A LOGIT ESTIMATION OF FACTORS DETERMINING ADOPTION OF CONSERVATION FARMING BY SMALLHOLDER FARMERS IN THE SEMI-ARID AREAS OF ZIMBABWE

by

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DEDICATION

I dedicate this thesis to my father, brothers and the four ladies; my wife, mother and two sisters. Thank you for your support

ABSTRACT

Despite heavy investment made by various organizations in Sub-Saharan Africa, to promote conservation farming, the adoption of this technology remained low. Therefore, this study was carried out to estimate the factors determining the adoption of conservation farming by smallholder farmers in Zimbabwe. The study was guided by theory of adoption. The data used in the study was collected from a survey done by ICRISAT between March and April 2010. The survey covered 416 smallholder farmers randomly selected from 15 districts where different non-governmental organizations had promoted conservation farming from 2006 to 2010.

The logit model and the maximum likelihood estimation procedures were used to analyze the data. Results from the study showed that CF was adopted by 77.4% of the participating households. Further, farming experience, access to output market, experience with conservation farming and asset ownership were found to significantly influence the adoption of conservation farming. Farming experience had adverse effects on CF adoption while access to output market and asset ownership had positive influence on the rate of adoption of conservation farming. Their elasticities were 0.956, 0.819, 1.570 and 1.326 respectively. Gender, age, education level, extension visits, family labor availability and access to input markets had no statistical significance on CF adoption. Given these results, the study recommends policy support in the creation of output markets, strengthening of existing markets, and linking farmers to output markets. In addition, promoters of conservation farming may consider targeting inexperienced farmers to practice conservation farming. This will lead to an increase in the rate of adoption of conservation farming holding everything else equal.

***Key words**: Rate of adoption, Conservation farming, Logit model*

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CA	Conservation Agriculture
CDF	Cumulative Distribution Function
CF	Conservation Farming
CIMMYT	International Maize and Wheat Improvement Center
CONFARM	Conventional Farming
CTIC	Conservation Technology Information Center
DFID	Department for International Development
ECHO	European Commission Humanitarian Aid Office
EU	European Union
FAO	Food and Agriculture Organization
GI	Gross Income
GM	Gross Margin
GoZ	Government of Zimbabwe
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFDC	International Fertilizer Development Centre
LF	Likelihood Function
LR	Linear Regression
MLE	Maximum Likelihood Estimation
NGOs	Non-Governmental Organizations
NR	Natural Regions
PRP	Protracted Relief Programme
ROA	Rate of Adoption
RoL	River of Life
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
TVC	Total Variable Cost

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

The agricultural systems of Sub-Saharan Africa (SSA) are diverse, with water being a major transient resource through space and time (Ryan and Spencer, 2001; Twomlow *et. al.*, 2002). Declining land productivity, insufficient rainfall, soil infertility, inappropriate farming techniques, poor market infrastructure, poor access to farm inputs and conflicts are some of the major causes of food insufficiency, insecurity and low incomes in SSA (Muyanga, 2008). Consequently, conservation agriculture (CA) has been proposed as a solution to agricultural problems in smallholder farming systems in SSA, a region with about 70% of the population deriving its livelihood from agricultural production (Hebblethwaite *et. al.*, 1996; Steiner *et. al.*, 1998; Fowler and Rockstrom, 2001; Derpsch, 2003; Haggblade and Tembo, 2003; FAO, 2007; Hobbs, 2007; Hobbs *et. al.*, 2008; Mazvimavi and Twomlow, 2008).

Conservation agriculture has many definitions, but the United Nation's Food and Agriculture Organization Conservation Agriculture Task Force for Zimbabwe define it as any tillage sequence that minimizes or reduces the loss of soil and water, and achieves at least 30% soil cover by crop residues (CTIC, 1999; Mazvimavi *et. al.*, 2007). Conservation farming is part of a growing group of conservation agriculture techniques, which cover a wide range of minimum and or zero tillage systems, and integrated pests, soil and water management practices. Conservation farming is actually a modification of the traditional pit system once common in southern Africa, and is also a variant of the *Zai* pit system from West Africa, which may also be considered a CF technology (Fatondji *et. al.*, 2007). When CA is practiced by smallholder farmers using small farm implements such as the hand hoe to create planting basins, it is referred to as conservation farming (Mazvimavi and Twomlow, 2008).

The two terms; “conservation farming” and “basin tillage” are used inter-changeably in Zimbabwe (Mazvimavi and Twomlow, 2008). Under this technology, seeds are sown in small basins, unlike in conventional farming where seeds are sown along furrows. The recommended dimensions for the basin tillage are simple pits of about 0.15 m long, 0.15 m wide and 0.15 m deep, prepared during the dry season when demand on family labour is relatively low. These basins are dug without having to plough the field, thereby overcoming the scarce animal draught power problem. Basin tillage work on the principle that rather than spreading nutrients and water uniformly over the field, it concentrates nutrients and water in these basins to maximize yield for a given level of inputs (Mazvimavi *et. al.*, 2008). When the rains begin, the basins are soon flooded with water thereby ensuring good germination and a healthy crop stand, even if a dry spell follows. The basin is combined with other crop and soil management practices, such as the use of crop residues when available, which are spread over the field to protect the top soil against erosion, or with composted manure, which enriches the soil with nutrients (Hove *et. al.*, 2008). ACTN, 2008 noted that CA corrects soil degradation, resulting from agricultural practices that deplete organic matter, and nutrient content of the soil such as the traditional conventional farming practice. Moreover, CA has been proposed to address the problem of intensive labor requirements in smallholder farming communities

1.2 Problem Statement

Conservation farming was borne out of heavy investment in research that dates back to as far as the 1900s in Zimbabwe and 1950s in Malawi (Nyagumbo and Rusike, 1999; Kabambe and Kadyampankeni, 2001). On-station and on-farm research trials on conservation farming have shown that conservation farming is agronomically effective in addressing declining land productivity, insufficient rainfall and soil infertility challenges that are heavily attributed to food self insufficiency in Africa (FAO, 2007; Muyanga, 2008). Mazvimavi *et. al.*, (2008) contents that the agronomic potential of the technology is quite high across all the Natural Regions of Zimbabwe, with an average of 1570 kg/ha of maize yield, while that of conventional farming remains at 766 kg/ ha. They added that even smallholder farmers in more marginal regions of Natural Regions 1V and V harvested in excess of 1000 kg/ ha of maize during the drought year of 2006/07. These yield gains from conservation farming were achieved because the technology enabled the concentration of water and fertility within the basin, so reducing the risk of crop failure (Nyagumbo and Rusike, 1999).

In 2004 more than 10 Non-Governmental Organizations (NGOs) through Protracted Relief Programme (PRP) under the United Kingdom's Department for International Development (DFID) began promoting CF across 13 districts in the semi-arid areas of Zimbabwe with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) providing technical assistance to these NGOs (Mazvimavi *et. al.*, 2007). Despite the apparent potential of conservation farming, its promotion by several non-governmental and international organizations, and heavy investment in conservation farming–related research, the adoption of this technology remains relatively low (Mashingaidze *et. al.*, 2007; Giller *et. al.*, 2009). There are several reasons for this low adoption (ROA), for example family labor constraints, low disposable income and poor extension services (Chiputwa *et.al.,* 2011).

1.3 Research Objectives, Questions and Hypotheses

The main objective of this study is to estimate adoption of CF by smallholder farmers in Zimbabwe using a binary logistic regression equation. The specific objectives are to:

1. Determine the main socio-economic characteristics of adopters against non-adopters of CF in Zimbabwe; and
2. Estimate the extent to which socio-economic and institutional factors affect the adoption of CF.

In order to achieve the above specific objectives, the following research questions will be answered;

1. What are the main socio-economic factors that influence the adoption of CF in Zimbabwe?, and
2. To what extent does adoption of CF influenced by smallholders' socio-economic characteristics and institutional factors?.

In order to answer these research questions, the following research hypotheses are going to be tested;

1. Gender, educational level, farming experience, conservation farming experience, extension visits, labor availability, age, cattle ownership, other asset ownership, access to both input and output markets determine the adoption of conservation farming; and
2. Gender, educational level, farming experience, conservation farming experience, extension visits, labor availability, asset ownership, access to both input and output markets influence adoption of conservation farming positively. Age, cattle ownership negatively influence the adoption of conservation farming.

1.4 Justification and Expected Contribution of the Study

Research in agriculture that aimed at reducing land degradation, conserving soil moisture and improving crop yield started as early as in the 1900 in Zimbabwe (Nyagumbo and Rusike, 1999). CF has three principles which are minimal soil disturbance, permanent ground cover and rotation. Research has found out that permanent ground cover (mulching) helps to promote more stable soil aggregates as a result of increased microbial activity and better protection of the soil surface. Increased soil cover results in reduced soil erosion. Soil erosion and land degradation processes occur when rainfall fails to infiltrate the soil and instead starts to flow over the soil surface and is lost as runoff. Practices that reduce the impact of raindrops on the soil surface and maintain soil pores intact will reduce soil loss through erosion and improve water infiltration. Soil cover will also protect the loss of water through evaporation and protect the soil from the heating effect of the sun. Soil temperature influences the absorption of water and nutrients by the plants, seed germination and root development, as well as soil microbial activity and crusting and hardening of the soil. Rotating cereals and legumes mainly aids in pest and disease control, exploration of different soil layers by crops of different types, and improving soil fertility through nitrogen fixation by legumes (Mazvimavi, 2011). Twomlow *et al*., (2006) also claim that CF is an old hat that is bringing new life in smallholder farming community.

Despite these claims, substantial investment put in agricultural research and the benefits associated with practicing CF, the adoption of this technology by smallholder farmers in Zimbabwe was reported to be extremely low (Mashingaidze *et al*., 2006). This study therefore seeks to find out the factors that influence smallholder farmers to adopt or not adopt the technology (conservation farming) developed for them. The results thereof would be beneficial to Agricultural Research Institutes, Policy makers, and the target group (smallholder farmers).

1.5 Organization of the Thesis

The thesis is organized into 5 Chapters; Chapter 1 presents the background to the study, the problem statement, research objectives, questions and hypotheses. It provides the scope of the study. The chapter also justifies the study.

Chapter 2 presents literature review. It gives an overview of theories of technology adoption occurring on the adoption of conservation farming in Zimbabwe and SSA. The theory looks at the pace, intensity, and incidence of adoption of technology. The theories also look at the process and adoption of technologies. It interprets evidence on past empirical methods and results of conservation farming in Zimbabwe and elsewhere.

Chapter 3 presents the framework used to conceptualize the study. The chapter presents research methods, including a description of study site, and data collection methods. The chapter ends by providing an analytical framework in which the specification and estimation of the model used in this study is presented.

Chapter 4 presents the findings of this study. The chapter begins by summarizing the means and standards deviation from the means of socio-economic and institutional variables. Results of the binary logistic regression model in which the effects of socio-economic and institutional factors on adoption of conservation farming are presented. This forms the basis of hypotheses testing. The chapter further presents the extent to which each factor affects the adoption of conservation farming.

Chapter 5 summarizes results of the binary logistic regression model. The chapter draws conclusions drawn from these results presented. Based on the binary logistic regression results, policy recommendations are proposed. The chapter ends by providing areas of further research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature on the process and rate of technology adoption. There are several theories which try to explain the process and rate of technology adoption. For example, the diffusion of innovation theory, theory of induced institutional innovation, theory of perceived benefits, and theory of adoption are some of the theories which explain the process and the speed of technological adoption (Rogers, 1995; Feder *et. al*., 1985; Bisanda *et.al.*, 1998; Liao, 2005; Pual and Motiwalla, 2007). Each of these theories has pros and cons.

There are several methods that can be used to measure the speed and intensity of technology adoption. This chapter will review some of these methods, such as linear regression, the probit, the logit and the tobit models. These models will help in establishing the cause-effect relationship between the dependent variable, and the independent variables. The existence of heteroskedasticity between these relationships require use of maximum likelihood estimation procedures to efficiently estimate the relationships between the dependent and independent variables.

The experiences and lessons from other technology adoption studies indicate that there is no general consensus between the dependent and independent variables in decision making studies. The experiences and lessons from these technology adoption studies are mostly drawn from sub-Saharan Africa. The chapter will end up by identifying the gaps in literature concerning these decision-making studies.

2.2 Theories of Technology Adoption

Feder *et. al.*, (1985) defines rate of adoption as the degree of use of a new technology in a long-run equilibrium when a farmer has full information about the new technology and its potential. The degree of use of a technology is the ratio of the number of people who have adopted a technology to the sampled population size. Adoption is broad and its assessment can be grouped into three categories, which are incidence of adoption, intensity of adoption and rate of adoption. Bisanda *et. al*., (1998) defines the incidence of adoption as the ratio of the number of people who have adopted a technology at a specific point in time to the sample population size. He further argues that intensity of adoption is the ratio of the size of land where a technology is practiced to the total arable land for individual farmers. The rate of adoption is defined as the ratio of the number of people who have adopted a technology over time to the sample population size (Feder et. al., 1985). These three categories of adoption consider time as an important factor, which makes adoption a process. There are several theories which attempt to explain the adoption process. These are for example, the diffusion of innovation theory, theory of induced institutional innovation, absorption theory, theory of perceived benefits, theory of consumer attitude, and the theory of the adoption.

The diffusion of innovation theory states that the spread of a technology adoption must follow five stages which are knowledge, persuasion, decision, implementation, and confirmation (Rogers, 1995). In knowledge stage, an individual is first exposed to a technology but lacks information about the technology. During this stage of the process the individual has not been inspired to find more information about the technology. An individual becomes interested in the technology, and actively seeks information about the innovation in the persuasion stage. In the decision stage, the individual takes the concept of the technology, and weighs the advantages and disadvantages of using the technology, and decides whether to adopt or reject the technology. Due to the individualistic nature of this stage, Rogers notes that it is the most difficult stage to acquire empirical evidence (Rogers, 1962). If the decision is to adopt, this leads to the implementation stage. In this stage, the individual uses the technology to a varying degree depending on the situation. During this stage, the individual determines the usefulness of the technology and may search for further information about it. In the confirmation stage, the individual finalizes their decision to continue using the technology, and may use the innovation to its fullest potential (Rogers, 1995).

The diffusion of innovation theory explains how the technology moves from one individual to another, but does not attempt to explain how the new technology is developed. The theory also assumes that all individuals adopt the technology at different times. In reality, not all individuals adopt a technology. Some individuals might reject a technology at any time during or after the adoption process. Further, this theory is silent about the rate or pace at which a new technology is adopted (Rogers, 1995; Liao, 2005).

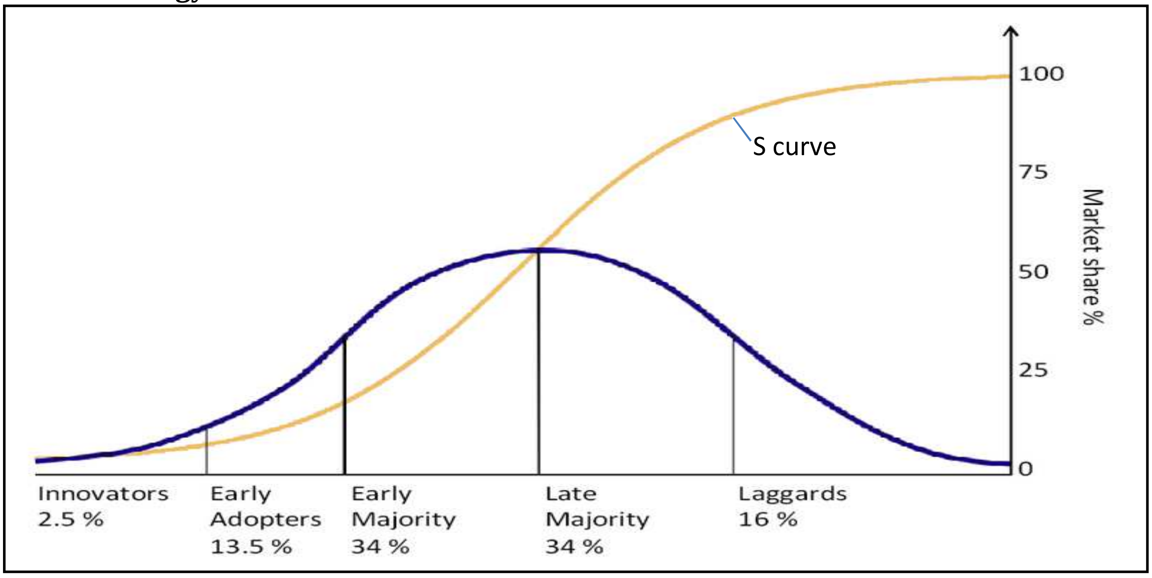
Some but not all of the weaknesses of the diffusion of innovation theory are addressed in the theory of induced institutional innovation. In this theory, the demand for institutional innovation is induced by changes in product demand, factor endowment and technical change (Hayami and Ruttan, 1985). That is, by bringing about disequilibrium in economic relationships, the three factors aforementioned create potential benefits to be realized by developing the institution to overcome the disequilibria. The supply of institutional innovation is influenced by the cost of developing the institution, which depends on advances in social science knowledge and cultural endowment. Individuals or groups in a society, as suppliers of institutional change, will innovate or develop an institution when they consider that institutional benefits will cover the innovation. The theory of induced institutional innovation explains how a new technology is developed but does not explain why some farmers adopt a technology while others reject the same technology (Hayami and Ruttan, 1985).

The theory of perceived benefits is also known as the absorption theory or the theory of consumer attitude. It explains the reason(s) for adopting a technology. The theory states that farmers adopt a new technology if they anticipate deriving greater benefit from it than the former technology (Kanter, 1983; Cohe and Levinthal, 1990; Liao, 2005; Pual and Motiwalla, 2007). The theory of perceived benefits conceptualizes that the success of an innovation hinges on how well the potential adopters can absorb pertinent information and applies the knowledge they have gained towards improving their level of satisfaction (Yates, 2001). He further argues that the theory is based on the notion that individuals will adopt an innovation if they perceive that the innovation has five attributes.

These five attributes are, first, the innovation is expected to have a relative advantage over an existing innovation. Second, the technology is expected to be compatible with the existing values, beliefs and practices of a group of farmers. Any technology introduced by farmers must not be against what that society values and beliefs otherwise it will be rejected in the initial stages. Third, the technology should be simple. Complex innovations might require some defined levels of literacy among farmers. Literacy rates can be hypothesized to have a linear relationship with the adoption of a particular technology. Fourth, the technology must have trial version. The technology can be demonstrated in the field or during field days, prior to its adoption by the target group. Finally, the technology should offer tangible results (Rogers, 1995). What the promoters of an innovation will be advocating for should be proven by farmers in their own fields. The theory of perceived attributes exposes some of the factors that influence adoption. These factors also have an influence on the rate of technology adoption. For example, a simple technology is likely to be adopted faster than a complex technology holding other factors, like education status constant. However, the weakness of this theory is that it does not reveal the speed at which a technology is adopted.

The theory of rate of adoption (ROA) explains the speed of technology adoption. ROA is usually measured by the length of time required for a certain percentage of farmers to adopt a technology (Yates, 2001). He further argues that the rates of adoption for technologies are determined by an individual's adopter category, such as the innovators, early adopters, late majority, and laggards. The theory of adoption suggests that the adoption of innovations is best represented by an s-curve or a logistic function. The logistic function can be represented in form of a graph such as in Figure 1. In addition, the theory holds that initially, adoption of a technology grows slowly and gradually. Finally, the ROA will then have a period of rapid growth that will taper off and become stable and eventually decline (Rogers, 1995). This S-shape in Figure 1 implies that farmers who adopt a technology first, the innovators, require a shorter adoption period than the late adopters.

Figure 2. The diffusion of innovations with successive groups of farmers adopting the new technology



Source: Rogers (1995)

The level of risk aversion among innovators is low that is innovators are risk lovers. Innovators constitute about 2.5% of the potential adopters. However, the level of risk aversion decreases with time in a given population. This is illustrated by the incremental number of individuals taking up the technology as time passes. Laggards adopt a technology last and constitute about 16% of the population of potential adopters. The level of risk aversion among them is the highest (Debertin, 2002).

Within the adoption there is a point at which an innovation reaches critical mass. This is a socio-dynamic term that describes the existence of sufficient momentum in a farming system such that the momentum becomes self-sustaining and creates further growth (Ball, 2004). This is a point in time within the adoption curve that enough farmers have adopted a technology for the adoption of a technology to be self-sustaining. In order to ensure that this stage is reached, there are several strategies that can be used. Such strategies include for example, having an innovation adopted by a highly respected farmer in a defined farming system, create an instinctive desire for a specific innovation, injection of an innovation into a group of farmers who would readily use that innovation, and provide positive reactions and benefits for early adopters of an innovation (Rogers, 1995). This theory provides a good explanation of the adoption of a technology.

2.3 Methods of Estimating Adoption of Technologies

Adoption is a common concept in literature that has been measured through space and time using different methods. Classical approaches such as the ordinary least squares, the tobit, the logit and the probit models have been used to measure the adoption of a technology. Linear regression analysis is used for modeling and analyzing several variables, when the focus is on the relationship between a dependent real variable and one or more real independent variables. More specifically, the linear regression analysis helps one to understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. The main advantage of the linear regression model is its simplicity. Its disadvantage is that it is unsuitable for solving inherently nonlinear problems.

In many statistical analyses of individual data, the dependent variable is censored such as the number of hours worked, the number of extramarital affairs, the number of arrests after release from prison, purchases of durable goods, and expenditures on various commodity groups (Greene, 2008). If the dependent variable is censored for a significant fraction of the observations, parameter estimates obtained by conventional regression methods such as the

Ordinary Least Squares (OLS) are biased. Consistent estimates can be obtained by the method proposed by Tobin (1958). This approach is usually called the tobit model and is a special case of the more general censored regression model. The tobit describes the relationship between a non-negative dependent variable and an independent variable (Tobin, 1958). It also supposes that there is a latent or an unobservable variable. This variable linearly depends on the independent variable via a parameter, which determines the relationship between the independent variable and the latent variable (Wendelin, 2005). In addition, there is a normally distributed error term, to capture the random influences on this relationship. The observable variable is defined to be equal to the latent variable whenever the latent variable is above zero and zero otherwise. The tobit model has the advantage of taking into account the existence of a mass-point at zero in the distribution of leverage ratios but still ignores their bounded nature. Despite being limited from below at zero, the tobit model still has no upper bound. Like the linear model, the tobit model cannot represent the true data generating process of leverage ratios.

However, in contrast to the linear model, the tobit model may constitute a very reasonable approximation to the true data generating process in some cases. In practical terms, the absence of an upper bond in the tobit model may be irrelevant in many cases, in particular when the proportion of very highly leveraged firms is insignificant. A more serious problem is that the tobit model is very stringent in terms of assumptions, requiring normality and homoskedasticity of the latent dependent variable (Hsiao, 2003). The assumption of each covariate to influence in the same direction, $Pr(Y > 0|X)$ and $E(Y|X, Y > 0)$ where Pr is the probability, E is the expected values, Y is the depended variable, X is a set of independent variables, may also be too restrictive in some cases. There are some modified tobit models that could be used such as, the heteroskedasticity-robust tobit estimator used by Wald, (1999), but none of them would solve simultaneously all the issues associated with the use of tobit models.

The logistic regression (LR), also known as the logit model, can be used for predicting the probability of occurrence of an event by fitting data to a logistic curve (Hororwitz and Savin, 2001). It is a generalized linear model used for binomial regression. Like many forms of regression analysis, it makes use of several predictor variables that may be either numerical or categorical. For example, the probability that a person has a heart attack within a specified time period might be predicted from knowledge of the person's age, sex and body mass index (Zellner and Rossi, 1984). Logistic regression is used extensively in the medical and social sciences fields, as well as marketing applications such as prediction of a customer's propensity to purchase a product or cease a subscription.

The LR model has several advantages over other models which are; it is more robust meaning the independent variable don't have to be normally distributed or have equal variables in each group; it does not assume a linear relationship between independent variables and the depended variable; it may handle non-linear effects; one can add explicit interaction and power terms; there is no homogeneity of variable assumption; normally distributed error terms are not assumed; it does not require the independent variables to be unbounded. The ease with which the logistic model can handle qualitative dependent variables makes it more preferable over the other techniques. However, there are some cons of using the LR. According to Zellner and Rossi (1984), the LR requires more data to achieve stable, meaningful results. They further argue that for LR, at least 50 data points per predictor are necessary to achieve stable results.

In order to explain the behavior of a dichotomous dependent variable, we have to use a suitably chosen Cumulative Distribution Function (CDF). The LR uses the CDF but this is not the only CDF that one can use. In some applications, the normal CDF is known as the Probit model or Normit model. The probit model is a popular device for explaining binary choice decisions. It has been used to describe choices such as labor force participation, travel mode, home ownership and type of education by household head. These and many more examples can be found in Amemiya (1981) and Maddala (1983). Given the contribution of economics towards explaining such choices, and given the nature of data that are collected, prior information on the relationship between a choice probability and several explanatory variables frequently exists.

Quantitatively, the logistic regression and the probit models give similar results but the estimates of the parameters of the two models are not directly comparable. The major difference between the logistic regression and the probit models is that the logistic regression has slightly flatter tails, that is, the normal or probit curve approaches the y-axis more quickly than the logistic curve (Michael, 1996; Horowitz and Savin, 2001).

2.4 Experiences and Lessons from Adoption Studies

Herath and Takeya (2003) conducted a study to determine the factors affecting intercropping by rubber smallholders in Sri Lanka with field crops. A sample survey was conducted between October 1997 and March 1998, covering the five major rubber-growing regions where over 80% of Sri Lanka's rubber was cultivated. A stratified random sampling methodology was employed in selecting a total of 588 smallholder farmers. Results from the logit analysis showed that the following farmer characteristics significantly affect the adoption of intercropping; number of extension visits, off farm income, nature of land farming experience with other crops and attitude. All of these factors, except for off-farm income and land ownership were found to be positively related to the dependent variable (Y), where Y is a dummy variable (Y=1, adopt intercropping; Y=0 does not adopt). This implies that the number of contacts with extension agents, educational level of the decision maker, experience with other crops recommended for intercropping and farmers' attitudes towards intercropping with immature rubber improved technology adoption while the availability of off-farm income and the nature of farm ownership reduced adoption. Most of the non-adopters had access to off-farm income (84%) compared to adopters (16%).

Several adoption studies on Conservation Agriculture have been conducted in Zimbabwe and the technology failed to perform well in farmers' fields. The reason for low adoption was attributed largely to the fact that the technology was developed and tested in researcher-managed trials, with limited consideration to the problems and priorities of smallholder farmers for whom they were intended (Anderson 1992, Ryan and Spencer 2001, Shiferaw and Bantilan 2004, Twomlow et al. 2006).

In similar studies done in Kenya by CIMMYT and other similar research institutions, the probit and logit models were used mostly to examine the factors that affect the productivity of maize and the adoption of farm technologies among maize growers. Results from these studies showed that farmer characteristics such as age, gender, levels of education and wealth, and institutional factors such as access to capital and labor markets, land tenure security and social capital were important in farm technology adoption decisions (Mwangi *et al*., 1998; Jackson and Watts, 2002; Doss, 2003; Nyangena, 2008; Foster and Rosenzweig, 2010). Factors such as age, level of education and wealth, and access to capital were found to positively influence the adoption of technologies.

In a different but related study, Ahouandjinou *et al* (2010) did a study in North-Benin using data from a stratified random sample of 198 shea butter producers to assess the adoption and impact of this semi-mechanization. A multinomial probit model was estimated to analyze the factors which explained the adoption of each type of technology. Results showed that the adoption of the crusher was influenced by the presence of electricity in the village and by the availability of family labor. As for the *shea* nuts grinder, the determinants of its adoption were the membership to a *shea* butter producers association, literacy in local language, and the availability of family labor. The results also reveal that the adoption of these technologies increased significantly the producers' incomes.

2.5 Conclusion

The theories of technology adoption which have been reviewed in this chapter are; the diffusion of innovation theory, theory of induced institutional innovation, theory of perceived benefits and the theory of the adoption. None of these theories attempted to explain the speed of technology adoption except the theory of the adoption. This thesis is guided by the theory of adoption.

To measure this adoption, the linear regression, the probit, the logit and the tobit models have been reviewed. Of the three models, the Probit and the Logit models have been widely used by other authors. These models use a series of characteristics of the farm or farmer which may be dichotomous or continuous variables to predict the probability of the adoption. The difference between the two models is that the dependent variable follows a logistic distribution (S-shaped curve) while the probit assumes a cumulative normal distribution, but the interpretation of the results is the same. In addition to this advantage, the logit model is easier to run and is suitable for discreet dependent variables. Therefore the logit model will be used to test the hypotheses set out in Chapter 1. A logit maximum likelihood procedure will be used to estimate the adoption of CF technology.

Despite the methods used, most studies done in SSA have found out farm and farmer characteristics to influence the adoption of different technologies. These are; number of extension visits, off farm income, nature of land farming experience with other crops, farmers' attitude, age, gender, levels of education and wealth, presence of electricity in the village and the availability of the family labor (Doss, 2003;Herath and Tekeya, 2003; Nyangena, 2008; Ahouandjinou *et. al.,* 2010).

Though most studies have shown that farmer characteristics significantly influence the adoption of a technology, it is not sufficient to infer these results for Zimbabwe. There is still a gap in literature on adoption studies done in Zimbabwe hence forth, this study seeks to bridge this gap.

Given the lessons learnt from literature, the broad objective would be achieved by using several research methods. The next chapter will specifically concentrate on the research methods that will be used to answer the research questions raised in chapter one.

CHAPTER 3: RESEARCH METHODS

3.1 Introduction

This chapter presents the research methods that will be used to test the hypotheses made in Chapter 1. It consists of the following sections: study area and data, conceptual framework, logit model specification, and the expected output of the theoretical model. The study area and data give details about the sampled areas, sample size, sampling procedure, data collection tools and the time the survey was conducted. The conceptual framework presents the economic relationships that exist between the social, economic, physical and institutional factors and adoption of a technology. This section is guided by the theory of adoption, experiences and lessons from adoptions studies.

The analytical framework starts by presenting the relationship that exists between adoption of a technology, and the factors determining the adoption of that technology. This section goes on to demonstrate how to estimate the parameters specified in the model. The estimation procedure quantifies the extent to which the independent variables affect farmers' action that is to adopt or not to adopt a technology. Therefore *a priori* results will be presented in the section on expected output of the theoretical model. The expected signs of the coefficients of the dependent variables in the relationship specified in the analytical framework will be presented. These will lay the basis for our hypothesis testing.

3.2 Study Area and Data

The study uses data from a survey that was conducted in Zimbabwe by ICRISAT between March and April 2010 when farmers had just completed harvesting their crops. The survey was conducted in 15 districts where different NGOs under the Department for International Development's (DFID's) Protracted Relief Programme (PRP), European Union (EU) and European Commission Humanitarian Aid Office (ECHO) funding have been promoting conservation farming from 2006 to 2010. The sample districts are located in different agro-ecological regions, known as Natural Regions (NR) in Zimbabwe and are spread over 8 provinces (Vincent and Thomas, 1960). These districts are Bindura, Murehwa, Seke (NR II); Masvingo, Chirumhanzu, Mt Darwin (NR 111); Nyanga, Nkayi, Insiza, Gokwe South(NR IV); and Chipinge, Chivi, Binga, Hwange, Mangwe (NR V).

Data was collected through formal interviews and focus group discussions using a questionnaire. Appendix B shows the draft questionnaire that was used to collect data. Four hundred and sixteen smallholder farmers were interviewed. These farmers were randomly selected from areas where NGOs were promoting CF. At each household a questionnaire was administered to the household member most knowledgeable with farming operations. focus group discussions were held to collect supplementary qualitative information on the adoption of CF. The questionnaire interviews were carried out first to avoid any bias that might arise from influences by other farmers who participated in group discussions.

The questionnaire captured the socio-economic and institutional factors that were thought to determine the adoption of conservation farming. A complete description of these factors is given in Table 1. These factors have been specified in the logit model presented in the following sections.

Table 1. Description of the variables specified in the model

Variable acronym	Variable meaning	Type of measure
Dependent variable		
ADOPT	Adoption	1= adopt 0= not adopt
Independent variables		
GENDER	Gender	1=Male 0=Female
AGE	Age	Years of household head
EDU	Education level	Years spent in school
FEXP	Farming experience	Years of farming
CFEXP	Conservation farming experience	Years of CF practice
EXTVISIT	Number of extension visits	Number of meetings
FLAVAIL	Family labour available	Number of full-time family labour
INPUTM	Access to input markets	Number of purchases
OUTPUTM	Access to output markets	Number of sales
COWN	Cattle ownership	Number of animals
AOWN	Other assets ownership	Number of assets

Source: Survey data

Data were analyzed using descriptive statistics and econometric models using the statistical packages for social sciences (SPSS version 16).

3.3 Conceptual Framework

The decision to adopt or not to adopt can be explained as a discrete variable. Hence, regarding choice of models, the most important aspect of the decision framework was the dichotomous dependent variable, to adopt or not to adopt. Classical linear methods are inappropriate for dichotomous choices since they can lead to heteroscedasticity variances (Greene,2008). This problem is typically remedied by using maximum likelihood estimation (MLE), although heteroscedasticity in MLE is also a potentially serious problem leading to inconsistent estimators (Greene, 2000). According to Wooldridge (2000), when heteroscedasticity is observed, such models require more general estimation. However, such models are not often used in practice, since logit and probit models with flexible functional forms in the independent variables tend to work well.

In making decisions about the adoption of a given technology, a farmer evaluates the new technology in terms of its incremental benefit. If the monetary benefit of using the technology is higher than the old technology, the preference or utility (U) for that technology, assuming monotonic relationship between utility and benefits, will be higher than the old technology (Debertin, 2002). According to Greene (2000), random utility models address these types of individual choice situations. A common specification is the linear random utility model.

Suppose an individual farmer's utility after adopting the new technology such as CF for a given vector of socio-economic and institutional factors (Z) is denoted by U_{CF} (Z), and the utility without adoption by U_{NCF} (Z). Then, the preference for adopting or not adopting can be defined as linear relationship

$$U_{CF}(Z) = Z\beta_{CF} + \varepsilon_{CF} \text{ ……………………..……………..(1)}$$

$$Y_{NCF}(Z) = Z\beta_{NCF} + \varepsilon_{NCF} \text{ ………………………………...(2)}$$

where, β_{CF}, β_{NCF} and $\varepsilon_{CF}, \varepsilon_{NCF}$ are response coefficients, and random disturbances associated with the adoption and non-adoption of conservation farming, respectively. By assuming that the qualitative variable *Y* indexes the adoption decision, then *Y* will take a value of one if the farmer adopts CF and zero if the farmer does not adopt the technology. The probability that a given farmer will adopt CF can be expressed as a function of *Z* as follows (Herath and Tekeya, 2002):

$$P(Y=1) = P(U_{CF} \succ U_{NCF})$$

$$= P(Z\beta_{CF} + \varepsilon_{CF} \succ Z\beta_{N\,CF} + \varepsilon_{NCF})$$

$$= P(Z\beta_{CF} - \beta_{NCF}) \succ (\varepsilon_{NCF} - \varepsilon_{CF})$$

$$= P(Z\beta \succ \varepsilon) = F(Z\beta) \text{ …………………………..(3)}$$

where *P* is a probability function, $\varepsilon = \varepsilon_{NCF} - \varepsilon_{CF}$ is a random disturbance term, $\beta = (\beta_{CF} - \beta_{NCF})$ is a vector of unknown parameters which can be interpreted as the net influence of the vector of the independent variables on adoption of CF, and $F(Z\beta)$ is the cumulative distribution function for ε and $Z\beta$.

The exact distribution of *F* depends on the distribution of the random term, ε. The probit model arises from assuming a normal distribution, and a logit model arises from assuming a logistic distribution. Under the standard assumptions about the error term, there is no *a priori* reason to prefer probit to logit estimation (Greene, 2000). Accordingly, in most applications, it seems not to make much difference. Considering all these aspects, a logit model was developed to study the factors affecting the adoption of CF in the semi-arid areas in Zimbabwe. According to the logit model, the probability of small holder farmer adopting CF, given the socio-economic, institutional characteristics (*Z*) is *P(*CF|*Z)* and can be specified as:

$$P(CF|Z) = \frac{\exp(Z\beta + \varepsilon)}{1 + \exp(Z\beta + \varepsilon)} \text{ ....(4)}$$

where $\alpha \prec Z\beta \prec \alpha$.

The probability of not adopting CF, $P(NCF|Z)$, is therefore,

$$P(NCF|Z) = 1 - P(CF|Z) = 1 - P(CF|Z) = \frac{\exp(Z\beta + \varepsilon)}{1 + \exp(Z\beta + \varepsilon)}$$

$$= \frac{1}{1 + \exp(Z\beta + \varepsilon)} \text{ ....(5)}$$

The relative odds of adopting versus not adopting CF are given by:

$$\frac{P(CF|Z)}{P(NCF|Z)} = \frac{[\exp(Z\beta + \varepsilon)][1 + \exp(Z\beta + \varepsilon)]}{[1 + \exp(Z\beta + \varepsilon)]}$$

$$= \exp(Z\beta + \varepsilon) \text{ ....(6)}$$

By taking the natural logarithms of both sides gives:

$$In\left[\frac{P(CF|Z)}{P(NCF|Z)}\right] = Z\beta + \varepsilon \text{ ....(7)}$$

The formula can be used in predicting changes in the probability of adopting conservation farming which can be employed to estimate the changes in the number of farmer adopting the technology (Adeongun *et.al.,* 2008). The maximum likelihood estimation approach can be used to estimate the above equation.

3.4 Analytical Framework

This section provides the framework within which the study will be analyzed. The section relates the methods of analysis with the hypotheses that have been raised in Chapter 1. The study has two hypotheses which will make use of different methods of analysis within a certain framework of analysis.

One of the hypothesis states that gender, educational level, farming experience, conservation farming experience, extension visits, labor availability, age, cattle ownership, other asset ownership, access to both input and output markets determine the adoption of conservation farming. The hypothesis will be tested by summarizing descriptive statistics from the survey. Descriptive statistics will be used to analyze a number of variables that are known to influence agricultural production. Use is made of three characteristics of univariate analysis; the distribution, the central tendency and the dispersion. The distribution is a summary of the frequency of individual or ranges for a variable. The central tendency locates the center of a distribution of values. The three major types of estimates of central tendency are the mean, the median and the mode. Dispersion is the spread of values around the central tendency. The two common measures of dispersion are the range and the standard deviation. T-tests will also be carried out to determine the significance of these analyses.

The t-test assumes bivariate independent variable, the dependent variable is continuous, each observation of the dependent variable is independent of the other observations of the dependent variable (its probability distribution is not affected by their values), and that the dependent variable has a normal distribution, with the same variance, σ^2, in each group (Greene, 2008). The test was introduced more than 100 years ago and this implies that it is limited to some degree.

The t-test is based on limited theoretical assumptions and do not take into account all we know about these days. It is not specific over one sample, though it has been suggested over large samples its accuracy is approximately correct. The Yuan's method which was introduced in 1974 is more accurate and well renowned test. It replaces the t-test as it takes out all the limitations of the t- test and is so more accurate and shows up the original tests limitations. Other tests that offer similar results are the F-test, which was developed in the 1920s and progresses on from the t-Test. Though there are better and more accurate tests, the t-test is still a popular test that does have limitations but still can be used quite accurately

The second hypothesis postulates that gender, educational level, farming experience, conservation farming experience, extension visits, labor availability, asset ownership, access to both input and output markets influence adoption of conservation farming positively while age, cattle ownership negatively influence adoption of conservation farming. The adoption of CF involves decision making between two alternatives which are to adopt or not to adopt CF technology. The classical linear methods are inappropriate for dichotomous choices since they can lead to heteroscedasticity variances. To deal with heteroskedasticity, the logit or binary logistic regression and probit models with flexible functional forms in the independent variables tend to work well. The logit model is preferred in this study because of its simplicity to work with. Given the logarithms function which says $\frac{P(CF|Z)}{P(NCF|Z)} = Z\beta + \varepsilon$

where *P(CF/Z)* is the probability of adopting conservation farming, *P(NCF/Z)* is the probability of not adopting conservation farming, and *Z* is a set of explanatory variables. A Statistical

Package for Social Sciences (SPSS) software, version 16.0 will be used to run this model. SPSS uses the maximum likelihood estimation procedure to estimate the socio-economic and institutional factors affecting adoption.

The goal of the maximum likelihood approach is to estimate the unknown parameters, denoted by β and ε in equation 7. The MLE entails finding the set of parameters for which the probability of the observed data is greatest. The maximum likelihood estimates are the values for β s that maximize the likelihood function. The critical points of a function, which are the maxima and minima occurs when the first derivative equals 0.

So, from equation 6 and 7 , $\beta = \beta_0, \beta_1, ...\beta_{12}$ which are the unknown parameters to be estimated, Z is a vector of independent variables $Z_1, Z_2, ..., Z_{12}$, where

To estimate these β s , let $\frac{[\exp(Z\beta + \varepsilon)][1 + \exp(Z\beta + \varepsilon)]}{[1 + \exp(Z\beta + \varepsilon)]}$ be equal to L .

Maximizing equation 7 with respect to the β s and setting them equal to 0 gives:

First Order Conditions

$$\frac{\delta \ln L}{\delta \beta_0} = 0 \text{ ....(8)}$$

$$\frac{\delta \ln L}{\delta \beta_1} = 0 \text{ ....(9)}$$

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$$\frac{\delta \ln L}{\delta \beta_{12}} = 0 \text{ ....(10)}$$

The solution of these equations give the MLEs, $\hat{\beta}_0$, $\hat{\beta}_1$,…, $\hat{\beta}_{12}$. However, there is no explicit solution for $\hat{\beta}_0$, $\hat{\beta}_1$,…, $\hat{\beta}_{12}$ unless the unrestricted least squares estimator satisfies the restriction, the Lagrangean multipliers will equal zero and $\hat{\beta}$ will equal b but this is unlikely (Greene, 2008). These ML estimators have to be solved numerically. This will be done by the Statistical Package for Social Sciences (SPSS) software used to run the logit model.

3.5 Expected Output of the Theoretical Model

Socio-economic characteristics of smallholder farmers such as gender, age, education level, farming experience, conservation farming experience, extension contacts, labour availability, asset ownership, and access to markets were hypothesized to influence the adoption of CF (Feder *et.al*., 1985; Belknap and Saupe, 1988). A complete description of the variables specified in this model, and the types of measures that have been employed is given in Table 2. It is hypothesized that gender, education level, farming experience, extension visits, labor availability, asset ownership, access to input and output markets are positively influencing the adoption of conservation farming. Age, and cattle ownership are hypothesized to negatively influence the adoption of conservation farming. The sign for conservation farming experience is indeterminate because it may be positive or negative.

Table 2. Hypothesized determinants of the adoption of CF by smallholder farmers in 15 districts of Zimbabwe, 2010

Independent Variables	H_0 Sign	Economic rationale for selecting variable
GENDER	+	Male farmers are more likely to adopt because they have broader source of income and labor supply.
AGE	-	Young farmers are less likely to adopt since they have accumulated less assets compared to the older farmers.
EDU	+	Education may promote adoption of new technologies by increasing household's access to information and ability to adapt to new opportunities.
FEXP	+	Low risk aversion in experienced farmers. Experienced farmers are more to adapt new farm technologies.
CFEXP	?	Farmers adopt a technology on the basis of perceived benefits of the technology. Experience with CF will increase the adoption if CF technology is associated with several benefits.
EXTVISIT	+	Extension agents increase information flow and therefore increase the probability of technology adoption.
FLAVAIL	+	CF is labor-intensive.
INPUTM	+	CF requires some inputs. Access to input markets by farmers does not hinder farmers from adopting the technology.
OUTPUTM	+	Access to output markets enables farmers to sell their products and plough the profit thereof into CF.
COWN	-	Farmers with draft power will not adopt CF but will continue with CONFARM.
AOWN	+	Farmers invest more if they have more resources at their disposal.

Source: Survey data

Holding everything else constant, these independent variables influence the adoption of CF either positively or negatively. For example, the relationship between gender and adoption of CF is expected to be positive. Male farmers are likely to adopt CF faster than females because they have broader source of income and labor supply. The influence of age on adoption of CF is anticipated to be negative. The level of risk associated with taking up a new technology is lower in older farmers than in younger ones because they have more assets. Farmers are assumed to accumulate assets as they grow up. Therefore, the adoption of CF by younger farmers is expected to be low and assets ownership is expected to increase the adoption of CF. Education level is expected to influence adoption of CF positively. Higher education level may increase the speed of adoption of CF by increasing households' access to information and ability to adapt to new opportunities. The relationship between farming experience and adoption of CF is hypothesized to be positive because of low risk aversion in experienced farmers, but for experience with CF, the relationship is indeterminate. It can either be positive or negative depending on the benefits associated with CF. If the benefits associated with CF are higher than the benefits farmers were getting from CONFARM, they will adopt CF faster, but if the benefits from CF are lower, the adoption is likely to be slower or farmers will not adopt the new technology. Extension visits is expected to positively influence the adoption of CF. Extension agents increase information flow and therefore increase the adoption of CF. Family labor availability is expected to have a positive impact on the adoption of CF because CF is labor-intensive. The relationship between access to both input and output markets and adoption of CF is anticipated to be positive. Access to markets enables farmers to buy inputs and sell products from farming. An inverse relationship is expected between cattle ownership and adoption of CF. The adoption of CF by smallholder farmers with cattle is likely to be slow, because CF is labor-intensive in preparing basins but for CONFARM, farmers use daft power for ploughing. Cattle are the source for draft power.

3.6 Conclusion

The data used in this study was collected through a survey done by ICRISAT between March and April 2010 using a household questionnaire and through focus group discussions. The survey covered 416 smallholder farmers randomly selected from 15 districts where different NGOs have been promoting conservation farming from 2006 to 2010. These districts are located in different natural regions and are spread over 8 provinces of Zimbabwe.

The adoption of CF involves decision making between two alternatives which are to adopt or not to adopt CF technology. Classical linear methods are inappropriate for dichotomous choices since they can lead to heteroscedasticity variances. To deal with hetroskedasticity, the logit or binary logistic regression and probit models with flexible functional forms in the independent variables tend to work well. The logit model is preferred in this study because of its simplicity to work with.

The logit model uses the maximum likelihood estimation procedure to efficiently estimate the factors affecting adoption of CF. Both the logit model and the maximum likelihood estimation procedure have been described in this chapter.

It has been hypothesized that technology adoption depends on social, economic, physical and institutional factors. Specifically, farmers' action to adopt or not to adopt a technology depends on; gender, age, education level, farming experience, conservation farming experience, extension contacts, labour availability, asset ownership, access to markets and natural regions. It was also hypothesized that gender, education level, farming experience, conservation farming experience, extension visits, labor availability, asset ownership, access to input and output markets will positively influence the adoption of conservation farming. Age, and cattle ownership were hypothesized to negatively influence the adoption of conservation farming.

CHAPTER 4: A LOGIT ESTIMATION OF FACTORS AFFECTING THE ADOPTION OF CF IN ZIMBABWE

4.1 Introduction

The chapter presents results from the analysis of the farming sampled-households. It tests the hypotheses raised in Chapter 1. The chapter specifically presents the mean values and standard deviations of the socio-economic and physical characteristics of the sampled households. It further presents logit model results and discusses them. The data used for this analysis came from the questionnaire survey that covered 416 households. The study data collected on adoption alone. This sample size was derived from 15 districts surveyed by ICRISAT. These districts were sampled from different natural regions where ICRISAT and other NGOs had introduced conservation farming since 2006 up to 2010.

The socio-economic characteristics and institutional factors such as gender, age, education, farming experience, conservation farming experience, labour availability, extension visits, cattle ownership, access to input and output markets, and other asset holdings are discussed in the contexts of their influence on adoption of conservation farming. These socio-economic and institutional factors are incorporated into the logit model. In running the logit model, several combinations of the independent variables were tried but only the combination corrected for collinearity and heteroskedasticity are presented. The chapter will end by discussing the results from this binary logistic regression model.

4.2 Characteristics of Sample Farmers

The farm and farmer specific factors included in the model are based on innovation diffusion theory, other theories, and other referenced studies (Rogers, 1995; Anderson, 1992, Ryan and Spencer, 2001; Herath and Takeya, 2003; Shiferaw and Bantilan, 2004; Twomlow et al. 2006). The selected variables for this study included gender of the household head (GENDER), age of the household head (AGE), education level of the household head (EDU)- number of years spent in school, farming experience of household head (FEXP)- number of years in farming, conservation farming experience of household head (CFEXP), number of extension visits (EXTVISIT), family labor availability (FLAVAIL), access to input market (INPUTA), access to output market (OUTPUTM), cattle ownership (COWN) and other asset ownership (AOWN). A summary of the mean values and standard deviation values of adopters and non-adopters from the sample farmers is presented in Table 3.

Table 3. Mean values and standard deviation values of the independent variables

Variable	All farmers (416)	Adopters N=322	Non-adopters	t-test for	P-value
Gender of the household head Male (%)	47.00 (3.20)	45.50 (3.00)	52.00 (3.21)	0.50	0.13
Female (%)	53.00 (2.89)	54.50 (3.12)	48.00 (3.00)	0.50	0.13
Age of the household dead	50.53 (15.69)	50.88 (15.48	49.20 (16.39)	15.68	0.18
Education level of the household head	6.61 (3.83)	6.56 (3.94)	6.83 (3.37)	3.83	0.37
Farming experience of the household head	25.07 (13.54)	26.14 (13.59	21.06 (12.60)	13.39	0.0000021
Conservation farming experience of the household	4.70 (1.65)	4.81 (1.69)	4.27 (1.42)	1.64	0.000038
Number of extension visits	9.04 (2.07)	4.93 (1.86)	24.42 (1.06)	91.78	0.0077
Family labor availability	1.38 (0.90)	1.37 (0.91)	1.42 (0.86)	0.90	0.47
Access to input market	1.45 (0.50)	1.44 (0.50)	1.50 (0.50)	0.50	0.13
Access to output market	1.46 (1.13)	1.43 (0.50)	1.54 (0.50)	0.50	0.0055
Cattle ownership	4.11 (5.30)	4.12 (5.30)	4.08 (4.01)	5.06	0.92
Other asset ownership	1.23 (0.71)	1.20 (0.62)	1.38 (0.98)	0.71	0.0037

Source: Survey data * Figures in parenthesis are the standard deviation from the mean

The mean values are the average values of independent variables for the sample population, adopters and non-adopters. The standard deviation in parentheses shows how far each variable is from the mean. The t-test and the p-value assess whether or not the means of the adopters and non-adopters are statistically different from each other. If the p-value is less than 0.05, the difference between the means of the two groups of farmers is significant, but if it is greater or equal to 0.05, the difference between the two means is considered insignificant.

Table 3 shows no significant difference in the mean values for gender, age, education level, family labour available, access to input markets, and cattle ownership. Significant differences were found in the mean values of farming experience, conservation farming experience, number of extension visits, access to output markets, and other assets ownership.

Though gender is not statistically significant, the sample population had 47% of males and 53% of females. For adopters, the proportion of males to females was 45.5% and 54.5% and that for non-adopters was 52% and 48% respectively. The average age of the household head is 50.53 years across the 15 districts. The average age of the household head for adopters and non-adopters is 50.88 years and 49.20 years respectively. There is no significant difference in the age of the household head and this can be attributed to people's preference to settle in the rural areas around their early 50s after retiring from formal employment (Mazvimavi *et.al.,* 2008). Education level of household heads was found to be statistically insignificant. The education level for adopters is on average 6.56 years and 6.83 years for non-adopters. This means that households across the 15 districts are literate with household heads attaining at least primary level education. Although this is the case, an educated household head is more likely to make informed decisions compared to an uneducated person (Shoemaker, 1971; Mittal and Kumar, 2000; Doss and Morris, 2001).

On average, household heads have been engaged in farming for about 25 years and there is no significant difference across the 15 districts. Adopters' farming experience (26.14 years) is higher than that of non-adopters (21.06 years) and of all the sample farmers. The influence of farming experience on adoption of CF is therefore expected to be positive. The average conservation farming experience of household heads across the 15 districts is 4.70 years and there is no significant difference between adopters and non-adopters. Conservation farming experience is higher in adopters (4.81 years) than in non-adopters (4.27 years). Extension visits across the 15 districts is statistically significant. On average, extension agents visited the sample population about 9 times per year. Extension agents visited adopters about 5 times more than they visited non-adopters. Family labor availability is statistically insignificant with households across the sampled districts having an average of 1.38 labour units. Labour availability is usually constrained by illness. A chronically ill household member cannot contribute to family labour, even the healthy members will lose production time in nursing the sick.

Access to input market was not statistically significant unlike access to output market. Access to both input and output markets was measured by the number of purchases and sales made by farmers, respectively. Non-adopters of conservation farming made more sales of their produce than adopters. More sales imply that farmers get more income hence level of risk aversion is low. Therefore the adoption of CF by farmers with access to output market might be positive. Further, there is no significant difference of cattle ownership between adopters and non-adopters across the 15 districts. On average, both groups of farmers had 4 cattle. There is a significant difference in asset ownership between adopters and non-adopters of CF in the sample population. Adopters had fewer assets than non-adopters. Asset ownership is assumed to reduce the risk associated with adopting a new technology. The relationship between asset ownership and adoption of CF might be positive.

Table 3 has also shown that of the 416 households interviewed, 322 (77.4%) adopted conservation farming while 94 households (22.6%) did not. This is relatively lower than 90% adoption found by Mazvimavi *et. al.*, (2008). This lower adoption of conservation farming was found from a survey done after the promotion period of conservation farming. Some farmers during focus group discussions done during the survey indicated that they used to get free agricultural inputs from NGOs which were promoting conservation farming. Maybe some farmers were using conservation farming because they wanted free inputs such that when NGOs stopped extending free inputs to such farmers, they also stopped using the technology.

4.3 Logit Model Specification and Estimation

Given the logarithms function which says $\frac{P(CF|Z)}{P(NCF|Z)} = Z\beta + \varepsilon$

where *P(CF/Z)* is the probability of adopting conservation farming, *P(NCF/Z)* is the probability of not adopting conservation farming, and *Z* is a set of explanatory variables. The explanatory variables included in the model are Z_1 = GENDER, Z_2 = AGE, Z_3 = EDU, Z_4 = FEXP, Z_5 = CFEXP, Z_6 = EXTVISIT, Z_7 = FLAVAIL, Z_8 = INPUTM, Z_9 = OUTPUTM, Z_{10} = COWN, and Z_{11} = AOWN defined in Table 1. We use a Statistical Package for Social Sciences (SPSS) software, version 16.0 to run this model. SPSS uses the maximum likelihood estimation procedure to estimate the socio-economic and institutional factors affecting adoption.

MLE entails finding the set of parameters for which the probability of the observed data is greatest. The maximum likelihood estimates are the values for β_s that maximize the likelihood function. The results of the estimated logit or binary logistic regression model are presented in the following Table 4.

4.4 Discussion of the Results of the Logit Model

Estimation of the above equation provides the following coefficient estimates, standard errors, asymptotic t-ratio and elasticity at means. A Logit analysis using SPSS software package shows that most of the coefficients are consistent with hypothesized relationships, and their tests of significance helped to indicate their importance in explaining the adoption of conservation farming by smallholder farmers. The parameter estimates for the model were evaluated at 5% level of significance. The logit model estimated results are presented in Table 4. The logit model used to estimate the factors determining the adoption of conservation farming is given as:

$$InL = \exp(-1.250 - 0.045FEXP - 2.00CFEXP + 0.451OUTPUTM + 0.282AOWN + \varepsilon) \quad ..(11)$$

where $\varepsilon = 0.740$. The model of goodness of fit was selected on the basis of the Chi-square, R^2, F-statistic, and number of significant variables. The R^2 indicates the percentage of dependent variable explained by the independent variables and 1- R^2 is the error term. The F-statistic is used to indicate the overall significance of the model (used to check if the model fits the data).

Table 4. Parameter estimates of the logit model

Variable	Coefficient estimate	Standard error	Asymptotic t-ratio	Elasticity at means
CONSTANT	-1.25	0.74		
Gender of the household head	-0.191	0.191	-1.000	0.826
Age of the household dead	0.014	0.008	1.750	1.015
Education level of the household head	-0.007	0.027	-0.259	0.993
Farming experience of the household head	-0.045	0.010	-4.500***	0.956
Conservation farming experience of the household head	-0.200	0.061	-3.279***	0.819
Number of extension visits	0.003	0.005	0.600	1.003
Family labor availability	0.067	0.101	0.663	1.069
Access to input market	0.309	0.187	1.652	1.362
Access to output market	0.451	0.190	2.374***	1.570
Cattle ownership	0.258	0.134	1.925	0.999
Other asset ownership	0.282	0.120	2.350***	1.326

Chi-square (χ^2): 60.28; -2log likelihood: 742.46; Cox and Snell R^2:0.075; Nagelkerke R^2: 0.116; Hosmer and Lemeshow Chi-square (χ^2): 19.127, F-statistic: 8.26

Source: Survey data

The model run was significant at 0.05 LOS (Level of Significance), and the F-statistics calculated (8.26) are greater than the critical F-statistic (3.48). Results show that apart from gender, age, educational level, extension visits, family labour availability, access to input markets, and cattle ownership which were not statistically significant in the adoption of conservation farming, farming experience, experience with conservation farming, access to input markets, and asset ownership were statistically significant at 5% level of significance. The sign of the constant is negative. This implies that in the absence of these socio-economic and institutional factors, the adoption of CF would be declining. The adoption of CF however changes in the presence of these factors. The relationships between adoption of CF and socio-economic and institutional factors are discussed below.

The dummy variable representing gender though not statistically significant has a negative correlation with adoption of conservation farming. This sign is contrary to *a priori* expectation, and this indicates that females would take up conservation farming technology faster than males. This result was consistent with the findings by Foster and Rosenzweig (2010). Farmer's age and education though not significant were found to be negatively and positively related to adoption of conservation farming, respectively. These two parameters are consistent with our *a priori* expectations. The implication of these findings is that a younger farmer with better education has the tendency to take risk and adopt the technology.

An inverse relationship existed between the farming experience and the adoption of conservation farming. An increase in the time farmers are exposed to farming by 1 year, the adoption of the technology decreases by a factor of 0.956. This negative relationship is contrary to *a priori* expectation, and findings by other researchers such as Herath and Takeya (2002), Jackson and Watts (2002), and Adeogun *et. al*., (2008). Focus group discussions revealed that most smallholder farmers judged their total farming experience as starting from the first day that they were going out with their parents to farm. There is a possibility that farmers may have overstated their farming experience, yet in reality their experience is low, hence inverse relationship exists between farming experiences and adoption.

The study revealed that the smallholder farmers with more experience with conservation farming rarely adopt the technology. This is consistent with the findings from Bangladesh by Lee and Stewart (1983) who found out that the potential for technologies to conserve input use, reduce costs, and provide economic benefits even in the short run could create incentives for adoption even among renters and part-time operators. Farmers adopted a technology on the basis of perceived benefits of the technology. In this study, it has been hypothesized that experience with conservation farming will increase the adoption of conservation farming if the technology is associated with several benefits. However if there are no or few benefits, farmers will not adopt the technology. Farmers found fewer or no benefits from conservation farming compared to their old farming practices. This could be the reason for the inverse relationship between this variable and the adoption of conservation farming such that an increase in the time farmers are exposed to conservation farming by 1 year, the adoption of the technology decreases by a factor of 0.819.

Extension visits, family labour availability, and access to input market were also not significant factors of conservation farming adoption as hypothesized. As anticipated, access to output market was found to be significant and positive. An increase in the sale of crops by 1 tone, the adoption of conservation farming increase by a factor of 1.57. This means that farmers with access to output market would adopt the technology while farmers with limited access to output markets would not adopt conservation farming technology. Lack of information about product as well as prices might contribute to low adoption. Adeogun *et. al.*, (2008) found a positive relationship between distance from the market and adoption of crop production technologies. Access to output market is therefore considered to be a significant predictor.

Cattle ownership though not statistically significant, influences adoption of CF positively. This is in contrast to what was hypothesized. Farmers with more cattle are likely to adopt conservation farming technology faster. Cattle ownership reduces the level of risk associated with adopting a new technology. A very strong relationship exists between assets ownership and adoption of conservation farming. Asset ownership is positively related to the adoption of conservation farming. A unit increases in the number of assets, other than cattle acquired increases the adoption of conservation farming by a factor of 1.326. The more assets a household acquires, the faster that household is likely to adopt conservation farming technology.

4.4 Summary

Results have shown that conservation farming was adopted by 77.4% of the participating households from sample farmers. From a set of socio-economic and institutional factors investigated, there was no statistically significant difference in the mean values of adopters and non-adopters of conservation farming in the following factors; gender of the household head, age of the household head, education level of the household head, family labour available, access to input markets, and cattle ownership. There was a significant difference between the population means of the adopters and non-adopters of conservation farming for farming experience, conservation farming experience, access to output market, number of extension visits, and asset ownership.

The following factors did not significantly influence the adoption of conservation farming; gender, age, education level, extension visits, family labor availability and access to input markets did not have a significant impact on the adoption of conservation farming. Farming experience, experience with conservation farming, access to output market and asset ownership significantly influenced adoption of conservation farming. Farming experience and conservation farming experience were found to negatively influence the adoption of conservation farming. Access to output market and asset ownership positively influenced the adoption of conservation farming.

CHAPTER 5: SUMMARY AND CONCLUSIONS

5.1 Summary

A logit model was used to analyze socio-economic and institutional factors that influenced the adoption of conservation farming technology in Zimbabwe. Data was collected by ICRISAT through formal interviews and focus group discussions using a questionnaire attached in Appendix B. The questionnaires covered 416 smallholder farmers from 15 districts across different natural regions. These farmers were randomly selected from areas where NGOs were promoting conservation farming.

Results have shown that conservation farming was adopted by 77.4% of the participating households. This is relatively lower than 90% adoption found by Mazvimavi *et. al*., (2008). This lower adoption of conservation farming was found from a survey done after the promotion period of conservation farming. Some farmers during focus group discussions done during the survey indicated that they used to get free agricultural inputs from NGOs which were promoting conservation farming. Maybe some farmers were using conservation farming because they wanted free inputs such that when NGOs stopped extending free inputs to such farmers, they also stopped using the technology.

There was a significant difference in the mean values of farming experience, experience with conservation farming, number of extension visits, access to output markets, and other assets ownership between the adopters and non-adopters of conservation farming. This implies that the above mentioned factors might have a significant influence on the adoption of conservation farming. For gender, age, education level, family labour available, access to input markets, and cattle ownership, no significant difference in the mean values between adopters and non-adopters of conservation farming was found. This implied that these variables may have no significant effect on adoption of conservation farming.

The study further found out that farming experience and conservation farming experience negatively influenced the adoption of conservation farming in Zimbabwe. This implies that adoption of conservation farming decreases with an increase in the number of years of farming and a decrease in the number of years of farming increases the adoption of conservation. This implies that maybe older farmers are resistant to change their traditional ways of farming. Conservation farming experience has similar effects of decreasing the adoption of conservation farming with passage of time since its influence on adoption on conservation farming is also negative.

Access to output market and asset ownership had a strong positive influence on adoption of conservation farming. The adoption of conservation farming increases as smallholder farmers gained access to markets where they could sell their agricultural products. An inaccessible output market led to a decline in the adoption of conservation farming. Also, the adoption of conservation farming increased as smallholder farmers accumulated more assets. Loss of assets will lead to a decline in adoption of conservation farming. The influence of gender, age, education level, extension visits, family labor availability, and access to input markets on adoption of conservation farming was not significant. This implied that an increase, decrease or no change in these factors would not affect the adoption of conservation farming.

5.2 Policy Recommendations

Empirical results showed that variables such as farming experience and conservation farming experience have significant negative effect on adoption of conservation farming technology. Though it might seem rational to target the farmers who have many years of farming, in promoting conservation farming, the adoption by this group of farmers is low and declining with more years in farming. It is therefore advisable that in order to increase the adoption of conservation farming by interested organizations and or the government, farmers with lesser experience should be targeted.

Access to output market and asset ownership had a strong positive influence on adoption of conservation farming. Poor access to output markets discourages farmers from adopting conservation farming. Improving farmers' access to output markets also gives farmers the capacity to purchase assets. Increase in asset ownership may also accelerate the adoption of conservation farming. However, in smallholder farming community of Zimbabwe, output markets are either not there, poorly functioning or a distant from farmers depending on the area. Government plays a vital role in creating a favorable policy environment that will increase the adoption of conservation farming. The role of policy support should ideally be able to create output markets in areas where there are no output markets or are a distant away from farmers, strengthen existing poorly functioning markets in areas where output markets are not functioning well and, link farmers to both new and already existing output markets in all these areas.

The influence of gender, age, education level, extension visits, family labor availability, and access to input markets on adoption of conservation farming was not significant. Since a change in any of these factors will not significantly affect adoption of conservation farming, this study recommends that policy-makers and development agencies do not focus on them if their objective is to alter the adoption of conservation farming technology. Targeting farmers on the basis of their gender, age, education level, extension visits, family labor availability, or access to input market may be a waste of time, money and human resources and other resources.

5.3 Conclusions

The main objective of this study was to estimate the factors that affect adoption of conservation farming so as to provide insights to other researchers, and policy makers responsible for the development and promotion of conservation farming. The study was guided by the diffusion of innovation theory, other theories and findings from other adoption studies. The data collected by ICRISAT from 416 smallholder farmers from 15 districts across different natural regions was analyzed using a binary logistic regression model, and maximum likelihood estimation procedure. Results showed that there was a significant difference in the mean values of farming experience, experience with conservation farming, number of extension visits, access to output markets, and other assets ownership between the adopters and non-adopters of conservation farming. There was no significant difference in the mean values of age, education level, family labour available, access to input markets, and cattle ownership.

Furthermore, farming experience and conservation farming experience were found to negatively influence the adoption of conservation farming in Zimbabwe. Access to output market and asset ownership had a significant positive influence on adoption of conservation farming. These results have policy implications. The study recommended the government to create output markets, strengthen the existing output markets, and linking farmers to output markets. In addition, the study proposed to promoters of conservation farming to consider targeting inexperienced farmers if they anticipate an increase in the adoption of conservation farming.

5.4 Areas of Further Research

The research concentrated on estimating the socio-economic and institutional factors that influenced the adoption of conservation faming. Future studies may estimate the same or other socio-economic and institutional factors which may affected the incidence of adoption, the intensity of adoption, and probability of adoption of conservation farming. Other studies may investigate the impact of conservation farming across different natural regions. In addition, future studies may include an evaluation of environmental externalities such as carbon sequestration, eutrophication and erosion, to give a fuller understanding on the cost and benefits of conservation farming.

This study used a binary logistic regression model and the maximum likelihood estimation procedure to estimate the factors determining the adoption rate of conservation farming. Future researchers may decide to use other different methods such as the probit, tobit or any other model depending on the nature of the data among other considerations to investigate the effects of different factors on the adoption of conservation farming. Further, since adoption can change over time, future research may want to validate the findings from this study by conducting the same study but at a different point in time.

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APPENDIX A: A LOGIT MODEL RESULTS

LOGIT VARIABLES Adoption

/METHOD=ENTER GENDER AGE EDUCAT AOWN FEXP CFEXP LOWN EXTVISIT FLAVAIL INPUTM OUTPUTM

LOWN

/PRINT=GOODFIT CORR

/CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).

[DataSet1] C:\Users\user23\Desktop\thesis_29Oct2011\31Dec2011\Analysis\analysis 31Dec2011\DATASET_W_RUN_MODEL.sav

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	55.170	11	.000
	Block	55.170	11	.000
	Model	55.170	11	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	707.084[a]	.073	.113

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	10.077	8	.260

Contingency Table for Hosmer and Lemeshow Test

		Adoption = Yes		Adoption = No		
		Observed	Expected	Observed	Expected	Total
Step 1	1	69	66.837	3	5.163	72
	2	68	63.888	4	8.112	72
	3	62	61.994	10	10.006	72
	4	61	60.583	11	11.417	72
	5	57	59.104	15	12.896	72
	6	55	57.110	17	14.890	72
	7	56	54.964	16	17.036	72
	8	45	51.816	27	20.184	72
	9	45	48.000	27	24.000	72
	10	47	40.706	29	35.294	76

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	GENDER	-.261	.195	1.789	1	.181	.770
	AGE	.015	.009	2.945	1	.086	1.015
	EDUCAT	-.013	.027	.225	1	.635	.987
	AOWN	.298	.133	5.027	1	.025	1.347
	FEXP	-.044	.010	19.039	1	.000	.957
	CFEXP	-.182	.061	8.842	1	.003	.833
	EXTVISIT	.003	.005	.317	1	.573	1.003
	FLAVAIL	.050	.104	.232	1	.630	1.051
	INPUTM	.339	.191	3.143	1	.076	1.403
	OUTPUTM	.497	.195	6.490	1	.011	1.644
	LOWN	-.001	.017	.006	1	.938	.999
	Constant	-1.279	.754	2.881	1	.090	.278

a. Variable(s) entered on step 1: GENDER, AGE, EDUCAT, AOWN, FEXP, CFEXP, EXTVISIT, FLAVAIL, INPUTM, OUTPUTM, LOWN.

APPENDIX B: HOUSEHOLD QUESTIONNAIRE

Confidential

Conservation Farming Survey, 2009/10

ICRISAT – Matopos Research Station

Please ask the household whether they are willing to participate in this survey interview. In most cases these are the same households interviewed in 2007/08 season and explain that we are making a follow up to conservation farming practices they are involved in. It is important to let the respondents know that this is planned to be a panel survey and we will be making similar follow-ups in the coming periods. Explain that we are interested in looking at opportunities for improving crop management. Respondents should understand that participation in this survey, and the answers provided, will not influence whether this household receives assistance of any sort in the future. All data are kept confidential. The results are to help ICRISAT improve its technical support for farmers throughout the drier regions of the country.

If this household does not want to participate, this should be noted on the sample list.

Date: ________________________ Enumerator: ____________________________

Province: _____________________ District: ________________________________

Ward: ________________________ Village: ________________________________

Household Local Name:____
(This could be an informal name for the household, but most commonly used by locals)

Respondent should be an adult who is a main decision maker relating to cropping activities for this household. If husband and wife jointly manage the crops, both should be interviewed together. Participation of the wife should be encouraged.

1. **HOUSEHOLD HEAD CHARACTERIZATION**

	Name (NB. This could be one person participating in all the sections below. Please repeat the same names to fill in the sections)	Relation to Head of Household *1=Head* *2=Spouse* *3=Son/Daughter* *4=Other relative* *5=Other non-relative*	**Gender** *1=Male* *2=Female*	**Age** (Years)	**Years spent in school**	**Year first started farming on his/her own?**	**Interviewed in 2009** 1=Yes, 2 =No
RESPONDENT1							
RESPONDENT2							
HEAD HOUSEHOLD		HEAD					

2. In which year did this household start practicing conservation farming (digging planting basins)? ________________________

2a) In which year were you first trained on conservation farming (Formal training)?

____

2b) Are you currently practicing CF (digging planting basins)? 1=yes, 2=no ________________

2c) If you have disadopted digging planting basins (If answer to 2b is NO), what other components related to CF have you continued to practice in other plots?

____

____

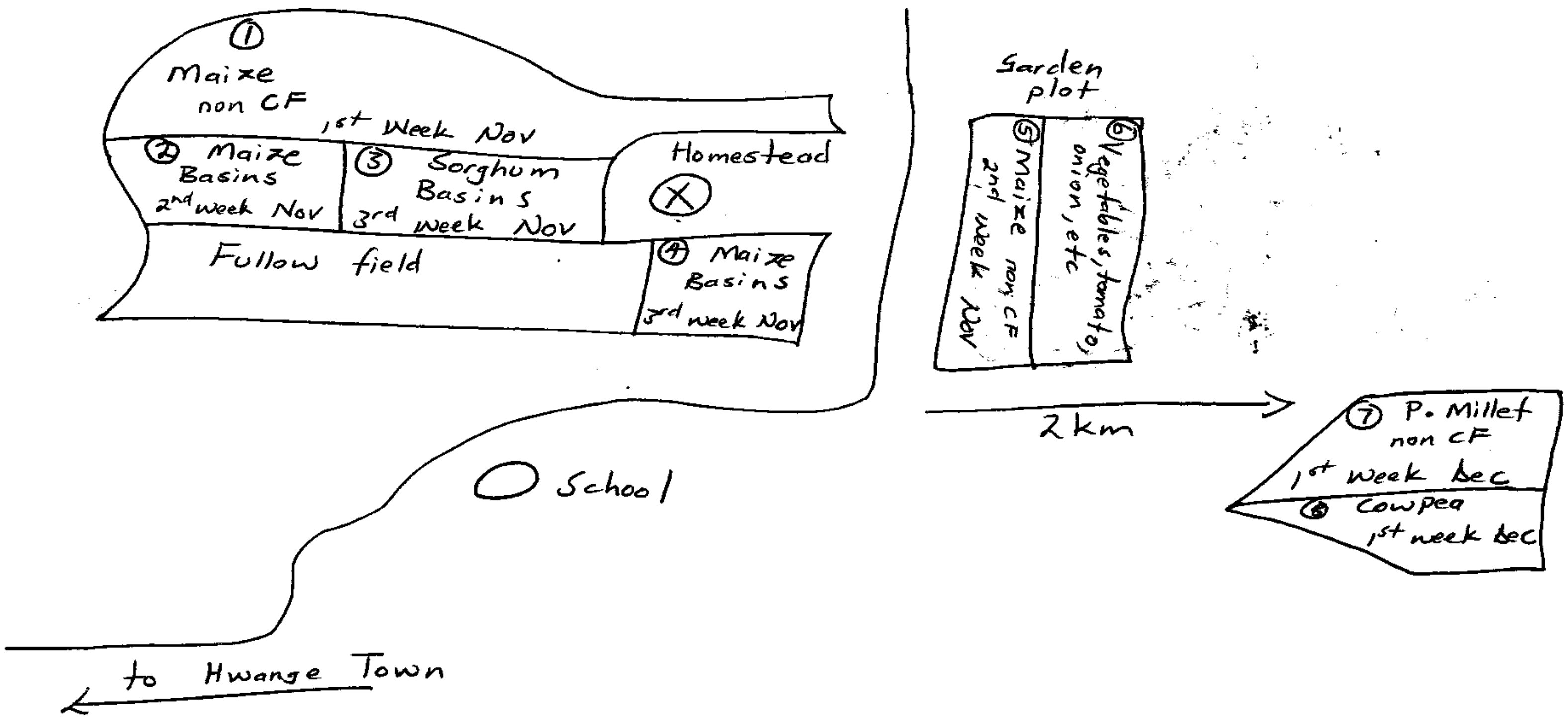
____

1=Mulching, 2=Rotation, 3=Timely weeding, 4= Spot application of fertility amendments, 5= other (SPECIFY)

PLOT LOCATIONS

3. Next we would like to draw a map that outlines your fields and homestead. Start by showing your homestead compound. Then draw the fields closest and furthest in a picture on the ground. Our enumerator will transcribe this to this page. Show any major landmarks near your homestead/fields like roads, school, and borehole. **Please try to estimate the distance to the basin plot to scale** (Also label the plot locations i.e. homestead, distant, garden, and hired plots)

An example is given below.



3. Next we would like to draw a map that outlines your fields and homestead. Start by showing your homestead compound. Then draw the fields closest and furthest in a picture on the ground. Our enumerator will transcribe this to this page. Show any major landmarks near your homestead/fields like roads, school, and borehole. **Please try to estimate the distance to the basin plot to scale** (Also label the plot locations i.e. homestead, distant, garden, and hired plots)

PLEASE DRAW THE PLOT MAPS HERE

CONSERVATION FARMING PRACTICES

4. Next we would like to know the background of your CF plots. Have you consistently dug basins on your CF plots and maintained the same planting stations each year? If there are changes what are the reasons for those changes? *(Please NOTE the plot numbers should correspond with numbers on the field map on Qn. 3.)*

Status of CF Practice	**Plot Location** 1=garden 2=homestead 3=distant field 4=land hired from neighbours	**CF plot #**	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	**Plot size**		**When did you start digging basins on this plot?** *(year)*	**Have you dug basins on this plot every year since you first started?** 1=Yes 2=No	**After you started CF practices on this plot, which seasons did you not dig basins?** 1=2008/09, 2=2007/08, 3=2006/07, 4=2005/06, 5=2004/05, 6=OTHER (Specify)				**What was the primary reasons for not digging basins in some seasons** 1=Labor intensive 2=Input shortages 3=NGO left 4=Other *(specify)*	**Have you used same planting stations since 1st year** 1=Yes 2=No	**If No why?** 1=Basins no longer visible 2=Crop rotation 3=Other *(specify)*
				size	**Units** 1=acres 2=ha 3= m^2									
2009/10 Season CF Plots														
Other CF Plots Established in the Past and Now on Non-CF Practice							**2**							
							2							
							2							
							2							

5**.** What components of CF techniques have you applied this season?

CF plot number *(This should be the same as in the plot map)*	**Plot #**	**Plot #**	**Plot #**	**Plot #**	**Plot #**
Year First established CF plot *(This should be the same as in Q4)*					
Technique	**Did you apply this practice in the current season (2009/10)** (1=Yes, 2=No)				
1=Winter weeding					
2=Application of mulch					
3=Digging planting basin					
4=Spot application of manure					
5=Spot application of basal fertilizer					
6=Spot application of top dress fertilizer					
7=Timely weeding					
8=Crop Rotation- Any at all since you first started CF practice in this plot					
9=Inter Cropping					

6. Do you have any other particular questions about CF practices? What are these?

a) ____

b) ____

c) ____

CROPS PLANTED AND SOURCE OF INPUTS

7a. For the 2009/10 season please tell us the crops planted in your **CF plots** and source of inputs used?

(Please NOTE the plot numbers should correspond with numbers on the field map on Qn. 3.)

Plot Location 1=garden 2=homestead 3=distant field 4=land hired from neighbours	**PLOT NO.**	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	**Is plot securely fenced or not?** 1=Yes 2=No	**Date planted** **Wk/mth**	**Area planted**		**Quantity of seed used**		**Source of seed used** 1=Local l shop 2=Distant shop 3=NGO Current (NAME) 4=NGO Previous (NAME) 5=GOVT/Maguta 6=GMB/ARDA 7=Local farmer 8=Own Stock – from previous harvest 9=Retained seed from other sources 10=Other (SPECIFY)	**Did you apply any manure?** 1=Yes 2=No	**Did you apply any mulch?** 1=Yes 2=No	**Quantity of basal fertilizer used**		**Source of basal fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)	**Quantity of top dressing fertilizer Used**		**Source of top dressing fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)
					Size	**unit** **1=acres 2=ha]** **3= m^2**	**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,				**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,		**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,	

CROPS PLANTED AND SOURCE OF INPUTS

7b. For the 2009/10 season please tell us the crops planted in your **Non CF plots** and source of inputs used?

(Please NOTE the plot numbers should correspond with numbers on the field map on Qn. 3.)

Plot Location 1=garden 2=homestead 3=distant field 4=land hired from neighbours	**PLOT NO.**	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambara nut 8=Cotton 9=Other (SPECIFY)	**Tillage method** 1=manual with hand hoe(non CF) 2=animal powered 3=tractor powered	**Is plot securely fenced or not?** 1=Yes 2=No	**Date planted** **Wk/mth**	**Area planted**		**Quantity of seed used**		**Source of seed used** 1=Local l shop 2=Distant shop 3=NGO Current (NAME) 4=NGO Previous (NAME) 5=GOVT/Maguta 6=GMB/ARDA 7=Local farmer 8=Own Stock – from previous harvest 9=Retained seed from other sources 10=Other (SPECIFY)	**Did you apply any manure?** 1=Yes 2=No	**Did you apply any mulch?** 1=Yes 2=No	**Quantity of basal fertilizer used**		**Source of basal fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)	**Quantity of top dressing fertilizer Used**		**Source of top dressing fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)
						Size	**unit** **1=acres** **2=ha]** **3= m^2**	**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,				**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,		**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250ml) cup, 6=Large (500ml) cup,	

7b. Continued…………

7b. For the 2009/10 season please tell us the crops planted in your **Non CF plots** and source of inputs used?

(Please NOTE the plot numbers should correspond with numbers on the field map on Qn. 3.)

Plot Location 1=garden 2=homestead 3=distant field 4=land hired from neighbours	**PLOT NO.**	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Ground nut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	**Tillage method** 1=manual with hand hoe(non CF) 2=animal powered 3=tractor powered	**Is plot securely fenced or not?** 1=Yes 2=No	**Date planted** **Wk/mth**	**Area planted**		**Quantity of seed used**		**Source of seed used** 1=Local l shop 2=Distant shop 3=NGO Current (NAME) 4=NGO Previous (NAME) 5=GOVT/Maguta 6=GMB/ARDA 7=Local farmer 8=Own Stock – from previous harvest 9=Retained seed from other sources 10=Other (SPECIFY)	**Did you apply any manure?** 1=Yes 2=No	**Did you apply any mulch?** 1=Yes 2=No	**Quantity of basal fertilizer used**		**Source of basal fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)	**Quantity of top dressing fertilizer Used**		**Source of top dressing fertilizer** 1=Local shop 2=Distant shop 3=NGO (NAME) 4=GOVT/Maguta 5=GMB/ARDA 6=Local farmer 7=Other (SPECIFY)
						Size	**unit** **1=acres** **2=ha]** **3= m^2**	**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250 ml) cup, 6=Large (500 ml) cup,				**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250 ml) cup, 6=Large (500 ml) cup,		**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 5=Small (250 ml) cup, 6=Large (500 ml) cup,	

QUANTITY HARVESTED

8a. How much did you harvest on the **CF PLOT** this cropping season (2009/10)? *(Data on CF Plot No., Crop and Area planted should match that of Table 7a)*

Plot No.	Crop 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	Area Planted		Number of weeding per plot	Have you harvested already or not? 1=Actual Harvest 2=Expected harvested	Quantity harvested (With cobs / unshelled)		Grain/Shelled estimate	
		Size	Units 1=acres 2=ha] 3= m^2			Amount	Units 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag,, 7=Scotch Cart, 8=Wheelbarrow, 9=5lt Bkt, 10=Bale, 11=200lt Drum	Amount	Units 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 9=5lt Bkt, 10=Bale, 11=200lt Drum

8b. How much did you harvest on **NON-CF PLOTS** this cropping season (2009/10)? *(Data on Non-CF Plot No., Crop, and Area planted should match that of Table 7b)*

Plot No.	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	**Area Planted**		**Number of weeding per plot**	**Have you harvested already or not?** 1=Actual Harvest 2=Expected harvested	**Quantity harvested** (With cobs / unshelled)		**Grain/Shelled estimate**	
		Size	**Units** 1=acres 2=ha 3= m^2			**Amount**	**Units** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 7=Scotch Cart, 8=Wheelbarrow, 9=5lt Bkt, 10=Bale, 11=200lt Drum	**Amount**	**Units** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 9=5lt Bkt, 10=Bale, 11=200lt Drum

8b. Continued……

8b. How much did you harvest on **Non-CF plots** this cropping season (2009/10)? *(Data on Non-CF Plot No., Crop, and Area planted should match that of Table 7b)*

Plot No.	**Crop** 1=Maize 2=W. Sorghum 3=R. Sorghum 4=P. Millet 5=Groundnut 6=Cowpea 7=Bambaranut 8=Cotton 9=Other (SPECIFY)	**Area Planted**		**Number of weeding per plot**	**Have you harvested already or not?** 1=Actual Harvest 2=Expected harvested	**Quantity harvested** (With cobs / unshelled)		**Grain/Shelled estimate**	
		Size	**Units** 1=acres 2=ha 3= m^2			**Amount**	**Units** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 7=Scotch Cart, 8=Wheelbarrow, 9=5lt Bkt, 10=Bale, 11=200lt Drum	**Amount**	**Units** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, 9=5lt Bkt, 10=Bale, 11=200lt Drum

INPUT MARKET ASSESSMENT

9. Next, we would like to assess the availability of input and output markets in your community and how accessible these markets are

9a) In the current season (2009/10) did you purchase any cropping inputs from retail outlets (whether local or distant)? 1=Yes, 2=No __________

9b) In the previous season (2008/09) did you sell any of your crops harvested and livestock? 1=Yes, 2=No __________

9c) Please indicate the market sources and input prices for the inputs you purchased/ and or sold. (If you did not purchase any inputs or sold any produce, you may indicate local prices if you know them)

INPUTS BOUGHT (2009/10 SEASON)							PRODUCE SOLD (2008/09 SEASON)						
Inputs (Seed & Fertilizer) 1=Maize 2=W. Sorghum 3=R. Sorghum 5=Groundnut 30= Basal fertilizer 31=Top dressing fertilizer	**Where bought** 1=Local retail shop 2=Distant retail shop 3= Wholesaler 4=Seed Company 5=GMB/CottCo Others (SPECIFY)	**Distance (km)**	**Quantity Bought**		**Cost per Unit**		**Produce** 1=Maize 2=W. Sorghum 3=R. Sorghum 5=Groundnut . 51=Cattle 52=Goats 53=Sheep 54=Chickens 55=Other Livestock	**Where sold** 1=Local retailer shop/butchery 2=Private Trader 3= Wholesaler 5=GMB Others (SPECIFY)	**Distance (km)**	**Quantity Sold**		**Selling Unit Price**	
			Amount	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag,	**Price** (Specify the Currency)	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag,				**Amount**	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, . 51=Lvstk	**Price** (Specify the Currency)	**Unit** 1=kg, 2=50kg bag 3=20lt Btk, 4=90kg bag, . 51=Lvstk

LIVESTOCK AND ASSET OWNERSHIP

10. What is the size of your livestock and household asset owned?

LIVESTOCK OWNED		ASSETS OWNED	
Livestock class	**Current Numbers**	**Type of Assets**	**Current Numbers**
1=Oxen (Including Bulls)		1=Plough	
2=Cows		2=Scotch Cart	
3=Calves		3=Cultivator	
4=Goats		4=Harrow	
5=Sheep		5=Tractor	
6=Donkeys		6=Wheelbarrow	
7=Chickens		7=Bicycle	
8=Guinea Fowls		8=Television	
9= Others (SPECIFY)		9=Radio	
		10=Cell phones	
		11=Other *(Specify)*	

HOUSEHOLD DATA

11. We would like to review the size and membership of this household. This will include people who normally reside here for more than 2 months per year.

Age group (Years)	***Gender***	**Number in household** **12 months ago**	Changes in number in household				**Number in Household** **Current**	How many members have been chronically ill **(sick more than 40 days)** in the past 12 months	How many members are currently contributing to FULL time on farm labor	**How many members are currently contributing to PART time on farm labor**
			Birth	**Deaths**	**Left household**	**Moved into household**				
0-5	Male									
	Female									
6-17	Male									
	Female									
18-39	Male									
	Female									
40-64	Male									
	Female									
Above 65	Male									
	Female									

Please thank the respondent for his/her assistance. Ask if he/she has any questions. Record these questions.