The estimates β_k, $\delta_1, \delta_2 ..., \delta_{j-1}$ are obtained by maximizing the likelihood function using the logistic distribution function G(·).

Before specifying the equation to estimate conservation farming practices, the approach used to order the practices is first discussed. Ordering practices requires care because "failure to impose a legitimate ranking on outcomes can introduce bias in estimates. This problem of biased estimates is more severe than treating categories as nonordered since the latter may simply result in the loss of efficiency" (Borooah 2001). There are two possible ways to rank soil and water conservation categories dealt with in this study; namely (1) on the basis of difficulty of use or (2) on the basis of impact on crop output or net returns. The former approach, as much as it may be relatively easier to implement, is not appropriate in the context of this study as the objective is not to measure difficulty of use of a specific practice.

The basis of net return would be more appropriate for ordering practices in this study but unfortunately there is no information on benefits and costs for the practices under study. Therefore, in this study practices have been grouped as shown in Table 9 below and a version of the promoters' expectations of the impact of the practices have been used to rank the categories of practices. The desire of the promoters is for individual farmers to use all the practices – see Haggblade and Tembo (2003a), and MACO and ORGUT (2003). This level of practice without question makes the greatest impact on productivity. The use of all practices can, in this respect, be ranked highest, i.e. a combination of practices (1), (2) and (3).

Table 9: General Grouping of Technologies

Rotation (FM) (1)	Soil Cover with Residue (FM) (2)	Reduced Soil Inversion (F) (3)
1. General crop rotation	1. Leave crop residue	1. Pot holing / Plant basins
2. Improved fallow		2. Other minimum tillage
3. Intercropping		

F = Fast track in yielding returns FM = Fast to medium in yielding returns

At the extreme end we have a farmer that does not use any soil and water conservation practice. This level of practice could be ranked zero. The practice of any fertility enhancement conservation practice was given the rank of one i.e. using any practice from (1) or practice (2). Moreover, farmers in Zambia experience very high variability in yields when there is inadequate rainfall. For this reason, reduced tillage practices (which have water conservation benefits), were not placed on the same level as (1) or (2). It was strongly felt that the deleterious effect of water forgone by not using practices like pot holing can not be compared to fertility benefits that a farmer may forgo from any practice in (1) or practice (2). It is true that crop residue could serve as mulch to reduce evaporation from soil but the water-gathering role played by practices like pot holing and planting basins are still incomparable. Crop residues when left in the field after harvest at times decompose and as such they do not effectively serve as mulch.

Yet still, even if practices are grouped as tillage practices and fertility practices, they indirectly have interrelated effects. Each practice has an effect on fertility and tillage. It is just the weight of the effect associated with a given practice that varies. For instance, pot holing is grouped as a tillage practice; yet the practice of not loosening soil on all the farm area reduces erosion of good soil and allows targeting of nutrients. It therefore provides benefits associated with fertility practices. Consider also soil cover with crop residue left in the field. It facilitates infiltration of moisture in the soil and sets a barrier to erosion. This practice again also provides benefits associated with tillage practices as well as erosion control practices. The above discussion simply shows that it may not be out of order to put reduced tillage (3) on an equivalent level with a combination of (1) and (2). In view of this, reduced tillage or a combination of one or more from rotation group of practices and soil cover was ranked two.

Finally, a combination of reduced tillage and soil cover practice or a combination of reduced tillage and one or more of the rotation practices was given rank three. Such a grouping approach was felt safer compared to the approach of dealing with each individual practice. Unless one is meticulously effective in comparing effects of each single practice, it can easily become a source of illegitimate ordering. Illegitimate ordering imposes a ranking on outcomes that they do not possess and invokes the assumption of parallel slopes.

The ranking of the practices[9] is summarized as follows:

Y_i = 0 if an individual did not practice any soil / water conservation practice

Y_i = 1 if an individual practiced any from (1) or (2);

Y_i = 2 if an individual practiced [(1) and (2)] or (3);

Y_i = 3 if an individual practiced [(1) and (3)] or [(2) and (3)];

Y_i = 4 if an individual practiced (1), (2) and (3).

---

[9] All the practices are based on the 1999/2000 agricultural season

4.2.2.2 Regression Specification for Conservation Farming and other Sets of Practices

The model to estimate conservation-farming practices is specified exactly as for pot holing. Tillage implements and oxen have been dropped down because conservation farming has a component of tillage practices such as pot holing:

consf = f(management ability, household resources Less tillage implements, Less oxen, incentives, physical constraints)

Where,

consf = Y_i empirically ordered and defined above and the right hand side (RHS) variables have the same definition as indicated before in the model for estimating intercropping. The only modification in this model is that conservation-farming practices have a component of tillage practices for which tillage implements or livestock resources may not be predetermined.

Interpretation of results of the ordered logit,

The interpretation of results is more or less the same as in binary choices. However, one has to be careful with the interpretation of the signs of the marginal effects for as Woodridge (2001) indicates, the direction of the effect for the middle ranked categories (i.e. $Y_i = 1$, $Y_i = 2$, and $Y_i = 3$) cannot be predicted. The direction of the change in probability can be either way.

4.2.3 Procedure to Analyze Disadoption of Practices

To track the utilization of practices among respondents over the two years, the study was guided by the following questions:

1. Did farmers use certain practices in 1999/ 2000 agricultural season but shift out of them in 2000/2001 agricultural season?
2. What farmer and farm characteristics differences exist between those who abandoned the practices the following season and those who continued, and between those who did not implement the practices in the two agricultural seasons and those who possibly used them the following season only?

To answer part of the questions raised above, percentages of farmers that abandoned individual practices were computed as follows: (Total number of individuals that ceased to follow practice *k* in 2000/2001 ÷ Total number of individuals that implemented practice *k* in 1999/2000). For more details and illustration of how exactly the computations were made, refer to Appendix Part 2.

To answer the question related to differences between farm and farmer characteristics between the groups of interest, each practice, except other minimum tillage, was individually analyzed. Under each practice, farmers were divided into those that used the practice in 1999/2000 (Yes) and those that did not (No). Then each of these categories was further divided into those that used the practice in 2000/2001 and those that did not use the practice in 2000/2001. Due to data limitation, analysis was based on t-test of mean differences within the Yes / No adoption categories. This study particularly focused on farm and farmer characteristics guided by the following hypotheses:

1. The older the farmer is the more likely the farmer would be consistent in using the practices, more especially those practices that could be considered as part of traditional cropping systems; for instance, intercropping;

2. The lower the level of education the more likely the farmer would be inconsistent in following practices other than intercropping and leaving crop residue due to difficulties in conceptualizing the logic behind the practices;
3. Households with low amount of labor abandon the practice of improved fallow; and
4. Access to support programs and land ownership may result in consistent use of practices.

The hypotheses were tested using the t-test of mean differences under the assumption that the variances were equal. The Levene's test (SPSS Statistical Package, Version 11) was used to ascertain this assumption and where the assumption could not hold, the t-tests based on unequal variance were employed.

A binary logit analysis of determinants of the decision whether to continue or not the practices were attempted with intercropping and improved fallow, which appeared to have a workable data but meaningful results could not be obtained.

CHAPTER 5

DATA ANALYSIS RESULTS

5.1 Adoption of Soil and Water Conservation Practices – Descriptive Analysis Results

The farmer profile of farmers and households in Table 10 shows that 81% of the survey participants were males. In addition, 82% of participants in the sample were married, and the average number of male and female adults was just about the same, two per each household. On average, the land area cultivated was 1.44 hectares though farms ranged from 0.6 to 15 hectares. Approximately, 93% of households headed by women were small-scale as compared to 79% of households headed by men. This reveals that only very small proportion of women farmers (7%) are medium-scale compared to male farmers (21%).

The most common soil/water conservation practice used by farmers was crop rotation followed by leaving crop residue in fields after harvest (See Table 11). Improved fallow and pot holing were used less frequently than the other practices. Based on the findings of the survey, a large majority of farmers stated that they learned about the practices as a traditional practice; the other key informants on the varied practices were the Ministry of Agriculture Extension Staff, neighbors of fellow farmers, and CLUSA Zambia (See Table 12). Table 13, indicating the source of information for specific practices, shows that most of the farmers learned intercropping and leaving crop residues as traditional practices. The indication of farmers that they learned practices through traditional sources (i.e. as traditional practices) probably means that the practices are different from what researchers know them to be. For instance, about 37% learned improved fallow as a traditional practice but considering the observations of Gladwin et al. (2002), and Place et al. (2002) that improved fallow is an information intensive practice requiring extension agents to teach farmers, it is quite surprising here to find that the traditional source should dominate even for this practice.

Table 10: Summary Statistics of Farmer and Farm Household Profile

Demographics and Others	Minimum	Maximum	Mean
Gender of household head (1=male)	0	1	.81
Number of male adults in household	0	12	1.85
Number of female adults in household	0	12	1.90
Marital status (1=married)	0	1	.82
Farm size[1] category of female headed households	0	1	.93
Farm size[1] category of male headed households	0	1	.79
Land area cultivated (ha)	.06	15.00	1.14
Total number of observations = 2524			

[1] The farm size: 0 = medium scale, 1= small scale

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table 11: Farmers Implementing Soil and Water Conservation

Type of Practice	% of households
Mixing of two or more crops in one field	21.1
Improved fallow	8.8
Pot holing / planting holes	8.2
Crop rotation	66.7
Leaving crop residues (except for cotton & tobacco)	51.5
Other minimum tillage practices	16.2
Total number of observations = 2524	

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000
Note: Other minimum tillage practices were not detailed in the survey

The other farmer organizations, CLUSA and other agricultural support programs have a relatively small percentage of farmers that learned the practices through them. There could be varied reasons for such a state of affairs, one of which could be sampling reasons. Projects work in highly defined areas that may not have been included in sampling. The other possible reason is that if organizations trained MACO extension agents or worked with them farmers might identify MACO rather than organizations as the source of information.

The percentage of farmers specifying that they learned a given practice traditionally differed across the levels of education. As shown by Table 14, on the whole the implementing farmers who did not go to school are in the majority of stating that the practices (with an exception of pot holing) were learned traditionally. Pot holing recorded other levels of education as being in the majority. These results appear to suggest some gaps in knowledge or potential misunderstanding about certain practices may exist among farmers.

Table 12: Source Where Farmers Learned about Any of the Conservation Practices[1]

Source	Frequency	Percentage	Cumulative (%)
Traditional practice	2292	49.8	49.8
MACO Extension agent	1093	23.7	73.5
Neighbor/Other farmer	520	11.3	84.8
CLUSA Group	277	6.0	90.8
Other farmer organization	102	2.2	93.0
Other NGOs	83	1.8	97.0
Radio/TV	43	.9	97.9
Clark Cotton	37	.8	98.7
DAPP	30	.7	99.3
Lonrho/Dunavant	22	.5	99.8
Omnia	8	.2	100.0
Others	97	2.1	95.2
Total number of valid multiple cases	4604	100	

[1] Each household was able to select the same source more than once for other practices. Only households that used a practice answered this section.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The source of information for the practices should be interpreted with reservations due to some difficulties with the survey questions. For instance, the questions did not make a provision for the possibility of joint execution of activities by promoters. In such a case, a farmer was left with no alternative other than choosing one from others.

Table 13: Source of Information for a Practice, for Those Who Used It

	Soil and Water Conservation Practice[1]					
	MC	IF	PH	CR	LC	OM
Source/Practice	% of households					
Traditional Practice	67.1	36.9	39.1	42.5	58.7	51.7
MACO Extension Agent	17.9	31.1	22.2	28.3	18.6	21.5
Neighbor/Other farmer	5.6	8.6	16.9	13.2	11.2	9.3
CLUSA Group	2.3	4.5	5.3	6.4	5.5	10.5
Other farmer organization	1.9	6.8	3.4	2.4	1.1	2.0
Other	5.3	12.2	13.0	7.2	4.9	5.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1]MC=Mixed cropping, IF=Improved fallow, PH=Pot holing or basins, CR=Crop rotation, LC=Leaving crop residue, and OM=other minimum tillage

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

A further examination of the level of soil and water conservation practices by farm size category revealed that a higher proportion of medium scale farmers practiced all the given practices with the exception of other minimum tillage practices compared to small-scale farmers. The pattern of the prevalence of the practices used, however, was the same between the two groups; crop rotation was the most prevalent followed by leaving crop residues in the fields (Table 15).

Table 14: Farmers that learned practices through traditional sources by level of Education

	Soil and Water Conservation Practice[1]					
	MC	IF	PH	CR	LC	OM
Level of Education	% of respondents					
None	78.0	50.0	44.8	52.9	68.4	57.6
Primary education	64.1	33.3	33.1	41.1	55.9	52.5
Junior secondary education	68.3	41.4	48.3	39.8	58.5	43.9
Senior secondary education	64.3	39.3	47.8	37.2	54.3	45.7
At least college education	50.0	40.0	50.0	28.9	60.0	0.0

[1]MC=Mixed cropping, IF=Improved fallow, PH=Pot holing or basins, CR=Crop rotation, LC=Leaving crop residue, and OM=other minimum tillage

The Percentage totals do not add up to 100 as they have been calculated within cells

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table 15: Farmers Implementing Soil / Water Conservation, by Farm Size Category

Farm Size Category /	Small Scale	Medium Scale
Soil / Water Conservation Practice	Percentage of farmers	
Intercropping	20.3	24.6
Improved fallow	7.9	12.7
Pot holing / planting holes	7.9	9.6
Crop rotation	64.0	78.9
Leaving crop residues	50.1	57.9
Other minimum tillage practices	16.5	15.1
Number of cases	2068	456

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Shifting the analysis to the level of farm size in relationship to gender and practice used, the results in Table 16 indicate some differences between the female medium scale farmers and their male counterparts on the practice of improved fallow, crop rotation and leaving crop residues in the field. The female farmers practiced more of improved fallow while the male farmers practiced more of crop rotation and leaving crop residue in the field after harvest. A comparison between the female small scale farmers and their male counterparts showed that the former registered a consistently lower level of participation in all the soil and water conservation practices except for minimum tillage.

Table 16: Farmers Implementing Soil and Water Conservation by Gender from the Given Total Number (N) within Each Farm Size Category

	Female		Male	
	Small	Medium	Small	Medium
Soil / Water Conservation Practice	% of households			
Mixing of two or more crops in a field	19	25	21	25
Improved fallow	5	19	9	12
Pot holing / planting holes	6	8	8	10
Crop rotation	56	67	66	80
Leaving crop residues	43	50	52	59
Other minimum tillage practices	17	17	16	15
Number of cases (N)	456	36	1612	420

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

One of the study's interests was to find out if the prevalence of the practices was the same across the rainfall zones. The prior expectation was that leaving crop residues would be most prevalent in Zone 3 because of low opportunity costs related to fodder.

However, the findings according to Table 17 show that leaving crop residues in the field after harvest was most common in the least rainfall zone (Zone 1) compared to the other two zones. The farmers in the intermediate rainfall zone (Zone 2) had preeminence in using crop rotation. Despite the unstable biophysics in the higher rainfall (Zone 3) and least rainfall zones, a considerable percentage of farmers appear to have focused on monocropping. These results seem to be consistent with the finding of Knepper (2002) that farmers in higher rainfall and the least rainfall zones still concentrated on growing maize in monocropped fields.

Table 17: Farmers Implementing Soil and Water Conservation Among all farmers by Rainfall Zone

	Zone 1	Zone 2	Zone 3
Soil /Water Conservation Practice	% of households within the zone		
Mixing two or more crops in a field	20.1	22.3	18.9
Improved fallow	9.6	9.2	1.9
Pot holing / planting holes	10.8	6.2	7.1
Crop rotation	57.6	77.8	46.7
Leaving crop residues	58.7	49.9	25.5
Other minimum tillage practices	6.6	26.7	2.4
Number of cases	1057	1255	212

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

To analyze the practices according to labor available at the household level, farmers were broken into quartiles (Refer to Table A1.3 in Appendix for labor summary statistics for each quartile). Table 18 shows that within the quartiles, less than 13% of the households practiced improved fallow and pot holing. Moreover, there was not any specific practice per se on which the second labor quartile placed more emphasis than the third labor quartile. It appears that there may be not much difference between a household with four personal labor units and one with only three. When however, a direct comparison of the first labor quartile to the fourth labor quartile is made, the results show that the former had a higher percentage of farmers that used other minimum tillage practices than the latter. The results here seem to match with the generally held notion that reduced tillage practices do not demand much household labor (Chelemu and Nindi 1999; MACO and ORGUT 2003; Mulenga 2003). More importantly, other minimum tillage practices were common in the bottom three quartiles whereas the practice of intercropping was common in the top three quartiles.

Table 18: Farmers Implementing Soil and Water Conservation within Each Adult Labor Quartile (Percentages)

Soil and Water Conservation Practice	Quartile 1 1-2 adults	Quartile 2 3 adults	Quartile 3 4 adults	Quartile 4 5 or more
Intercropping	17.0	22.2	25.1	23.6
Improved fallow	6.3	8.6	8.4	12.6
Pot holing / planting holes	6.6	7.7	10.4	9.5
Crop rotation	63.0	65.6	67.3	72.2
Leaving crop residues	47.1	50.5	53.3	57.1
Other minimum tillage	17.8	17.6	17.0	12.9
Number of cases	957	465	394	708

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The fourth labor quartile had higher levels of farmer participation in mixing of two or more crops, improved fallow, crop rotation and leaving crop residue. Since the latter two practices are not considered as labor intensive, we would not expect a very big difference in the prevalence of the two practices between households with few personal labor units compared to those with many labor units.

Similarly, breaking land area cultivated into quartiles (See Table A1.4 in the appendix for summary statistics) revealed some differences to the effect that those with very small cultivated land areas tended not to practice crop rotation and leaving crop residues compared to those farmers that cultivated large land areas (See Table 19). This possibly may be an indication of the flexibility those with large farm-size have to engage additional land under cultivation without necessarily affecting the main crops. The reason why large farm size may be associated with leaving crop residue is not very clear.

Table 19: Farmers Implementing Soil and Water Conservation within Each Quartile of Land Area Cultivated

Soil and Water Conservation Practice	Quartile 1 0. 06 – 0.4 Hectares	Quartile 2 0.41 - 0.76 Hectares	Quartile 3 0.77 - 1.27 Hectares	Quartile 4 1.28 - 15 Hectares
	% of households implementing			
Intercropping	18.9	22.0	21.2	22.2
Improved fallow	6.7	9.0	7.1	12.4
Pot holing / planting holes	9.5	7.4	7.6	8.2
Crop rotation	53.1	69.9	69.1	74.8
Leaving crop residues	45.5	49.0	51.3	60.2
Other minimum tillage	16.5	17.6	17.1	13.8
Number of cases	631	631	631	631

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

One of the major interests of this study is to look at uses of multiple soil and water conservation practices. As noted by MACO and ORGUT (2003), the main interest of promoters is to get a lot of farmers using multiple practices instead of single practices. The effectiveness of practices on productivity increases with number of complementary practices used by farmers. Table 20 shows that about 15% did not implement any conservation practice, 34% used at least one practice from the rotation group, 30% used what was classified as the third level of conservation practices, 8% followed the fourth level of conservation practices while about 12% implemented all practices (all groupings) or at least three elements with each grouping represented. The level of utilization of all the three different components of conservation farming according to three groupings of soil and water conservation indicated in Table 9 is still low among farmers.

Table 20: Combination of Practices Used Among Farmers

Practices	Frequency	Percentage
Crop rotation & residue	461	18.3
Crop rotation only	421	16.7
Did not practice conservation practice	376	14.9
Left crop residue only	220	8.7
Pot holing, crop rotation & residue	163	6.5
Mixed cropping & crop rotation	127	5.0
Mixed cropping, crop rotation & residue	125	5.0
Pot holing & crop rotation	113	4.5
Mixed cropping, pot holing, rotation & residue	62	2.5
Pot holing & residue	55	2.2
Fallow, crop rotation & residue	52	2.1
Pot holing only	45	1.8
Mixed cropping, pot holing & residue	35	1.4
Mixed cropping & residue	34	1.3
Mixed cropping only	31	1.2
Mixed cropping, pot holing & rotation	30	1.2
Mixed cropping, fallow, pot holing, rotation & residue	28	1.1
Improved fallow & crop rotation	27	1.1
Fallow, pot holing, crop rotation & residue	20	.8
Mixed cropping , fallow, crop rotation & residue	19	.8
Fallow, mixed cropping & crop rotation	17	.7
Fallow & residue	16	.6
Fallow, pot holing & crop rotation	10	.4
Mixed cropping, fallow, pot holing & rotation	9	.4
Improved fallow only	8	.3
Mixed cropping & fallow	5	.2
Mixed cropping & pot holing	4	.2
Mixed cropping, fallow & residue	4	.2
Fallow, pot holing & residue	4	.2
Mixed cropping, fallow, pot holing & residue	2	.1
Fallow & pot holing	1	.0
Total	2524	100.0

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

5.2 Adoption of Technologies – Econometric Analysis Results

The previous section has dealt with the descriptive analysis of the practices of farm households. In this section the focus shifts to presentation of results for the factors that influenced the use of practices in the multivariate context. The results for individual soil conservation practices are first presented, after which the results for conservation farming and other sets of conservation practices are presented.

5.2.3 Regression Results for Intercropping and Potholing

A binary logit analysis was undertaken to determine quantitatively how the relevant factors interact to influence farmers in their choice of pot holing or intercropping, respectively. The regression results in Table 21 below show that the likelihood ratios are considerably high and significant at 1%, thus the model in general explained factors associated with the practices of intercropping and pot holing. The likelihood of using intercropping, on the whole, was high but modest for pot holing. The predicted probabilities at mean values were 19% and 6%, respectively. Thus, for example, the likelihood of an average farmer using intercropping is 19%. According to Table 11, about 21% used intercropping whereas 8% implemented pot holing. The model compares well to what was actually obtaining on the ground as may be noted from the predicted probabilities. The results further indicate that a number of factors significantly influenced a farmer to choose intercropping and pot holing as noted by the asterisks. In this chapter and elsewhere the presentation and discussion of the marginal effects are made under the assumption that all other factors are held constant, and unless where specified they were computed at the means of the parameters.

It was earlier hypothesized that intercropping and pot holing practices are likely to be more appealing to households living in areas where inadequate rainfall occurs. The coefficients for zones are used to test this hypothesis. The coefficient for rainfall (1998/99), on the other hand, is used to determine if inadequate rainfall received the previous season influenced farmers to use risk options aimed at minimizing crop failure the following planting season. Farmers may safeguard against occurrences of crop failure by implementing crop diversification (e.g. intercropping) and/or engaging in water conserving technologies such as pot holing. Therefore, the zone variable is capturing the typical climatic condition of a given place whereas the rainfall variable is capturing the short-term risk. A place may generally be known to be receiving adequate rainfall and thus be placed in Zone 3 yet there may be occasional bad years.

The coefficient for Zone 1 (Table 21) where rainfall is lowest of the three zones is significant at 1% level for intercropping practice where as the coefficient for Zone 2, a relatively low rainfall zone as well, is significant at 10% level. The marginal effects (dy/dx) indicate that, all else constant, if a farmer is in Zone 1, the probability of using intercropping increases by 19% over a farmer in Zone 3. As for a farmer in Zone 2, he/she has an increased probability of 7% of using intercropping over a fellow farmer in Zone 3. This is also evident from the odds ratio result presented in Table 23, which shows that the probability of a farmer living in Zone 1 using intercropping is 3.2 times more than a farmer in Zone 3; whereas a farmer in Zone 2 is 1.5 times more likely to use intercropping than a farmer in Zone 3. This simply means that intercropping could indeed be a risk management strategy for farmers in the lower rainfall zones.

The results for pot holing indicate that there was no significant difference between a farmer living in Zone 1 or Zone 2 and a farmer living in Zone 3. The non-significance of the coefficients for Zone1 and Zone 2 under pot holing is some how surprising considering that this technology is being promoted as a water conservation technology, useful in regions with erratic rainfall.

The results (Table 21) specifically show that the effect of amount of rainfall received the previous season on the farmer's choice to use either practices was not as expected. The prior expectation was that decreased amount of rainfall received the previous season would influence a farmer to use pot holing or intercropping as a risk management strategy. The results, however, appear to be suggesting that the more rainfall experienced the previous season the greater the possibility of a farmer using intercropping or pot holing. This could be suggesting that a good season the previous year reflect results in some asset accumulation, which increases farmer capacity at start of the season.

Regarding geographical factors, the results in Table 21 show that a farmer in Eastern Province or in Lusaka Province or in Southern Province faces a reduced probability of using intercropping compared to a farmer in Central Province in the order of 10%, 9% and 15%, respectively. As also may be noticed in Table 22, the odds ratio are less than one, implying that the event of using intercropping in any of these provinces is less likely to take place compared to Central Province. In the case of pot holing, only Lusaka and Southern provinces had positive significant coefficients, signifying increased likelihood of a farmer living in either province to use this practice over a farmer in Central Province.

Table 21: Econometric Analysis of Factors Affecting the Use of Selected Individual Practices (Logit Regression) [a]

Variable	Intercropping				Pot holing			
	Coef.	dy/dx	Z		Coef.	dy/dx	Z	
Age	0.01	0.001	1.91	*	0.00	0.0002	0.54	
Education level	0.02	0.003	1.17		0.03	0.0014	1.28	
Program contact	0.34	0.055	2.47	**	0.48	0.0285	2.03	*
Farm size	-0.00	-0.001	-0.41		-0.01	-0.0005	-0.57	
Adult labor	0.04	0.007	1.73	*	0.03	0.0017	0.94	
Off-farm income	-0.12	-0.018	-1.08		0.12	0.0061	0.72	
No. livestock	0.00	0.000	0.08		-0.02	-0.0010	-2.22	**
No. of ploughs	-0.08	-0.013	-1.10		-	-	-	
No. of harrows	0.04	0.007	0.28		-	-	-	
Tenure status	0.69	0.087	3.00	***	0.19	0.0092	0.65	
Fertilizer price	-0.01	-0.001	-3.49	***	-0.01	-0.0004	-3.36	***
Maize price	0.00	0.000	0.16		0.02	0.0010	3.13	***
Dist. main road	0.02	0.003	6.90	***	0.01	0.0007	4.00	***
Dist. to town	-0.02	-0.004	-6.92	***	-0.02	-0.0009	-3.30	***
Dist. Feeder road	0.02	0.002	0.51		-0.07	-0.0036	-1.61	
Average rainfall	0.01	0.001	4.95	***	0.00	0.0002	2.73	***
Zone 1	1.18	0.192	3.81	***	-0.66	-0.0332	-1.10	
Zone 2	0.44	0.067	1.73	*	-0.14	-0.0074	-0.38	
Eastern Prov.	-0.63	-0.097	-1.96	*	-0.06	-0.0034	-0.15	
Lusaka Prov.	-0.75	-0.092	-2.99	***	1.77	0.1914	1.85	*
Southern Prov.	-1.20	-0.152	-5.18	***	1.48	0.1130	1.83	*
Number of observations =	2524							
LR chi2	165.78					163.17		
P-value	0.000					0.000		
% Correctly classified	78.96					91.80		
Predicted prob. at mean	0.190					0.055		

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.
/a. The estimation included a constant though it has not been included in the table.
Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table 22: Odds Ratios for Selected Variables Affecting Individual Practices

Variable	Odds Ratio			
	Mixed cropping		Pot holing	
Zone 1	3.242	***	0.519	
Zone 2	1.549	*	0.868	
Eastern	0.534	**	0.937	
Lusaka	0.472	**	5.863	***
Southern	0.302	***	4.404	**
Tenure status	1.997	**	1.209	
Program contact	1.401	***	1.612	**

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The coefficient for tenure status was not significant for pot holing. It was anticipated earlier that those without land were likely to use pot holing as a fast track yielding technology due to its water gathering effect. This result, however, should not be surprising because pot holing requires a major investment in labor during the establishment stage, which most likely discourages farmers who do not own land and hence lack tenure security. Even then, ownership of land does not either appear to be associated with the practice of pot holing as a major investment in labor of which benefits have to be reaped in a long run. In this respect, this study's finding appears to be inconsistent with Gebremedhin and Swinton's (2003) work in Ethiopia on terracing and bunding. Their study found stable land tenure very important for adoption of major investments, especially terrace construction.

Pot holing has been promoted in Zambia as a labor saving technology since less than one-third of the land is expected to be tilled. The results of this analysis indicate that available household labor was not a significant factor. This does not match with prior expectation of either positive or negative coefficient. The first year or second demands more labor for establishment of potholes and weeding than latter years. The difference in labor demands between first/second and later seasons could have had a canceling effect resulting in insignificant results.

The effect of incentives on the use of either practice suggests that farmers are more likely to implement intercropping or pot holing with decrease of fertilizer prices. This is contrary to prior expectation. All held constant, higher fertilizer prices mean the input has to be used efficiently, thus the increase in the use of pot holing whereas if fertilizer prices go down farmers are expected to implement monocropping since they put fertilizer mainly on maize. From the output point of view, the results suggest that farmers are more likely to implement pot holing with increased maize price where as for intercropping maize prices were insignificant. Shorter distance to town acted as an incentive to implement either practice. These results show the importance of accessibility to the market and locations where support services are coordinated other than the main roadside market.

Regarding services aimed at building the capacity of a farmer to produce, results in Table 21 show that program contact increased the chances of a farmer to use intercropping by a response probability change of almost 6%. In the case of pot holing the response probability change was 3%. The matching information of the odds ratio in Table 22 indicates that a farmer with agricultural support program contact was 1.4 times more likely to use intercropping and 1.6 times more likely to use pot holing than a farmer without any contact with an agricultural support program. Related studies such as Manyong et.al (1999) and Baidu-Fordson (1999) also found that farmer contact with agricultural support agents had a positive effect on farmer's choice to practice soil conservation.

The capacity of a farmer to implement intercropping appear not to be enhanced by household resources related to off-farm income sources, keeping livestock and farm implements as they were not significant. Regarding pot holing, only household resources related to keeping livestock not associated with draft power were significant.

5.2.4 Results for Ranked Practices (Ordered Logit)

This section now deals with the results from ordered logit analysis of conservation farming and other sets of conservation practices. The specific procedure to order the multiple practices is discussed in Chapter 6. There are five levels of soil conservation practices. The first level deals with zero use of soil conservation practices and the extreme end (highest level of practice) represents using all the three grouped practices (Refer back to Table 9). The interpretation of the marginal effects for the first alternative (lowest level of conservation practice) and the last alternative (highest level of soil conservation practices) is straightforward. For the lowest level, a positive value for the marginal effect means the probability of choosing the lowest level (retaining the status quo) increases whereas a negative marginal effect means the probability of shifting out of the lowest level into higher-level categories increases. Shifting out of the lowest level does not necessarily mean moving into the next level but simply means a choice probability shifts into higher categories (Borooah 2001). In the case of the highest level, a positive marginal effect implies an increased probability for the farmer to use all practices, whereas a negative marginal effect indicates increased probability for a farmer to move into lower levels of the conservation practices.

The estimated regression has a high likelihood ratio and is significant at 1% level (Table 23). This means the model has high explanatory power of the joint association of factors influencing the adoption of multiple practices. According to the predicted probability an average farmer had a probability of 12.9% not to practice any of the soil conservation practices, a probability of 36.7% to practice either a rotation related practice or soil cover with residue (second level), 31.3% probability of using a combination of rotation practices and soil cover with crop residue or reduced tillage (third level). The predicted probability to practice a combination of reduced tillage with crop residue or reduced tillage with rotation had a modest value of 8.4% (fourth level). The highest ranked practice (following all practices) had a predicted probability of 10.6%, which could also be considered as modest. The model compares quite well with the actual reported in Table 20 though it consistently overestimated.

A number of factors were found to be significant across the levels of practices though the direction of their effects as denoted by the signs of the marginal effect values on farmer's choice were varied. According to Table 23, capacity enhancing factors due to household resources such as access to off-farm income sources and livestock were not significant. Equally true was the effect of incentives arising from maize prices. This result was contrary to prior expectation that maize price would influence farmers to follow certain of the conservation practices.

A related anticipation was made on fertilizer price that if it increased, the likelihood of a farmer to follow conservation practices would also increase. This study, based on the marginal effects associated with input price, shows that this was not the case for the two obvious levels of conservation practices, namely the first and highest levels. Table 23 indicates that a farmer who is currently not using any soil conservation technology faces decreased likelihood of switching over to higher levels of conservation practices following a unit increase in the price of fertilizer. The results obtained here seem to contradict the premise of conservation and land management promoters whose underlying argument state that improved agronomic techniques that utilize crop residues and nitrogen fixation practices reduce fertilizer demands (MACO and ORGUT 2003). Increased likelihood for a farmer to use higher levels of conservation practices due to decreased input prices may be meaningful if conservation farming practices, especially pot holing reduce yield risk and increase responsiveness of fertilizer such that there is complementarity in uses. Alternatively it may be logical if agricultural support programs provided a form of subsidized credit for inputs as they promoted the practices. This state of affairs would be in line with other studies' findings that subsidized inputs act as incentives for the practice of soil conservation technologies (Huszar, 1999; Sanders and Cahill, 1999).

As noted before, no specific observation is made on the middle ranked practices (Second to fourth level practices). Just as Woodridge (2001) states, it is difficult to predict the direction of the effects of the coefficients. It suffices, therefore, just to note that the predicted probability response on the middle ranked practices due to a unit change in fertilizer is minimal (ranging from 0.03% to 0.06%). However, since price

Table 23: Marginal Effects for the Estimated Parameters: Conservation Farming Practices (Ordered Logit Regression) [a1 / a2]

Practice [b] /	No conservation practiced			Rotation or crop residue		Red. Till or crop residue & Crot		Red. Till & Crot / Red.Till & Cres		All	
Variable	Dy/dx	Z		Dy/dx	Z	Dy/dx	Z	Dy/dx	Z	Dy/dx	Z
Age	-0.0006	-1.99	**	-0.0008	-1.99	0.0005	1.99	0.0003	1.98	0.0005	1.99
Education level	-0.0044	-3.64	***	-0.0053	-3.61	0.0037	3.58	0.0023	3.57	0.0037	3.63
Program contact	-0.0391	-4.13	***	-0.0539	-3.68	0.0311	4.38	0.0227	3.67	0.0391	3.51
Farm size	-0.0026	-2.78	***	-0.0032	-2.76	0.0022	2.75	0.0014	2.75	0.0022	2.77
Adult labor	-0.0036	-1.71	*	-0.0043	-1.71	0.0030	1.71	0.0018	1.71	0.0030	1.71
Off-farm income	0.0050	0.57		0.0060	0.57	-0.0042	-0.57	-0.0026	-0.57	-0.0042	-0.58
No. livestock	0.0004	1.01		0.0004	1.00	-0.0003	-1.00	-0.0002	-1.00	-0.0003	-1.01
Tenure status	-0.1083	-3.37	***	-0.0729	-7.35	0.0879	3.75	0.0379	4.81	0.0554	5.40
Fertilizer price	0.0004	3.41	***	0.0005	3.38	-0.0004	-3.36	-0.0002	-3.35	-0.0004	-3.39
Maize price	0.0002	0.54		0.0002	0.54	-0.0001	-0.54	-0.0001	-0.54	-0.0001	-0.54
Dist. main road	-0.0008	-3.96	***	-0.0009	-3.92	0.0006	3.87	0.0004	3.88	0.0006	3.94
Dist. to town	0.0014	5.32	***	0.0017	5.25	-0.0012	-5.15	-0.0007	-5.11	-0.0012	-5.30
Dist. Feeder road	0.0096	4.32	***	0.0116	4.27	-0.0081	-4.21	-0.0050	-4.23	-0.0081	-4.30
Average rainfall	-0.0003	-4.90	***	-0.0004	-4.82	0.0003	4.75	0.0002	4.74	0.0003	4.86
Zone 1	-0.0934	-4.18	***	-0.1179	-4.16	0.0726	4.68	0.0507	4.06	0.0879	3.76
Zone 2	-0.1910	-8.49	***	-0.1970	-10.61	0.1329	10.32	0.0907	8.90	0.1644	8.13
Eastern Prov.	-0.0019	-0.08		-0.0023	-0.08	0.0016	0.08	0.0010	0.08	0.0016	0.08
Lusaka Prov.	-0.0944	-8.58	***	-0.1924	-5.94	0.0211	1.20	0.0750	6.72	0.1907	3.91
Southern Prov.	-0.0561	-3.01	***	-0.0792	-2.64	0.0434	3.49	0.0333	2.64	0.0587	2.45
Number of observations = 2524											
LR Chi2 = 371.74			P-Value = 0.000								
Predicted Prob. (Mean)	0.13			0.37		0.31		0.08		0.11	

/a1 ***, **, * denote significance at 1%, 5% and 10% level, respectively and is binding across except where shaded.
/a2 The marginal effects were computed at the Means of the parameters
/b. Red. Till = Reduced tillage; Crot = Rotation; Cres = Crop residue; All = Reduced tillage, rotation and crop residue.
Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

changes are normally in thousands it seems, based on these marginal effects, that fertilizer prices could have a substantial effect on the farmer's choice of middle ranked conservation practices. For instance, if the price for fertilizer initially at ZMK33,000.00 increased to ZMK34,000.00, which is a change of the magnitude of ZMK1000.00, a farmer faces 30 to 60-percentage point increase or decrease in the marginal probability of using the conservation practices over the previous price scenario.

The earlier expectation that a farmer who is close to the market is more likely to follow conservation practices due to the anticipated cash benefits, and easy access to agricultural development activities was tested using the marginal effects for distance to town, distance to feeder road and distance to the main road. The effect arising from distance to district town and distance to the feeder road had an expected sign of positive for the lowest level of conservation practice; it indicates that as a farmer moves further from the market and locations of support services, the probability not to implement conservation practices increases. As for the highest ranked level of conservation practices, the probability to implement them increases with close proximity to the market and places where support services are found. For all levels of conservation practices, the marginal effect of the respective distances on farmer's choice seems to be minimal but when large magnitude of the distances that may exist are taken into account proximity to market may be quite important. For instance, the marginal effect of distance from town on the choice of the highest level of conservation practices is 0.0012 (Table 23). All else held constant, if one farmer is 20 Km from town while another is 50 Km away, the former has a percentage point increase of $(50\text{-}20)*0.0012*100 = 3.6\%$ in the marginal probability of using the conservation farming practice over the latter.

The effect of the main road on the farmer's choice of higher levels of conservation practices from the level not implementing conservation practices did not have the expected sign of positive, and a sign of negative on a farmer who was using all the conservation practices. This may not be surprising as the results may simply be suggesting that very few farmers after all have access to the main road as the network for paved or well-maintained roads are limited in the country.

The factors that relate to improved management skills of farmers were significant and had expected signs. For example the predicted response probability associated with farmer contact with agricultural support programs shows that if a farmer who is currently not following any soil conservation practice has contacts with agents of agricultural development, the likelihood of that farmer following one of the conservation practices increases by approximately 4% - though not a particularly large increase in probability.

In this study the covariates that appear to have noticeable effects on farmer's choice of the conservation practices are tenure status (ranging from 4 to 11% across the various levels of soil conservation practices), geographical factors, for instance (8% to 19%) for Lusaka and physiographical factors associated with zones. The importance of physiographical factors in adoption of conservation practices also emerge in studies for Ervin and Ervin (1982), Gebremedhin and Swinton (2003) and Holden et.al. (1999). Moreover, rainfall could have a potentially very large impact even though the marginal probability coefficient is very small. As an example, the marginal probability on rainfall for the highest level is 0.0003 thus looking small. However, holding everything else constant, a household located in an area that received 1100 mm of rainfall the previous season (as opposed to being in an area that received only 800 mm of rainfall) would be:

0.0003 * (1100-800) = 0.0003*300=0.09. This is a 9 percentage point increase in the marginal probability of using the conservation farming practice. It here appears that if sufficient rainfall is received the previous season, households are encouraged to implement conservation practices.

Only household resources related to farm size and adult labor had a significant impact on the farmer's choice of the conservation farming practices. In both cases, having more of these resources increase the farmer's prospect to implement the conservation farming practices.

CHAPTER 6

DYNAMICS OF CONTINUITY OF USE OF SOIL AND WATER CONSERVATION PRACTICES

6.1 Descriptive Analysis of Abandonment of Practices

As indicated in Chapter 6, to track the use of practices among respondents over the two years, the study was guided by the following questions:

1. Did farmers use certain practices in 1999/ 2000 agricultural season but shift out of them in 2000/2001 agricultural season?
2. What differences exist in farmer and farm characteristics between those smallholders who abandoned the practices the following season and those who continued, and between those who did not use the practices in the two agricultural seasons and those who possibly used them the following season only?

According to the findings of this study, a considerable number of farmers shifted out of the previously used individual practices in the 2000/2001 agricultural season. Table 24 below shows that 12.6% of farmers who used improved fallow during the 1999/2000 did not use this practice in the subsequent season whereas 9% of those that mixed crops in the same field during the first agricultural season did not follow the practice the following season.

Table 24: Abandonment of Practices by Farmers over the Period of 1999/2000 and 2000/2001 Agricultural Season

Practice	Number of households using in 1999/2000 who abandoned	% of households using in 1999/2000 who abandoned
Mixing two or more crops in one field	48	9.0
Improved fallow	28	12.6
Pot holing / planting holes	13	6.3
Crop rotation	67	4.0
Leaving crop residues	68	5.2
Other minimum tillage practices	16	3.9

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The descriptive analysis in Table 25 tries to explain what happened at geographical level. It was found that deciding not to use individual practices in the second year varied from province to province. A large majority of farmers from Eastern Province (21.9%) shifted out of the practice of improved fallow compared to the second highest province that recorded 10.7%. In the case of leaving crop residue in the field, 10.5% of the respondents in Southern province shifted out of the practice in 2000/2001 compared to 4% in Central Province and 2.1% in Eastern Province. These figures on discontinuation of leaving crop residues in Southern Province may be due to the opportunity cost of crop residue for fodder in a region with livestock. In addition the practice of free animal grazing in all fields by the community might have been a disincentive to leave crop residues in fields.

Table 25: Farmers Abandoned Specific Practices in 2000/2001 (As a Percentage of Those Who Used the Practice in 1999/2000) by Province [a]

	Central		Eastern		Lusaka		Southern	
Type of Practice	N	%	N	%	N	%	N	%
Mixing crops in one field	13	10.5	23	7.6	5	21.7	7	8.3
Improved fallow	6	10.7	16	21.9	2	9.1	4	5.6
Pot holing	6	12.0	3	6.3	2	11.1	2	2.2
Crop Rotation	13	4.1	43	4.2	3	5.2	8	2.8
Leaving crop residue	11	4.0	12	2.1	4	5.3	41	10.5
Other minimum tillage	3	8.1	8	2.5	1	6.7	4	12 .5

/a. The percentage totals do not add up to 100 as they have been computed within cells
Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Seeing that resource endowment may vary between male households and female households, it was felt important to find out whether there was any noticeable difference between female and male farmers. Comparisons between male and female and between married and non-married farmers showed that a higher percentage of male farmers shifted out of practices than female farmers concerned (Table 26). The most distinct abandoned practice was improved fallow where 14% of the male farmers were recorded compared to no female farmers. It should, however, be mentioned that the number of females that actually implemented improved fallow in 1999/2000 were few compared to male farmers (28 compared to 194). In the case of comparisons based on marital status, pot holing was most affected among the married; 24% against 0% of the non-married farmers (inclusive of the widowed) did not use the practice the following season. Moreover, 14.4% of married farmers compared to 2.9% of non-married farmers shifted out of improved fallow. The low level of non-married farmers shifting out of pot holing and improved fallow could be due to labor constraints.

This study's finding that males surpassed the females in not continuing with the recommended practices is somehow different from the finding of MACO and ORGUT (2003) where it was indicated that the overall disadoption level of 2% could be attributed to a drop in adoption of married female category. The MACO and ORGUT study however, had a different time frame as it covered the two seasons of 2000/2001 and 2001/2002 and it did not specifically focus on individual soil conservation practices being looked at in the current study.

Table 26: Farmers Who Disadopted Specific Practices in 2000/2001 (As a Percentage of Those Who Use the Practice in 1999/2000) by Gender and by Marital Status

Type of Practice	Male	Female	Married	Not Married
	% of households		% of households	
Mixing crops in same field	9.9	5.2	9.6	6.5
Improved fallow	14.4	0	14.4	2.9
Pot holing	6.8	3.3	24.0	0
Crop Rotation	4.0	3.9	3.9	4.5
Leaving crop residue	5.2	5.6	5.1	5.9
Other minimum tillage	4.3	2.4	4.7	0

/a. The percentage totals do not add up to 100 as they have been computed within cells

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

The comparisons of disadoption based on farm size and land ownership did not reveal many differences. The practice that would be worth noting is mixing of crops in the same field. The disadoption rate among medium scale farmers was five percentage points below the small scale farmers whereas those who did not own land were nine percentage points below those who owned land (Table 27).

Table 27: Farmers Who Abandoned Specific Practices in 2000/2001 (As a Percentage of Those Who Used the Practice in 1999/2000) by Farm Size Category and by Tenure Status

Type of Practice	Small	Medium	Own land	Without land
	% of households		% of households	
Mixing crops in the same field	10	5	9	0
Improved fallow	13	10	11	13
Pot holing	6	7	6	7
Crop Rotation	5	2	4	0
Leaving crop residue	6	4	5	5
Other minimum tillage	5	0	4	0

/a. The percentage totals do not add up to 100 as they have been computed within cells

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

6.2 Statistical Comparisons Based on T-Tests of Mean Differences

This analysis looked at mean differences of farmer and farm characteristics that existed between those who abandoned the practices the following season and those who continued, and then between those who did not use the practices in the two agricultural seasons and those farmers who assumed new practices the following season. Therefore, the comparisons are made within the category of those who implemented a given practice in 1999/2000 separately, and also, separately, within the category of those that did not implement a given practice in 1999/2000 (See Table 28). Within each category means of selected variables are compared between those who continued the practice in 2000/2001 and those that abandoned the practice in 2000/2001.

The results in Table 28 indicate that there were some significant differences at 1% level between those who continued the practice of mixing of crops in the same field and those who abandoned it the following season based on land area cultivated and tenure status. Those with large cultivated areas continued the practice whilst a relatively high proportion of those who owned land shifted out of the practice. The latter result is not surprising because owning land does not necessarily lead into investment in land as studies have found mixed results. In a related study Platteau (1996) indicated that in the case of Malawi, investment in land was negatively related to land ownership or tenure security whereas Feder and others (1988) cited a study which found that there was a correlation between farm investment and index of tenure security in Costa Rica, but the positive correlation was not significant.

At 5% significance level, those with high level of schooling did not continue the practice. These results are as anticipated that increased education level is likely to bias a farmer towards monocropping. The lack of significance of this variable may also mean that those with increased level of education have access to other sources of income, which reduces their dependence on intercropping as the only risk management strategy. Furthermore, at 10% significance level, ownership of farm implements such as harrows and ploughs could be associated with the capacity to continue the practice of mixing crops in the same field (Table 28). This may suggest that implements may contribute in relieving household labor pressure for the required agronomic care.

Table 28: Descriptive Statistics of Selected Variables by Decision to Use Intercropping

	Used the Practice in 1999/2000		Did Not Use the Practice in 1999/2000	
Used the Practice in 2000/01	Yes	No	Yes	No
No. of respondents	[N = 484]	[N = 48]	[N = 78]	[N = 1914]
Variable Name	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Age of household head	47.32 (14.81)	45.62 (16.25)	43.44 (13.96)	44.80 (15.07)
Number of labor unit	3.95 (2.17)	3.94 (2.04)	3.47 (1.92)	3.72 (2.33)
Level of schooling	1.16 (0.94)	1.48** (1.07)	.96 (0.73)	1.18** (0.95)
Area cultivated (Ha)	1.20 (1.29)	.86*** (0.72)	.87 (1.00)	1.14** (1.25)
Owned farm equipment	.32 (0.48)	.21* (0.41)	.18 (0.39)	.33*** (0.47)
Support program contact	.25 (0.43)	.23 (0.42)	.22 (0.42)	.19 (0.39)
Land tenure status	.97 (0.17)	1.00 *** (0.00)	.96 (0.19)	.94 0.23)

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Age, contrary to expectation, had no role in a farmer being consistent in using practices such as intercropping. This, understandably, could be due to most farmers' indication that they learned intercropping as a traditional practice. This may imply that the practice has become a standard procedure among farmers.

A comparison between those who did not use intercropping in the first season but attempted the following season and those that did not attempt at all in both seasons, the results indicate that at 1% significance level a higher proportion of those who owned farm equipment did not attempt at all in both seasons. It appears here that those who did not own implements now decided to implement intercropping the following season. The findings here seem to give mixed results where by implements appear to be associated with adoption and disadoption. It leaves, in this case, the role of implements on farmer's continued use of this practice inconclusive. The results further show that at 5% significance level, those farmers with higher level of schooling, tended not to use intercropping at all (Table 28), as was the case with farmers that had draught power and those that cultivated larger land areas. This could probably be suggesting that those with higher schooling or have more wealth have other risk reduction options other than intercropping. In addition, the past promotion of pure crop stands by crop researchers and extension agents against mixed cropping (Jalloh 2001) could have gained much acceptance amongst the more educated or wealthier farmers and continue to prevail to date.

For the practice of improved fallow, those with a younger age did not continue with the practice at the 1% significance level (Table 29). Generally, studies have found age not to be associated with the practice of a given technology. For the practice of improved fallow in eastern part of Zambia, Place et al. (2002) found only farm size to be associated with the practice of this technology. Possibly the young aged farmers did not continue due to opportunity cost associated with small farm size. A closely related finding in this study could be the significant difference that existed in land area planted between those that opted to use the practice in 2000/2001 (within the 'did not use the practice in 1999/2000 category') and those that maintained the status of not using in 2000/2001.

The finding of this study with respect to agricultural support program is not as anticipated. A larger proportion of farmers who had contact with agricultural support programs did not continue using improved fallows when tested at 10% significance levels. Also, with respect to labor, this study found that labor did not have any significant impact between those who did not continue the practice and those that continued to use the practice.

Within the category of those that did not use improved fallow in 1999/2000, quantity of labor, area cultivated, ownership of farm equipment, and access to support programs were significant at 1% to 10% level. Poor access to support services or low resources could be associated with those who did not attempt the practice at all in both years (See Table 29). It appears here that labor emerged as a constraint such that those with less household labor units did not attempt the practice.

Those who stated that they followed the practice in both years were comparable in number of personal labor units to those that decided to start the practice in 2000/2001. This seems to suggest that labor may be important in using improved fallow, which could be in line with the findings of studies such as Thangata et al. (2002). Their study in Kisungu, Malawi, concluded that sufficient labor could lead a household to adopt improved fallow. The finding of this study contradicts Kwesiga et al.(2003) who appears to suggest that farmers in eastern Zambia could use improved fallow without any additional requirement of labor as farmer's main cropping strategy. The results are probably not comparable due to the localization of the study and differences in method of analysis.

In the case of pot holing, very few variables were significant (Table 30). Those who did not have access to agricultural support program were more likely to use pot holing in both years compared to those who abandoned the practice the following season. Further indications are that those with labor constraints did not use pot holing in both years. This may reflect the relatively high labor needed for establishment of the system. Lower level of schooling or non-ownership of farm equipment could be associated with those who are less likely to have used the practice in both years.

Table 29: Descriptive Statistics of Selected Variables by Decision to Implement Improved Fallow

	Used the Practice in 1999/2000		Did Not Use the Practice in 1999/2000	
Used the Practice in 2000/01	Yes	No	Yes	No
No. of respondents	[N = 194]	[N = 28]	[N = 50]	[N = 2252]
Variable Name	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Age of household head	49.22	40.50***	44.78	44.98
	(15.54)	(10.12)	(13.96)	(15.02)
Number of labor unit	4.51	4.39	4.48	3.67 *
	(2.76)	(2.94)	(2.87)	(2.20)
Level of schooling	1.35	1.36	1	1.16
	(0.90)	(0.95)	(0.90)	(0.95)
Area cultivated (Ha)	1.38	1.31	1.54	1.11 **
	(1.42)	(1.41)	(1.32)	(1.22)
Owned farm equipment	0.43	0.39	0.54	0.30 ***
	(0.50)	(0.50)	(0.50)	(0.46)
Support program contact	0.25	0.43 *	0.34	0.19 **
	(0.43)	(0.50)	(0.48)	(0.40)
Land tenure status	0.96	0.96	0.98	0.95
	(0.19)	(0.19)	(0.14)	(0.22)

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

In the within category of those farmers that implemented crop rotation in 1999/2000 season, less labor, low level of schooling, and lack of farm equipment could each be associated with those that disadopted this practice in the following season (Table 31). The results here are suggesting that education may play a part in enhancing the capacity of farmer understanding of the practice. When ownership of farm equipment and opportunities to grow cash crops are associated with capacities to generate and access wealth, it is of little surprise to see those with none of these being under pressure to grow a food crop every year on the same land.

Table 30: Descriptive Statistics of Selected Variables by Decision to Implement Pot Holing

	Used the Practice in 1999/2000		Did Not Use the Practice in 1999/2000	
Used the Practice in 2000/01	Yes	No	Yes	No
No. of respondents	[N = 194]	[N = 13]	[N = 50]	[N = 2252]
Variable Name	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Age of household head	45.52 (14.20)	46.08 (12.24)	46.12 (13.01)	45.22 (15.15)
Number of labor unit	4.15 (2.62)	3.85 (2.41)	4.65 (2.14)	3.71 ** (2.26)
Level of schooling	1.32 (0.98)	1.54 (0.97)	1.50 (1.13)	1.16 * (0.94)
Area cultivated (Ha)	0.99 (0.85)	0.78 (0.57)	1.55 (1.15)	1.15* (1.27)
Owned farm equipment	0.27 (0.45)	0.38 (0.51)	0.50 (0.51)	0.32 ** (0.47)
Support program contact	0.19 (0.39)	0.62 *** (0.51)	0.24 (0.43)	0.20 (0.40)
Land tenure status	0.93 (0.25)	0.92 (0.28)	0.97 (0.17)	0.95 (0.22)
Grew purely cash crop	0.18 (0.39)	0.38 (0.51)	0.38 (0.49)	0.23 * (0.42)

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

In the within category of those that did not implement crop rotation in 1999/2000, household labor, level of schooling, owning farm equipment were each important for a farmer attempting the practice in 2000/2001 (Table 31).

As for leaving crop residues in the field, age of household head, level of schooling, area cultivated, ownership of farm equipment, contact with agricultural support programs and growing cash crops were significant (See Table 32). All variables were significant at 1% level except for level of schooling and area cultivated which were significant at 5% and 10% levels, respectively. Farmers associated with larger cultivated land areas or higher levels of schooling or those with farm equipment are more likely to abandon the practice in the subsequent season. It appears that level of education does not have an influence on continued use of leaving crop residues. This may simply be confirming that the practice is not highly technical requiring high schooling.

Table 31: Descriptive Statistics of Selected Variables by Decision to Implement Crop Rotation

	Used the Practice in 1999/2000		Did Not Use the Practice in 1999/2000	
Used the Practice in 2000/01	Yes	No	Yes	No
No. of respondents	[N = 1617]	[N = 67]	[N = 55]	[N = 785]
Variable Name	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Age of household head	45.53 (14.72)	45.45 (16.97)	44.89 (15.25)	44.70 (15.50)
Number of labor unit	3.92 (2.35)	3.27 *** (1.86)	3.42 (1.88)	3.50 (2.19)
Level of schooling	1.21 (0.94)	0.94 ** (0.90)	1.18 (1.00)	1.13 (0.96)
Area cultivated (Ha)	1.20 (1.16)	1.06 (1.11)	0.82 (0.84)	1.06 * (1.41)
Support program contact	0.27 (0.45)	0.21 (0.41)	0.16 (0.37)	0.06 (0.24)
Land tenure status	0.97 (0.18)	1.00 ** (0.00)	0.96 (0.19)	0.91 *** (0.28)
Grew purely cash crop	0.30 (0.46)	0.10 *** (0.31)	0.13 (0.34)	0.08 *** (0.28)

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

In the within category of farmers that did not implement the practice in 1999/2000 season, those that still did not leave crop residue in 2000/2001 could be associated with farmers that did not own land, or those that had no contacts with agricultural support programs or those that owned farm equipment than those that attempted the practice in 2000/2001 season (Table 32). Land tenure was significant at 1% level while the others were significant at 10% level. What we see here is that a farmer could be influenced to start covering soil with residue if s(he) has land or accesses program support services that build human capital.

Table 32: Descriptive Statistics of Selected Variables by Decision to Leave Crop Residue after Harvest

	Used the Practice in 1999/2000		Did Not Use the Practice in 1999/2000	
Used the Practice in 2000/01	Yes	No	Yes	No
No. of respondents	[N = 1232]	[N = 68]	[N = 25]	[N = 1199]
Variable Name	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
Age of household head	46.25 (15.23)	40.57 *** (12.25)	42.32 (14.92)	44.56 (14.90)
Number of labor unit	3.96 (2.41)	4.06 (3.09)	3.28 (1.51)	3.55 (2.09)
Level of schooling	1.20 (0.95)	1.47 ** (1.03)	1.08 (0.76)	1.14 (0.93)
Area cultivated (Ha)	1.22 (1.29)	1.65 * (1.95)	0.88 (0.63)	1.04 (1.13)
Owned farm equipment	0.37 (0.48)	0.59 *** (0.50)	0.12 (0.33)	0.25 * (0.43)
Support program contact	0.23 (0.42)	0.12 *** (32)	0.36 (0.49)	0.18 * (0.38)
Land tenure status	0.96 (0.21)	0.96 (0.21)	1.00 (0.00)	0.94 *** (0.23)
Grew purely cash crop	0.25 (0.43)	0.09 *** (0.29)	0.24 (0.44)	0.21 (0.41)

***, **, * denote variable significant at 1%, 5% and 10% level, respectively.

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

CHAPTER 7

DISCUSSION OF RESULTS AND IMPLICATIONS

7.1 Pot holing and Intercropping

The important factors for using intercropping were comparable to pot holing on the aspect of accessibility to market and support services, based on proximity to district town (Table 21). These practices need accompanying services for them to be used. For example pot holing is a water conservation practice and the extension message for pot holing indicates using fertilizer. Considering that fertilizer becomes more expensive as the farmer gets further from the distribution point (which generally is the district town) due to increased costs of service delivery, it may be of little surprise that farmer's choice for the practices is negatively influenced by input prices. The consistence of this view as relates to cost of inputs or provision of services when distance from the hub of activities increases is supported by the negative relationship of the distance to feeder road for the practice of pot holing (Table 21).

Moreover, improved accessibility is equally important for reduced transaction costs that could be reflected in improved maize prices, which seem to be incentives for implementation of pot holing. The importance of output prices as incentives for adoption of soil conservation practices have also been echoed in literature and studies by Sanders and Cahill (1999), Reardon and Vosti (1997a) and Bekele (2003). This means that creating an environment facilitating favorable prices to farmers, while at the same time not creating disincentives to other sectors could increase the likelihood of farmers to follow pot holing practices. The above discussion is not meant to give an impression that the only things that matter for the farmer to follow conservation practices are incentives such as improved market accessibility. Just as Malla (1999) tries to explain about market accessibility being not a sufficient condition, this study notes that physiographical constraints associated with Zone 1 and Zone 2 and then the geographical factors associated with Central Province are equally important for the practice of intercropping. In the case of pot holing, the physiographical factors associated with zones are not critical but what matters most are the geographical factors associated with Southern Province. There could be a number of reasons why pot holing is relevant to Southern Province. The Province has been worst hit in terms of cattle mortalities and it has been experiencing a declining trend in rainfall; the rain season appears to have been getting shorter and shorter over the years. Thus, farmers could have used this practice as a risk reduction option, which is closely related to the findings of Keyser and Mwanza (1996). Their study found that farmers were using this practice not because of the desire to conserve soil but because they considered themselves poor which again well agrees with this study's result for adjusted number of livestock (Table 21).

The two practices are not comparable on the aspect of farmer experience conveyed by age of the household head. For intercropping, experience plays a role though minimal while for pot holing experience did not seem to have any significant impact on the farmer's choice for the practice. Moreover, as should be expected, a farmer who does not have the capacity afforded by livestock is more likely to use pot holing. A further point of divergence is the capacity afforded by household resources related to family labor and owning land. Both resources appear to be more relevant to the implementation of intercropping than pot holing. The dynamic nature of pot holing requires understanding the stage of establishment of this practice hence the results obtained by this study could not be used to categorically state that labor is not an issue regardless of the stage.

7.2 Individual Practices in General

The indication of the majority of farmers that they learned crop rotation as a traditional practice may be a source of concern whether such farmers have their version of the practice contrary to crop husbandry recommendations (Table 13). Indeed, adoption literature has indicated that farmers adapt the technologies (CIMMYT 1993) and most likely this may be the case here. The particular concern here is whether the practice is being used such that farmers are achieving all the possible benefits.

The practice of leaving crop residues as a fertility enhancing technology still needs to be evaluated. As with crop rotation, most farmers learned to leave crop residues as a traditional practice (Table 13). Again here the issue of concern is whether the practice is an adapted version of the practice that is promoted. In addition, the high prevalence of this practice in Zone 1 (Table 17) where livestock rearing is still prominent may call into question whether cattle graze the residues that are left in the fields. According to Sanders and Cahill (1999) there are many incentives and disincentives. The culture of cattle rearing in Southern Province is such that fields more or less become common property after harvest to the effect that animals from any quarter are free to wander in the fields, reducing the private incentive to leave residues in the field for soil conservation purposes.

7.3 Ranked Conservation Practices

Ranked conservation practices (conservation farming and other sets of conservation practices) revealed interesting results most of which are in line with theory.

The importance of tenure status and building management ability has emerged in this study (Table 23). Moreover, farmers invest in conservation farming practices with due consideration to physical constraints associated with physiographical factors and climatic factors (e.g. rainfall) in line with the observations of Clay et al. (2002), Ervin and Ervin (1982), Reardon and Vosti (1997a) and Gebremedhin and Swinton (2003). This implies that identifying locations with similar physical constraints and targeting the necessary support services and incentives could influence farmers to implement the conservation practices.

The work of building human capital has a cost implication in terms of building more schools, providing adequate health facilities so as to increase life expectancy at birth. Closely linked to this aspect of health could be the need to watch for the debilitating effects of the scourge of HIV-AIDS on human capital, which currently is estimated to affect 20% of the population (Saasa 2003). The scourge may be a drain on skilled and experienced household labor.

The facilitating role of the government is still cardinal in order to improve farmer contact with program support activities. The services agricultural support agents provide entail transport costs for instance, which are exacerbated by poor road conditions. Therefore appropriate attention to roads would not only facilitate the provision of support services but also would reduce market transaction costs from farmer's point of view.

7.4 What key factors might hasten disadoption?

The importance of building human capital, and increasing household resources related to labor for the continuation of rotation practices emerged. This may be plausible for indeed lower education level may be associated with less efficient use of new technologies and inadequate labor may result in small cultivated land areas. The capacity to only cultivate small areas may be a constraint on a farmer to plant crops other than those perceived by the farmer to be crucial to the household food security. The importance of improved manageability through program support services is well in line with observations by Gladwin et al. (2002) that practices such as improved fallow are knowledge intensive whereas the study of Manyong et al. (1999) reveal the importance of extension contact.

The abandonment of leaving crop residue after harvest by younger farmers makes sense as they characterize a farmer that has reduced capacity to farm and use the practice. Youth may be associated with lack of experience to adapt practices for best use on the farms. As for pot holing, the discussion on what possible factors may hasten the disadoption of this practice is approached with caution. The study's finding that farmers that had access to agricultural support programs were more likely to disadopt the practice the following season may have two interpretations: (1) The support programs that farmers accessed did not lay much emphasis on reduced inversion practices such that farmers did not implement the practice in a way to achieve the benefits, or (2) the farmers were no longer eligible to participate or they did not desire to participate in programs that required use of specific practices. If farmers did not see the benefits of practices, removal of program inducements could have resulted in discontinuing the practices.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion of this Study

This study embarked on understanding the factors that influenced the use of conservation farming and other sets of conservation practices. The findings show that addressing conditions that may inhibit financial incentives arising from reduced production costs and accessibility to source of support services would positively influence farmers to implement conservation farming and other sets of practices. In addition, building management capability (human capital) through farmer training while at the same time ensuring there is no drain on human capital due to mortalities would also improve the adoption of conservation practices. Equally important is the revelation that practices could be associated with certain physiographical conditions hence necessitating the need to target support services such as extension services that build management skills and that translate into financial incentives among farmers.

The study found that intercropping appears to have been used as a risk reduction strategy in least rainfall areas. Contrary to expectation however, it is a farmer who is in Central Province that is likely to follow the practice instead of a farmer in Southern Province. Pot holing did not appear as a risk reduction option for zones with erratic rainfall. The practice, however, is more likely to be used by a farmer in Southern Province than a farmer in Central Province probably due to the decimation of cattle stocks. Generally, there appears to be a lot of room for support programs to promote reduced tillage among farmers since few of them indicated that they learned about it through traditional sources. However, the impact of labor on the choice of pot holing for now remains unclear due to the dynamic nature of the practice.

The study on farmer's disadoption of practices found that intercropping or improved fallow require sufficient labor and improved management ability. The probable factors that may lead farmers to abandon rotation practices are those that undermine the build-up of management ability (human capital), and deplete household resources related to labor. In the case of the practice of soil cover with crop residue, drain on experienced household heads play a big role in influencing a farmer to abandon this practice. Moreover, the exact cause of its abandonment in Southern Province is not very clear. For now one of the possible explanations is that the practice became expensive due to the continued drop in level of rainfall or because animal fodder needs became an overriding factor.

This study had some data limitations, which limit the generalization of the findings. The nature of the questions in the instruments used to take the observations did not allow further investigations on the technologies being practiced. For example, as mentioned before, crop rotation was based on what the farmer declared and not on the observation of an enumerator.

Moreover, the practice of intercropping still remains difficult to deal with. Many people intercrop for a variety of reasons that have nothing to do with conservation. This requires well-tailored questions to solicit the farmer's intent in using individual practices related to soil conservation. For future studies it would be worthwhile to look at farmer practices against the background that farmers do make adjustments to the recommended practices and follow certain practices for various reasons. To have a general sense of where farmers stand with regard to given practices studied, future research will have to precisely measure what farmers are actually using. This approach will need also to clarify what exactly these practices are which farmers indicated were learned as traditional practices.

The current study only managed to track farmers' practices over two years but did not attempt to find out if the farmers did intend to use a given technology again in year three. Even though intentions are not very reliable, the information could have assisted in establishing whether the discontinuation was likely to be temporal or not. The study does indicate that farmers are trying new things as well as dropping some practices. Thus looking at both adoption and disadoption provides valuable information, but a longer time frame would be valuable.

8.2 Recommendations from This Study

The specific recommendations this study envisages would enhance the practice of soil conservation practices are:

1. The road infrastructure, more especially the feeder roads have consistently emerged as an important factor in most of the practices. They should be developed to facilitate market access and shorten the effective distance to town. This would increase the likelihood of using the practices especially those that showed that they have a negative relationship with the input prices, Furthermore, infrastructure enables relatively easy flow of information that could improve the agronomic practices and facilitate well informed production and marketing decisions.
2. Agricultural support programs should carefully evaluate what they are doing, their incentive structures and so forth as they promote the soil and water conservation

practices among farmers. This course of action will reduce the costs incurred on training farmers who in the process disadopt the practices.

3. The dissemination of appropriate practices should be cognizant of farmers' role in conveying information to their fellow farmers. The indication by a moderate proportion that they learned the practices through fellow farmers should be exploited. The double pronged approach in trying to reach out to farmers will result in rationalization of resources.
4. The farmers' know-how on practices related to soil conservation appears to be based on what farmers learned from their predecessors. It is therefore, important to establish if farmers are appropriating the intended benefits of the recommended practices. This will facilitate well tailored intervention in promoting soil conservation practices where appropriate.
5. The factors cited as likely to affect farmers to abandon conservation practices (e.g. lack of management ability (human capital), declining household resources such as labor) should be well monitored and where need be appropriate recourse should be designed.

This study has found that increasing maize prices could be an incentive to smallholder farmers in Zambia to use pot holing. Nevertheless, conservation farming practice as a package, and its pieces or sets of its elements appear not to be influenced by maize price incentive. Increased maize price may not negatively affect farmer's use of intercropping possibly due to household's desire to insure against crop failure and unanticipated decline in market prices. On the input side, reduced fertilizer prices may act as an incentive for smallholder's adoption of conservation practices considered by this study. The premise that raising fertilizer prices would increase the likelihood of farmers to implement the fertility enhancing technologies has not been supported by the findings of this study. Therefore, development of alternative technologies to inorganic fertilizer still remains a challenge. Furthermore, intercropping is possibly a risk reducing strategy for low rainfall areas of Central Province but for drier areas of Southern Provinces pot holing appear to be more relevant as a risk reduction option.

Improved management ability, sufficient household resources related to labor and stable tenure status, are factors that give a farmer the capacity to act and are important for the implementation of most of the conservation practices. Therefore, policy directions aimed at building human capital, while at the same time reducing mortalities as a way of retaining skilled capital, is a way forward to promote the practices. This same step will ensure a greater likelihood of farmer's continued use of practices. The importance of physiographical factors in this study underscores the need to streamline support and intervention efforts to specific areas. The cost of service delivery could be minimized by improved infrastructure, which at the same time could improve farmer accessibility to the market and support services especially found in district towns.

APPENDICES

Appendix 1: Technology Adoption Tables

Table A1.1: Soil Conservation Practice by Level of Education for Farmers who Traditionally Learned About the Practices

Level of education		Did you use this practice? No	Did you use this practice? Yes	Total
None	Count	22	503	525
	% within Level of education	4.2	95.8	100.0
	% within Did you use this practice?	26.5	22.8	22.9
Primary	Count	48	1197	1245
	% within Level of education	3.9	96.1	100.0
	% within Did you use this practice?	57.8	54.2	54.3
Junior level secondary	Count	7	255	262
	% within Level of education	2.7	97.3	100.0
	% within Did you use this practice?	8.4	11.5	11.4
Senior level secondary	Count	2	213	215
	% within Level of education	.9	99.1	100.0
	% within Did you use this practice?	2.4	9.6	9.4
Equivalent to college level	Count	4	41	45
	% within Level of education	8.9	91.1	100.0
	% within Did you use this practice?	4.8	1.9	2.0
Total	Count	83	2209	2292
	% within Level of education	3.6	96.4	100.0
	% within Did you use this practice?	100.0	100.0	100.0

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table A1.2: Classification of Districts by Rainfall Level

	Annual average rainfall level		
District	Least Rainfall	Lower Rainfall	Higher Rainfall
Chibombo	0	*	0
Kabwe Urban	0	*	0
Kapiri Mposhi	0	*	*
Mumbwa	0	*	0
Chadiza	0	*	0
Chama	0	*	*
Chipata	0	*	0
Katete	0	*	0
Lundazi	0	*	0
Mambwe	*	*	0
Nyimba	*	*	0
Petauke	*	0	0
Chongwe	*	*	0
Choma	*	0	0
Gwembe	*	*	0
Kalomo	*	0	0
Kazungula	*	*	0
Livingstone	*	*	0
Mazabuka	*	0	0
Monze	*	0	0

* denotes rainfall zone of the respective districts. Some districts have area in more than one rainfall zone.
Source: Compilations based on Meteorological Department Data

Table A1.3: Summary Statistics for Quartiles of Labor

Quartiles of Labor	Mean	Range	Maximum	Minimum
1	1.88	1.00	2.00	1.00
2	3.00	.00	3.00	3.00
3	4.00	.00	4.00	4.00
4	6.66	18.00	23.00	5.00

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table A1.4: Summary Statistics for Quartiles of Land Area Cultivated

Quartiles of Land Area Cultivated (Ha)	Mean	Range	Maximum	Minimum
1	.32	.34	.40	.06
2	.58	.35	.76	.40
3	.97	.51	1.27	.76
4	2.69	13.73	15.00	1.28

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Table A1.5: Quartiles of Land Area cultivated * Farm Equipment Crosstabulation

		Farm equipment		
Quartiles		No	Yes	Total
1	% Within quartiles of land area	88.6	11.4	100.0
2	% Within quartiles of land area	79.1	20.9	100.0
3	% Within quartiles of land area	69.4	30.6	100.0
4	% Within quartiles of land area	35.8	64.2	100.0
Total	% Within quartiles of land area	68.2	31.8	100.0

$X^2 = 2766.88$; $P = 0.000$

Source: Post Harvest Survey 1999/2000 and Supplemental Survey 1999/2000

Appendix 2: Abandonment of Practices

Procedure Used to Compute Abandonment of Practices

The computations for abandonment of practices were made as follows:

$$\frac{\sum \Pr act99_{ik} - \sum \Pr act00_{ik}}{\sum \Pr act99_{ik}}$$

Where,

$\Pr act99_{ik} = 1$ if individual *i,* used a specific practice in 1999/2000, otherwise 0

$\Pr act00_{ik} = 1$ if individual *i,* again used a specific practice in 2000/2001, otherwise 0

k = specific type of practice used by an individual farmer.

The simplified meaning of the expression above is: (Total number of individuals that only implemented practice, *k* in 1999/2000 ÷ Total number of individuals that implemented practice, *k* in 1999/2000).

The above expression gives a proportion of farmers that did not continue with the same practice the following year. For instance mixing of two crops or more in one field is calculated as:

$$\frac{532 - 484}{532} = \frac{48}{532} = 9\%$$

Total number of individuals that used mixed cropping in 1999/2000 = 532
Total number of individuals that again used mixed cropping in 2000/2001 = 484
Number of individuals that abandoned the practice of mixed cropping the following year = 532 – 484 = 48.

REFERENCES

Baidu-Forson, J. (1999). "Factors influencing adoption of land-enhancing technology in the Sahel: lessons from a case study in Niger." Agricultural Economics **20**: 231 - 239.

Banda, F. A. (2002). Zambia Agrometeorological Bulletin; Issue No. 09. Lusaka, Zambia, Meterological Department.

Barlowe, R. (1978). Land Resource Economics, Englewood Cliffs, N.J: Prentice Hall.

Bebbington, A. (1999). "Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty." World Development **27**(12): 2021-2044.

Bekele, W. (2003). Theory and Empirical Application to Subsistence Farming in the Eastern Ethiopian Highlands. PhD dissertation, Department of Economics, Swedish University of Agricultural Sciences.

Borooah, V. K. (2001). Logit and Probit: Ordered and Multinomial Models. New Delhi, Sara Miller McCune, SAGE Publications.

BOZ (2003). Zambia Agricultural Investment Promotion Conference. Lusaka, Bank of Zambia, CDC Capital Partners.

Chelemu, K. and P. Nindi (1999). Conservation Tillage for Soil and Water Conservation Using Draft Power in Zambia. Meeting the Challenges of Animal Traction. A Resource Book of the Animal Traction Network for Eastern and Southern Africa. P. Starkey and P. Kaumbutho. London, Intermediate Technology Publications.

CIMMYT (1993). The Adoption of Agricultural Technology: A Guide for Survey Design. Mexico, International Maize and Wheat Improvement Center.

Clay, D. C., V. Kelly, E. Mpyisi and T. Reardon (2002). Input Use and Soil Conservation Investments among Farm Households in Rwanda: Patterns and Determinants. Natural Resources Management in African Agriculture. C. B. Barrett, F. Place and A. A. Aboud. New York, NY, CABI International.

Clearfield, F. and T. B. Osgood (1986). Socilogical Aspects of the Adoption of Conservation Practices. Washington D C, Soil Conservation Service.

Ellison, G. and D. Fudenberg (1993). "The Rules of Thumb of Social Learning." Journal of Political Economy **101**(4): 612-643.

Ervin, C. A. and D. E. Ervin (1982). "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, evidence and Policy Implications." Land Economics **58**: 277-292.

FAO (2001). The Economics of Conservation Agriculture. Rome, Food and Agriculture Organization of the United Nations.

FAO (2001). Economics of Soil Productivity in Sub-Saharan Africa. Rome, Food and Agriculutre Origanization of the United Nations.

Feder, G., R. E. Just and D. Zilberman (1985). "Adoption of Agricultural Innovations in Developing Countries: A Survey." Economic Development and Cultural Change **33**: 255-298.

Feder, G., T. Onchan, Y. Chalamwong and C. Hongladarom (1988). Land Policies and Farm Productivity in Thailand. Baltimore, MD, Johns Hpopkins University Press.

Fernandez-Cornejo, J., C. Alexander and R. E. Goodhue (2002). "Dynamic Diffusion with Disadoption: The Case of Crop Biotechnology in the USA." Agricultural and Resource Economics Review **31**: 112-126.

Field, B. C. (2001). Natural Resource Economics - An Introduction, New York, NY: McGraw Hill.

Gebremedhin, B. and S. M. Swinton (2003). "The Role of Land Tenure Security and Public Programs." Agricultural Economics **29**: 69-84.

Gladwin, C. H., J. S. Peterson, D. Phiri and R. Uttaro (2002). Agroforestry Adoption Decisions, Adjustment and Gender in Zambia. Natural Resources Management in African Agriculture. C. B. Barrett, F. Place and A. A. Aboud. New York, NY, CABI International.

Greene, H. W. (2003). Econometric Analysis, Upper Saddle River, N.J: Prentice Hall.

Haggblade, S. and G. Tembo (2003 a). Conservation Farming in Zambia. Lusaka, IFPRI and FSRP - MSU.

Haggblade, S. and G. Tembo (2003 b). Development, Diffusion and Impact of Conservation Farming in Zambia. Lusaka, IFPRI and FSRP - MSU.

Haggblade, S., G. Tembo and C. Donovan (2004). Household Level Financial Incentives to Adoption of Conservation Agricultural Technologies in Africa. East Lansing, Michigan State University (FSRP).

Holden, S. T. and B. Shiferaw (1999). Incentives for Sustainable Land Management in Peasant Agriculture in Ethiopian Highlands. Incentives in Soil Conservation:

From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Huszar, P. C. (1999). Justification for Using Soil Conservation Incentives. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Jalloh, A. (2001). Promoting Appropriate Intercropping Technologies for Sustainable Agricultural Production in Africa: a farmer centered approach. Freetown, Siera Leone, Institute of Agricultural Research.

Kerr, J., G. Pangare, L. V. Pangare and P. J. George (1999). Effect of Watershed Project Subsidies on Soil and Water Conservation Investments in India's Semi-arid Tropics. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Keyser, J. and M. H. Mwanza (1996). Conservation Tillage. Lusaka, Zambia, The Institute of African Studies, University of Zambia.

Knepper, E. T. (2002). Factors Affecting the Use of Fertilizer by Small and Medium-Sized Farming Households in Zambia, 1997 to 2000. Masters' Thesis, Department of Agricultural Economics, Michigan State University: 109.

Knox, A., R. Meinzen-Dick and P. Hazell (1998). Property Rights, Collective Action and Technologies For Natural Resource Management. Washington, D.C, IFPRI.

Kwesiga, F., S. Franzel, P. Mafongoya, O. Ajayi, D. K. Phiri, E. Rosa , K. kantashula, F. Place and T. Chirwa (2003). Improved Fallows in Eastern Zambia: History, Farmer Practice and Impacts. Pretoria, IFPRI, NEPAD, CTA.

MACO and ORGUT (2003). Land Management and Conservation Farming: 1999-2002 Completion Report. Lusaka, Zambia, Ministry of Agriculture and Cooperatives, Field Services Department.

Malesu, M. and K. Luputa (1999). Impact Assessment Study of SCAFE Activities in Eastern Province. Lusaka, Zambia, Land Management and Conservation Farming SCAFE Project.

Malla, Y. B. (1999). Tree Management and Household Strategies in a Changing Rural Economy: Beyond the Use of Direct Incentives. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Manyong, V., V. Houndekon, P. Sanginga, P. Vissoh and A. Honlonkou (1999). Macuna Fallow Diffusion in Southern Benin. Ibadan, International Institute of Tropical Agiculture.

Marra, M. C., B. J. Hubbell and G. A. Carlson (2001). "Information Quality, Technology Depreciation, and Bt Cotton Adoption in the South East." Journal of Agricultural and Resource Economics **26**(1): 158-175.

McConnell, K. E. (1983). "An Economic Model of Soil Conservation." American Journal of Agricultural Economics **65**(1): 83-89.

Mukherjee, C., H. White and M. Wuyts (1998). Econometrics and Data Analysis for Developing Countries. London; New York, Routledge.

Mulenga, N. (2003). Conservation Farming in Zambia. Lusaka, Technical Services Branch, MACO.

Nibbering, J. W. (1999). Land Use Change in Upland Java: Incentives and Opportunities. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Norris, P. E. and S. E. Batie (1987). "Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis." Southern Journal of Agricultural Economics **19**(1): 79-80.

Pagiola, S. (1999). Economic Analysis of Incentives of Soil Conservation. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Place, F., S. Franzel, J. Dewolf, R. Rommelse, F. Kwesiga, A. Niang and b. Jama (2002). Agroforestry for Soil Fertility Replenshment: Evidence on Adoption Processes in Kenya and Zambia. Natural Resources Management in African Agriculture. C. B. Barrett, F. Place and A. A. Aboud. New York, NY, CABI International.

Platteau, J.-P. (1996). "The Evolutionary Theory of Land Rights: A Critical Assessment." Development and Change **27**: 29-49, 72-77.

Rajasekharan, P. and S. Veeraputhran (2002). "Adoption of intercropping in rubber smallholdings in Kerala, India: a tobit analysis." Agroforestry Systems **56**(1): 1-11.

Reardon, T. and S. A. Vosti (1995). "Links Between Rural Poverty and the Environment in Developing Countries: Asset Categories and Investment Poverty." World Development **23**(9): 1495-1506.

Reardon, T. and S. A. Vosti (1997 a). Policy Analysis of Conservation Investments: Extension of Traditional Technology Adoption Research. Sustainability, Growth, and Poverty Alleviation. T. Reardon and S. A. Vosti. Baltimore, The Johns Hopkins University Press.

Reardon, T. and S. A. Vosti (1997 b). Poverty-Environment Links in Rural Areas of Developing Countries. Sustainability, Growth, and Poverty Alleviation. T. Reardon and S. A. Vosti. Baltimore, The Johns Hopkins University Press.

Saasa, O. S. (2003). Macro Study - Agricultural Intensification in Zambia: The Role of Policies and Policy Processes. Lusaka, Zambia, Institute of Economic and Social Research, University of Zambia.

Sadoulet, E. and A. de Janvry (1995). Quantitative Development Policy Analysis. Baltimore, Maryland, The Johns Hopkins University Press.

Sanders, D. W. and D. Cahill (1999). Where Incentives Fit in Conservation Programs. Incentives in Soil Conservation: From Theory to Practice. D. W. Sanders, P. C. Huszar, S. Sombatpanit and T. Enters. Enfield, New Hampshire, Science Publishers Inc.

Sayre, K. D., M. Mezzalama and M. Martinez (2001). Tillage, Crop Rotation and Crop Residue Management Effects on Maize and Wheat Production for Rainfed Conditions in the Altiplano of Central Mexico. Mexico, CIMMYT.

Scherr, S. J. (2000). "A downward spiral? Research evidence on the relationship between poverty and natural resource degradation." Food Policy **25 (200)**.

Shaw, A. B. (1985). "Constraints on Agricultural Innovation Adoption." Economic Geography **61**(1): 25-45.

Shiferaw, B. and S. T. Holden (2000). "Policy Instruments for Sustainable Land Management: the case of highland smallholders in Ethiopia." Agricultural Economics(22): 217-232.

Siachinji-Musiwa, J. M. (1999). Conservation Tillage in Zambia: Some technologies, indigeneous methods and environmental issues. Meeting the Challenges of Animal Traction. A Resource Book of the Animal Traction Network for Eastern and Southern Africa. P. Starkey and P. Kaumbutho. London, Intermediate Technology Publications.

Swinton, S. M. and R. Quiroz (2003). "Is Poverty to Blame for Soil, Pasture and Forest Degradation in the Peru's Altiplano." World Development **31**(11): 1903-1919.

Swinton, S. M. and R. Quiroz (2003). "Poverty and the Deterioration of Natural Soil Capital in the Peruvian Altiplano." Environment, Development and Sustainability **5**: 477-490.

Thangata, P. H., P. E. Hilderbrad and C. H. Gladwin (2002). Modelling Agroforestry Adoption and Household Decision Making in Malawi, African Studies Quarterly - The Online Journal for African Studies. **2004**.

Wooldridge, J. M. (2001). Econometric Analysis of Cross Section Data and Panel Data, Cambridge, Mass: MIT Press.