DETERMINANTS OF ADOPTION OF SOIL AND WATER CONSERVATION TECHNIQUES IN BURKINA FASO

By
Eugenie Windkouni Haoua Maiga
Bachelor of Science
University of Ouagadougou
Ouagadougou, Burkina Faso
2002

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial Fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2005

DETERMINANTS OF ADOPTION OF SOIL AND WATER CONSERVATION TECHNIQUES IN BURKINA FASO

Thesis Approved:

Tracy Boyer

Thesis Advisor

Chanjing Chung

Arthur Stoecker

A. Gordon Emslie

Dean of the Graduate College

ACKNOWLEDGEMENTS

I would like to my sincere appreciation to my advisor, Dr. Tracy Boyer for her invaluable help, guidance and support. My gratitude goes to my committee members, Dr. Chanjin Chung and Dr. Art Stoecker for their constructive comments and their support throughout the research process. I am also grateful to the Fulbright Program for funding my master's studies. A special thanks to the administrators of the project JIRCAS/UO (Japanese International Research Center for Agricultural Sciences/University of Ouagadougou) for making the data available for this research. I would also like to thank all the faculty, staff and graduate students of the department of Agricultural Economics for the supportive environment under which I studied. Another special thanks to my family members for all the love and support they gave me. Finally, I would like to express my deep gratitude to my mother for the sacrifices she made to take care of my son Pingwende while I study.

TABLE OF CONTENTS

CHAPTER PAGE

List of Tables and Figures

LIST OF FIGURES

LIST OF ABBREVIATIONS

FAO : Food and Agricultural Organization
FCFA : Franc de la Communauté Financière Africaine
NGO : Non Governmental Organization
ONG : Organisation Non Gouvernementale
PNGT : Programme National de Gestion des Terroirs
PNLCD : Plan National de Lutte Contre la Désertification
PRB : Population Reference Bureau
PSB : Programme Sahel Burkina
RAF : Réforme Agraire et Foncière
SSA : Sub Saharan Africa
SWC : Soil and Water Conservation
UNDP : United Nations Development Program

Chapter 1

INTRODUCTION

Background

Burkina Faso is located in the semi-arid sub region of West Africa, called the Sahel. This landlocked country's area is 274,200 km^2 and the population was estimated at 13,575,000 in mid-2004 (Population Reference Bureau). Roughly 33% of the area is devoted to agricultural production. The country is flat and the relief consists of a vast plateau with 749 m as highest point. The climate of Burkina Faso is tropical and is characterized by a long dry season and a short rainy season lasting from May/June to September with large variations in rainfall across years. Current environmental concerns include desertification, soil degradation, pest incidence, erratic rainfall, and overgrazing. Several governmental and non-governmental organizations (NGOs) are working on alleviating these environmental stresses. On the government side, we have the National Program for Combating Desertification (PNLCD[1]), the Pogramme Sahel Burkina (PSB), the LUCODEB (lutte contre la desertification au Burkina) and the National Program for the Management of Rural Areas (PNGT[2]). On the NGO side, there are 145 NGOs currently working in Burkina Faso 75% of which are focusing in combating desertification (Bandré and

---

[1] French acronym for PlanNational pour la Lutte contre la Désertification.
[2] French acronym for Programme National de Gestion Des Terroirs.

Batta). In 1984 the government introduced the Agrarian Land Re-organization (RAF[3]) to address the security of land rights in order to favor sustainable protection of the environment through land enhancing initiatives but this law is not really effective because of the persistence of customary land distribution system that still prevails.

As far as climate is concerned, four regions can be distinguished in Burkina Faso:

1) The Sahelian region in the north where the average annual rainfall is less than 500 mm. This region has 40 to 50 rain days per year;
2) The Soudano-sahelian region in the northern-central part of the country with an average annual rainfall between 500 and 750 mm, and 60 rain days per year. It is a grazing zone and the main crops grown are groundnuts, millet, and sorghum;
3) The Soudanian region in the southern-central part of the country with an average annual rainfall between 750 and 1000 mm, and 70 to 80 rain days per year. This region has characteristics similar to those of the Soudano-sahelian region; and,
4) The Soudano-guinean region in the south-west where the average annual rainfall is more than 1000 mm, and the rain days more than 100. In this region, demanding crops like cotton, maize, rice, fruits and vegetables are produced.

---

[3] French acronym for Réforme Agraire et Foncière.

Source: maps.com

Figure 1. Map of Burkina Faso (the stars represent the approximate location of surveyed provinces).

The main crops produced in Burkina Faso are sorghum (42.5% of the cultivated land), millet (36%), maize (5.5%), and rice (1%). Farm size is small, averaging only 2 hectares. The economy of the country is based predominantly on agriculture with about 80% of the active population working in agriculture (FAO). In 2003, the value added in agriculture as a percentage of GDP was 31% (World Bank). Therefore water, land scarcity and quality issues, and environmental degradation are of overwhelming importance for agricultural productivity and livelihoods.

Problem statement

Sub Saharan Africa (SSA) has the highest rate of soil erosion and degradation in the world (Lal; Cleaver and Donovan). The root cause of soil degradation is rapid population growth. SSA has the world's fastest rate of rural population growth, 2.7% per year for the period 1975-2002 (UNDP). In Burkina Faso this rate is estimated at 2.7% for the same period and is expected to remain high, 3% for 2002-2015 (UNDP). The mounting pressure on land resources has led to accelerated soil erosion because of shorter fallow period, cultivation of fragile lands, and overgrazing (Nkonya et al.). Dejene et al. estimated that land erosion affects 65% of cropland in all of SSA in 1997. The increasing degradation of land resources shows the need to address environmental stresses in SSA. According to Kambou et. al. 24% of arable land is severely degraded in Burkina Faso. The impact of high population growth has led to two competing theories about its consequences on resource conservation. The neo-malthusian view predicts that farmers in developing countries will not be able to sustain agricultural productivity because they are not capable of innovation in response to land scarcity. By contrast, Boserup contends that farmers will respond to land degradation and yield decline by developing methods and techniques to achieve sustainable growth in agricultural productivity and income. One way of addressing land degradation is to invest in soil and water conservation (SWC) techniques. Why do some farmers respond to these environmental stresses by adopting improvement practices and some do not? Understanding what influences farmers to adopt SWC measures could suggest the need for environmental education among farmers since the quality of natural resources must be sustained in the face of mounting environmental and social pressures that lead to increasing degradation of agricultural land.

The purpose of this study is to examine the adoption three prevalent soil and water conservation and improvement practices, zaï, stone bunds, and manure enrichment by farmers in three agro-ecological zones in Burkina Faso. We choose here to examine how land tenure, plot characteristics, household demographics, income and community pressure affect the adoption of soil and water conservation methods. Both logit model and multinomial logit model (which jointly estimates tradeoffs between adopting any one of the measures) are presented. We also present Tobit estimates to see what changes are brought about when estimating intensity of use of SWC techniques rather than just adoption.

Objectives

The general objective of this study is to investigate how to increase the adoption of soil and water conservation practices among farmers in Burkina Faso. Specifically we intend to determine what factors affect the adoption of three specific techniques by farmers in three agro-ecological zones in Burkina Faso and determine whether alternative models yield different results.

This study goes beyond previous literature in three ways. First it uses recent farm-level data collected during summer 2002 that has been tailored to address adoption problems. Second, it takes into account a key variable, community pressure: neighbors have a stake in conservation adoption since it has off-site costs (externalities such as runoff from uphill fields to downhill fields and siltation of rivers and reservoirs). Third, this study estimates alternative models to get more insight about adoption behavior.

Logit, multinomial logit and Tobit models are used in this study to determine the factors affecting adoption of three well-known conservation practices in Burkina Faso.

The logit model is a naïve model since it estimates independent equations when farmers face three choices but it provides intuition about adoption behavior. The multinomial logit model gives a joint estimation where the farmers can choose to adopt one or more techniques or none at all. The Tobit model can be used to estimate independent equations as well as joint estimation of two or more techniques. In this study a joint Tobit estimation is conducted to get the intensity of use as well as the probability of the technique being adopted.

The remainder of this thesis is organized as follows. Chapter 2 reviews the relevant previous literature on soil conservation. The methods and data used to determine the factors affecting the adoption of three prevalent conservation measures in Burkina Faso are described in chapter 3. Chapter 4 presents and discusses the results obtained. This thesis ends with chapter 5 which summarizes the study and its implications and recommends issues to address for further research.

Chapter 2

LITERATURE REVIEW

Abundant literature on conservation techniques in agriculture exists and uses increasingly sophisticated econometric methods. At first, logit and probit models were the most used (Wang et. al., Lee and Stewart, Rahm and Huffman, etc.), models which estimate the probability of adopting one technique dependent on some explanatory variables. Then multinomial logit, ordered probit, Tobit and double hurdle (Cragg) models became more employed (Pender and Kerr, Adesina and Zinnah, Kazianga and Masters, Gebremedhin and Swinton, etc.) because they allow for joint estimation when several techniques are available to the adopter. A diverse set of explanatory variables have been used to assess conservation adoption: physical incentives to invest, plot characteristics, market access factors, capacity to invest, household demographic characteristics, socio-institutional factors, and land tenure security. These previous studies have one or more of the following shortcomings: failure to distinguish between short and long term investment types,[4] failure to take into account community pressure, and failure to use alternative models.

The literature on technology adoption reviewed here focuses on SWC practices adoption but also summarizes papers that described the adoption of other technologies

---

[4] Some conservation techniques have long term carryover effects, others have short term effects (annual) and the tenure rights attached to the plots may be long or short term rights.

using relevant econometric methods. This chapter is organized by topics in order to attempt to present the most relevant previous literature. The first section of this chapter presents the literature on factors influencing adoption decision. The second topic addresses the determinants of conservation investments levels. The relationship between human capital and soil conservation makes up the essence of the third section. The last section of this chapter describes the few studies that have looked at the eventual effects of community pressure (neighbor influence) on adoption decisions.

Factors influencing adoption of conservation practices or new agricultural technologies

Slingerland and Stork compared and assessed why two indigenous SWC techniques, zaï and mulching were used or not in Burkina Faso. The zaï technique consists of digging planting pits in the ground and filling them with organic matter (manure, compost, household waste) in order retain moisture and increase nutrient availability. Mulching is implemented by spreading crop residues, dried herbs or tree leaves on the soil surface; this technique is expected to reduce splash erosion effects from rainfall, and to increase infiltration and conservation of water in the soil. Slingerland and Stork employed a factor and cluster analysis and t tests to determine the relationships between knowledge, opportunity and application of zaï and mulching techniques. They find that farmers' knowledge about the techniques comes from the direct environment. The SWC techniques were used mainly on bush fields, highly degraded (zipelle) and lateritic (zegdega) soils, and dry eroded valley soils, but not on wet valley soils. The techniques were used for sorghum but not for legumes. Zaï requires more labor than mulching, and its adopters have more livestock, larger households, more means of transportation and are richer than those households that adopt mulching alone.

In their study of technology adoption decisions in Sierra Leone, Adesina and Zinnah tested the role of perception of technology-specific characteristics in the adoption and use intensity of selected modern mangrove swamp rice varieties by farmers. A Tobit analysis was used on 124 rice farmers in the Great Scarcies area to estimate three models: a model of farm and farmer characteristics, a model of farmer's perception of technology-specific characteristics and a model combining both. For the first model, only participation in on-farm trials and contact with extension agents were significant. Farm size, number of years of experience in mangrove rice farming, and age of the farmer were not significant. For the farmer's perception of technology-specific characteristics model, the superiority of the yield of the improved variety compared to the local ones, the ease of cooking, the tillering capacity and the ease of threshing significantly affected the adoption and use intensity of the new variety; the superiority of the new variety's taste over local ones did not. When a combined model was run, only perceptions of technology-specific characteristics variables except taste were found significant (yield, cook, tiller, and thresh).

Baidu-Forson investigated the factors influencing the adoption of two land-enhancing techniques in Niger, improved 'tassa' (traditional conservation technique consisting of digging small planting holes to hold rainwater in order to increase moisture) and half-crescent shaped earthen mounds using a Tobit model. He found that highly degraded cropland, extension education, low risk aversion, and the availability of short-term profits increase the adoption and intensity of use of the two techniques. Age of the farmer and the differential between farm and non-farm income did not significantly affect adoption and intensity of use. Baidu-Forson recommended that extension education be provided and that technologies be targeted at areas with high percentages of degraded land. He argued that younger farmers not be targeted because age did not significantly affect adoption.

In their study of farmers' conservation decisions in two Virginia counties, Norris and Batie used Tobit analysis to estimate a conservation tillage acreage model (for conservation tillage) and a conservation expenditures model (for other conservation practices). The authors distinguished between conservation tillage and other conservation practices for several reasons. Previous studies have found that they are affected by different factors because conservation tillage is used as a production practice rather than for erosion control. Norris and Batie argue that conservation expenditure is not an appropriate measure for investment in conservation tillage since the use of the latter indicates the potential for increased returns (negative expenditures) over what a conventional tillage method would bring about. For the first model they found that perception of erosion, farm size, income, and existence of a conservation plan positively and significantly influence conservation expenditures. Off-farm employment, the debt level, tenure status and tobacco acreage significantly and negatively affect conservation expenditures. The conservation tillage model yielded the following results. Intergenerational expectations and farm size significantly and positively impact conservation tillage acreage. That is, farmers who know their farm is going to the future generation and larger farms invest more in conservation. Age, income, off-farm employment, and erosion potential significantly and negatively affected conservation tillage acreage. Norris and Batie concluded that the factors influencing conservation tillage acreage and those influencing conservation expenditures for other conservation measures were different since only three variables, income, size, and off-farm employment affected both dependent variables and the sign for income was different for the two models.

Determinants of conservation investments levels

Shiferaw and Holden examined the determinants of investments in conservation practices on a highly erodible area in the Ethiopian Highlands. They used two models, a perception model and an adoption and level of conservation decision model. Ordinal logit models were employed for both cases since the dependent variable consists of three categories in each case. For the perception model, the dependent variable measured the perceived level of the parcel exposure to soil erosion ranging from no risk to high exposure. In the adoption and level of conservation decision model, the dependent variable measured the degree of use of conservation practices on a given plot: completely removing, partially removing or maintaining the bunds. The perception model tests the determinants of farmers' level of concern about the erosion problem. The results of the perception model suggest that the slope of the plot is the most important determinant in the belief that erosion was a serious problem. The belief that traditional methods are inefficient implies higher recognition of the erosion problem. Household characteristics such as rate of time preference and technology awareness were found to significantly and negatively affect adoption of conservation for the former, and positively affect adoption for the latter. Education and age of household head were not significant. Household assets such as livestock holdings and the ratio of cultivable land to family size were found to significantly and negatively affect the perception of the erosion problem. Among the technology characteristics variables, only the soil retention variable that measures the effectiveness of the technology to retain soil was found to be significant. Likewise, for the farming system variables, the location of the parcel was found to significantly and positively affect the perception of the erosion problem. Shiferaw and Holden's adoption and level of conservation decision model yields the following results. The perception of level of exposure to erosion, the desire to try new technology at own cost, the technology awareness*,* the land/man ratio*,* the type of house, the slope of the parcel, the parcel area and the productivity of the technology were found to positively and significantly affect the retention of conservation structures. The age of the household head*,* the family size, group (a dummy indicating whether the farmer has a parcel in the project catchment), and the location of the parcel were found to negatively affect the retention of such structures.

Pender and Kerr examined the determinants of farmers' indigenous SWC investments in three villages in semi-arid India. A Tobit model analysis was conducted, in which the dependent variable was the total value of investment (value of labor time and cash expenses). They found that imperfections in land markets led to lower investment in conservation in two of the villages; that is, leased land and plots subject to sale restrictions significantly reduce levels of investment in conservation. Households with more male adults, more farm servants and less land were found to invest more in

SWC (characteristics imperfect labor markets) as did those with more debt and off-farm income (characteristics of imperfect credit markets). The number of years of education positively and significantly affected SWC investment in two of the villages, Aurepalle and Shirapur. Belonging to the low caste positively and significantly affected adoption in Aurepalle and Shirapur, but negatively affected adoption in Kanzara. The area farmed had a negative effect on adoption in Aurepalle and Kanzara and a positive effect in Shirapur. The plot size coefficient was significant and positive for Aurepalle only and the quality ranking coefficient negative and significant for Shirapur only. Irrigation status positively and significantly affected adoption in Aurepalle and Kanzara, and pre-existing land investments positively and significantly affected adoption in Aurepalle and Shirapur.

In their paper on investments in long-term conservation measures, Featherstone and Goodwin investigated the factors influencing Kansas farmers' investments in conservation improvements using a Tobit model. The dependent variable was the total expenditure by farmer on long-term conservation measures. The results show that older farmers, farms with high proportion of rented acres and irrigated acres, and livestock-based farms invest less in conservation. Farms that participate in government programs, have large family sizes and are corporately organized invest more in long-term conservation measures.

Kazianga and Masters examined the determinants of farmers' investments in two SWC techniques, field bunds (barriers to soil and water runoff) and microcatchments (small holes in which seeds and fertilizer are placed) in Burkina Faso. Tobit functions and alternative models were used to conduct the analysis. The dependent variables were percentage of cropland covered by field bunds, microcatchments and both. They found that for both techniques, labor supply (female), cropland used but not owned, livestock intensification (number of adults monitoring animals), regional dummy variables, gender, wealth, and off-farm income significantly affected investment in SWC. They argued that secure property rights over cropland and pasture could trigger investment in SWC and increase the productivity of factors applied to land.

Hayes, Roth and Zepeda worked on the impacts of different levels of tenure security on farm investment, input use and yield in Gambia. Using a generalized probit model they found that complete rights over cropland, a village dummy variable, wealth, farm size, plot proximity to homestead, a pre-existing well, plot size, rice plot, and a pre-existing fence significantly affect long-term investments in conservation (post acquisition of well or fence). Gender and preferential rights were not found to be significant in explaining investment in wells or fences. Complete rights,[5] preferential rights,[6] farm size, and plot proximity were found to significantly affect the planting of trees on a plot which is considered by the authors as a long-term type of improvement. Medium-term improvements (fallowing or manure application) were also investigated: preferential rights, village dummies, wealth, percentage of non-farm income, gender, and remittances were found significant. Long-term investments, soil fertility, pre-existing well and fence, and complete rights over farmland did not significantly affect medium-term investments. They argued that secure tenure rights (right of sale and use rights) are likely to increase the probability of making investments and therefore yields.

---

[5] The right to sell and to rent the land (includes preferential rights and use rights).

[6] Preferential rights assign use rights only.

Tenure security and soil conservation

Land tenure status has been emphasized in conservation adoption literature. Secure land tenure, usually ownership is generally believed to increase the incentives for land owners to invest in long-term improvement. McConnell showed that optimal private soil depletion decreases as the farmer's planning horizon increases in length from farm renter to family farm to corporate farm. Lee also found that land tenure security encourages soil conservation investment. Kazianga and Masters found that farmers who have more ownership rights over farmland tend to invest more in SWC practices. These authors took land tenure status to be known with certainty. However, this may not be the case in SSA where expectation of future land tenure may change over time, that is, the land may be taken back after the authorized period of use (Besley).

The interaction between land tenure expectations and willingness to invest in soil conservation has also been investigated. Feder, Just and Zilberman found that land titling in Thailand is associated with increased adoption of land improvements. Gebremedhin and Swinton found long-term investments to be associated with secure land tenure while short-term investments relate to insecure land tenure. Li, Rozelle and Brandt, in their study of land rights and farmers investment incentives in China, found that long-term use rights over farmland encourages land-saving investments.

By contrast, Wang, Young and Camara, and Place and Hazell did not find tenure status significant in explaining adoption of conservation practices. Place and Hazell tested the relationship between indigenous tenure arrangements and land improvements (agricultural productivity) using data from Ghana, Rwanda and Kenya. A logit model was employed with 6 types of land improvement as the dependent variables. The main conclusion is that land rights do not significantly affect the choice to improve land, but do affect the type of land improvement selected.

Lee and Stewart investigated the relationships between landownership and adoption of minimum tillage using data on U.S. farmers. A logit model was used to conduct the analysis. Controlling for land quality and regional location, they found that adoption of minimum tillage was lowest among full-owner operators and landowners with small holdings; nonfamily corporate structure was found to be insignificant in explaining adoption of minimum tillage. The authors concluded that small size hinders minimum tillage adoption more than does separation of ownership from farm operation.

Human capital and soil conservation

Household demographic characteristics such as age, education, gender and household size have also been emphasized as explanatory variables of SWC measures adoption decision. Gender, the female headed household variable was found to be significantly and negatively related to adoption of field bunds and microcatchments by Kazianga and Masters. Gebremedhin and Swinton found that only age significantly and negatively affect the adoption of soil bunds. Having a literate household head, the dependency ratio and a male head did not significantly explain the adoption of both soil bunds and stone terraces.

Wang, Young and Camara identified the factors associated with the reduced tillage adoption, continuous spring cropping and the number of changes made in response to wind erosion in eastern Washington, USA. Logit and ordered probit models were used to assess the role of environmental education in predicting adoption of wind erosion control practices. Prior to the survey that gathered data for this study, an educational campaign named “PM-10” (dust particles less than 10 microns in diameter) was initiated. The first independent variable measures the knowledge of farmers about the PM-10 program in the study region. That variable was found to have a significant and positive effect on the dependent variables across all three equations (reduced tillage, continuous spring cropping and changes made). Age, percentage of cropland leased and off-farm income were not significant for any of the dependent variables. Education significantly and positively affected reduced tillage only. Farm size significantly increased the adoption of both reduced tillage and continuous spring cropping.

Rahm and Huffman used a probit model to assess the role of human capital and other variables in the adoption efficiency of reduced tillage. The number of years of normal schooling completed by farm operator, continued education (dichotomous variable equals 1 if farm operator or spouse attended short courses, conferences and meetings on Iowa State University campus), and the use of private medias sources of information were found to significantly and positively affect the efficiency of the adoption decision. The farm operator’s health, the number of years since farmer began to operate independently, and the farmer’s participation in meetings and training sessions by extension agents were not found to be significant.

Community pressure and soil conservation

Few researchers have investigated the influence of other people's opinions (community pressure) on farmers' SWC measures adoption decisions. In their study of Iowa farmers' adoption of conservation practices, Bultena and Hoiberg used analysis of variance and cross tabulation to compare three categories of farmers, early adopters, late adopters and non-adopters. Bultena and Hoiberg found the timing of conservation tillage adoption to vary significantly with the strength of the perceived negative social attitude of the local community towards farmers who failed to use conservation practices. By contrast, Gebremedhin and Swinton in their study of soil conservation investments in northern Ethiopia found that social capital as measured by farmer perception of community pressure to curb soil erosion did not contribute significantly to conservation investment.

The studies presented above have one or more of the following shortcomings: the failure to distinguish between short and long term investment types, the failure to take into account community pressure and farmers' perception of erosion, and the failure to use alternative models.

This study intends to understand what factors determine farmers' investment on three prevalent conservation practices in Burkina Faso using field-level data. We hope to not only examine the determinants of SWC efforts, but also add to the literature by addressing neighborhood effects. Relevant variables used such as perception of the erosion problem by farmers, extension impacts, cost of labor, crops prices, yield effects of SWC techniques, and short/long term investment characteristics of the techniques provided insight about to conservation adoption in previous studies. Given the data available to this study, these variables are not included in the estimation. In addition, cost implementation of the techniques was not included because there was not enough variation in the data on cost (only two households reported non-zero cost for one of the techniques). Regional dummies variables (due to multicollinearity among them) and the source of property rights over cropland (due to collinearity with land tenure) are also not included in the model.

Chapter 3

EMPIRICAL MODEL AND DATA

Model framework

Probit and logit models have been widely used to assess the adoption of SWC technologies (e.g. Wang, Young and Camara; Anim; Lapar and Pander; Rahm and Huffman). These models are appropriate when the dependent variable is a binary variable. In situations where more than two choices are available, a multinomial logit model is appropriate. In this study logit, multinomial logit and Tobit models will be used to conduct the analysis. First, the logit analysis for each of the 3 techniques is presented to provide intuition on the individual effects of the determinants. Second, the study uses the multinomial logit model to estimate the significance of factors believed to influence a household's choice of adopting a soil and water conservation technique for their farm or none at all in rural Burkina Faso. The multinomial logit model describes the behavior of farmers who largely are intent on preserving or improving soil quality but face a variety of possible techniques to achieve a common objective. The model examines the choice between the set of practical soil and water conservation techniques or adopting none at all. If only two choices exist, to adopt or not adopt a specific technique, the multinomial logit form is simply a logit specification. Third, the Tobit model jointly estimates the factors affecting adoption (decision to invest) and intensity of use (decision of how much to invest) of SWC techniques.

We assume that farmers base their adoption decisions upon utility maximization as in Rahm and Huffman. A given technology is adopted when the anticipated utility from using it exceeds that of non-adoption. Although it is not observed directly, the utility for a given farmer *i* of using a given technology *t* can be defined as a farm-specific function of some vector of technology characteristics and a zero mean random disturbance term as follows:

$$U_{it} = X_i\alpha_t + \varepsilon_{it},\ t = 1, 0 \text{ for logit} \qquad (3.1)$$
$$t = 0, 1, 2, 3 \text{ for multinomial logit}$$
$$i = 1, \ldots, n$$

Where 1 denotes the new technology and 0 the continued use of the old technology for logit; 0 denotes non adoption, 1, 2 and 3 the three alternative techniques. Farmers are assumed to choose the technology that gives them the largest utility in the technology set. The i^{th} farmer adopts t=1 if $U_{i1}>U_{i0}$. Let Y be the variable that indexes the adoption decision:

$$\begin{aligned} Y_i &= 1 \text{ if } U_{i1} > U_{i0} \\ &= 0 \text{ if } U_{i1} \le U_{i0} \end{aligned} \qquad (3.2)$$

The probability that Y is equal to one can be expressed as a function of farm-specific characteristics:

$$\begin{aligned} P_i &= P_r(Y=1) = P_r(U_{i1} > U_{i0}) \\ &= P(X_i\alpha_1 + \varepsilon_{i1} > X_i\alpha_0 + \varepsilon_{i0}) \\ &= P(\varepsilon_{i1} - \varepsilon_{i0}) > X_i(\alpha_1 - \alpha_0) \\ &= P(\gamma_i > X_i\beta) = F(X_i\beta) \end{aligned} \qquad (3.3)$$

Where P_r (.) is a probability function, and $\gamma_i = \varepsilon_{i1} - \varepsilon_{i0}$ is a random disturbance term, $\boldsymbol{\beta} = \alpha_0 - \alpha_1$ is a coefficient vector; $F(\boldsymbol{X}_i\boldsymbol{\beta})$ is the logistic distribution function for γ_i evaluated at $\boldsymbol{X}_i\boldsymbol{\beta}$ in the multinomial logit model and represents the cumulative normal distribution in the Tobit model. For the multinomial logit model, we assume that the technique chosen has a higher utility than the two alternatives and non-adoption.

Description of the techniques

The *zaï* method is an indigenous conservation technique that addresses both water and wind erosion. The word zaï comes from "zaïegré" that means in Mooré (the main national language spoken in Burkina Faso) "Hurry to get the land ready for farming". The technique consists of holes of 10-30 cm diameter and 8-20 cm depth that act as water and silt catching devices. With a spacing of 50 to 120 cm between holes, the number of holes is estimated at 12,000-15,000 for a hectare of millet or sorghum field (Bandré and Batta). This setup significantly reduces water runoff, as an estimated 1 mm of water is lost for every 25 mm that is infiltrated. The zaï technique catches the runoff water around the plants thus increasing water infiltration in the soil. It gives the best results on poor and highly eroded soils. The zaï technique can be implemented on any type of soil except clay and highly sandy soils (Tiemtoré). There are 2 types of zaï: the "simple zaï" which consists of digging the holes only and the "improved zaï" which adds manure or compost in the hole. The improved zaï results in a doubling or an increase of yields by 50 percent in the short run in some regions (Ministère de l'Action Coopérative Paysanne). The addition of manure or compost in the holes attracts the termites that dig galleries that make easier the infiltration of rainwater and runoff and the retention of moisture. Zaï is sometimes associated with water runoff slowing techniques like stone bunds, earth bunds or quickset hedges. This technique lessens the waste of manure, allows a good mix of farming and reforesting increases productivity and restores soils. Zaï is very labor intensive: it requires 300 hours of labor for one man to implement it on one hectare (Roose). However some researchers and NGOs are trying to introduce the use of animal traction and motorized traction to make the Zaï technique implementation easier (Tiemtoré).

Stone bunds are line of stones implemented on the contour slopes of a field. The bund line height ranges between 20 and 30 cm and is designed to reduce runoff. Between 1972 and 1988 roughly 2% of the cultivated areas in Burkina Faso used the stone bunds and earth bunds techniques (Kessler and Geerling). There are two types of stone bunds: bunds made by lining up one big rock at a time and those made by overlapping 3 small rocks (a furrow is dug and two rocks are placed underneath and one above). Both types are expected to reduce runoff, to increase sediment trapping upstream of the bund, to control erosion by reducing the slope and by creating permeable micro-terraces, and increase the water intake on the plot. Zougmoré, Kaboré and Lowenberg-DeBoer estimated the cost of stone bund construction at 4850 FCFA/ha ($9.7) if rocks are available nearby the field. According to Bandré and Batta, the stone bund technique is widely used on slopes of millet, cowpea and groundnut fields. Bandré and Batta give a general magnitude of about 100 additional kilograms per hectare for sorghum and millet yields with stone bunds.

Manure enrichment is principally used to conserve soil nutrients through the use of farmers' own livestock excrement. Farmers collect their livestock manure and apply it on the surface of the plot. It is the easiest technique to implement, but its disadvantage is that it is less permanent since it can be carried away by runoff if no other technique is used. Manure application is not exactly a conservation technique; it is rather a short term means of improving and/or maintaining productivity. The three techniques, although not technically mutually exclusive, were not simultaneously chosen but in a couple of cases.

Logit Model

There are 3 SWC measures that serve as dependent variables for separate logit estimations of the probability of adoption. The three techniques are zaï (small depressions in the ground acting as water and silt catching devices), stone bunds (bunds or stone contours made of rocks) and manure application from livestock. The logit model is defined as follows:

$$P(Y=1)=\frac{\exp(X'\beta)}{1+\exp(X'\beta)}$$

(3.4)

$$P(Y=0)=\frac{1}{1+\exp(X'\beta)}$$

Where Y takes the value 1 if one of the techniques is adopted and 0 otherwise; $\mathbf{X}$ is the row vector of independent variables and $\boldsymbol{\beta}$ the corresponding parameter vector.

Multinomial logit model

For the multinomial logit model, there are four possible dependent variables including: the choice to not adopt any technique, adoption of the zaï technique, adoption of stone bunds, and manure application with non-adoption as the reference choice. The multinomial logit model is specified as follows (Greene).

$$\begin{aligned} P(Y=j) &= \frac{\exp(X_i'\beta_j)}{1+\sum_{k=1}^{J}\exp(X_i'\beta_k)} \qquad j=1,2,\ \ldots,\ J. \\ P(Y=0) &= \frac{1}{1+\sum_{k=1}^{J}\exp(X_i'\beta_k)} \end{aligned} \tag{3.5}$$

Where Y indicates the choice made (there are J+1 choices, 4 choices in this analysis, one of them being non-adoption). The log-likelihood function is:

$$\ln L = \sum_{i=1}^{n}\sum_{j=0}^{J} d_{ij} \ln \Pr(Y_i = j) \tag{3.6}$$

Where d_{ij} =1 if alternative j is chosen by farmer i and 0 if not. The log odds ratio is given as the probability of observing adoption of category j, given P(Y=0), the base category or non-adoption, as follows:

$$\begin{gathered} \ln\left[\frac{P_{ij}}{P_{i0}}\right] = \beta_j' x_i \\ \textit{or} \\ \frac{\Pr(y=j)}{\Pr(y=0)} = e^{B_j' x_i} \qquad j=1,2,\ldots,J. \end{gathered} \tag{3.7}$$

Tobit model

Given the absence of expenditures data in the dataset, the percentage of cropland on which the technique has been applied is used as a proxy for conservation efforts. When any of technique has not been adopted, the dependent variable is equal to zero. The threshold is therefore zero. The reasons for non-adoption could be one or more of the following: farmers were not aware of the existence of the technique, were limited technically, had low incomes or were constrained culturally by custom. Indeed, according to Kessler and Geerling, the customary land tenure rights system prevailing in Burkina Faso forbids the planting of trees or the construction of anti-erosion sites (stone and earth bunds) when the land has been loaned by the chief of land in a village. This may explain the large number of missing values for the stone bunds variable. The Tobit analysis is preferred in the case of censure in the sample and limited dependent variable because it uses both the data at the threshold as well those above threshold to estimate the model. The multinomial logit model only addresses the adoption of conservation techniques while the Tobit model also takes into account the intensity of use of the techniques. Another interesting characteristic of the Tobit model is the elasticity decomposition it allows: change in the elasticity of the probability of being above the limit (elasticity of adoption) and change in the elasticity of the probability of being an adopter (elasticity of effort given adoption occurs).

Following the exposition of McDonald and Moffit, the stochastic model that underlies the Tobit model is specified as:

(3.8)
$$\begin{aligned} Y &= X\beta + \gamma \text{ if } X\beta + \gamma > 0 \\ &= 0 \text{ if } X\beta + \gamma \leq 0 \end{aligned}$$

Where *Y* denotes the dependent variable indexing the adoption decision, ***X*** a vector of technology characteristics, and γ is a normally distributed error term with zero mean and constant variance σ^2. The log-likelihood function is defined as follows (Greene):

(3.9)
$$\ln L = \sum_{y_i>0} -\tfrac{1}{2}\left[\ln(2\pi) + \ln\sigma^2 + \tfrac{(y_i - x_i\beta)^2}{\sigma^2}\right] + \sum_{y_i=0} \ln\left[1 - \phi x_i(\tfrac{x_i\beta}{\sigma})\right]$$

The relationship between the expected value of all observations and the expected conditional value above the limit is given by:

(3.10)
$$E(Y) = F(z)E(Y^*)$$

Where F is the cumulative normal distribution, z is equal to $\boldsymbol{X\beta}$, *Y** represents the observations above the threshold. Consideration of the marginal effect of the kth variable of ***X*** on *Y* led to the following decomposition:

(3.11)
$$\partial E(Y)/\partial X_k = F(z)\left[\partial E(Y^*)/\partial X_k\right] + \left[\partial F(z)/\partial X_k\right]E(Y^*)$$

Multiplying both sides by $X_k / E(Y)$ yields the usual elasticities. Equation 3.11 suggests that the total change in elasticity of Y can be decomposed into a change in probability of the expected level of use of Y for current users (first term on the right hand side) and a change in the elasticity of the probability of being an adopter (second term on the right hand side).

Data

This study uses farm-level data on three soil and water conservation techniques that were collected on 254 households in four agro-ecological zones in Burkina Faso over 1999-2003. Cross-sectional data collected during summer 2002 is used because that was the year during which SWC information was first introduced and collected. In 1999, a collaborative team of the School of Economics and Management of the University of Ouagadougou (Burkina Faso) and the Japanese International Research Center for Agricultural Sciences (Japan) began a panel data survey in the following regions: Sahelian, Soudano-sahelian, Northern-guinean and Southern-guinean. Although the main objective of the household survey was to determine what the effects of structural adjustment policies, initiated in 1991, were on household land management behavior, the information needed to look at SWC efforts was also available in this data set. Given that in the fourth, zones two of the techniques have not been used, our sample size is reduced to 129-190 households for the three other regions depending on the technique. The three prevalent techniques of zaï (water catchments), stone bunds (stone contours), and manure enrichment of soil are examined. Table 3.1 gives a summary of the variable definitions and measures.

Variables descriptions and hypotheses

Table 3.1 Variables Descriptions

	Definition and Units
Dependent Variables	
Zaï	Small depression in the ground acting as water catching devices (1 if adopted, 0 otherwise)
Stone Bunds	Stone field contours made of rocks (1 if adopted, 0 otherwise)
Manure	Fertilizer consisting of livestock excrement (1 if adopted, 0 otherwise)
Technic	% of cropland on which zaï, stone bunds and manure have been adopted.
Independent Variable	
Location	Plot location (1 if near homestead, 0 otherwise). This was a subjective measure used by interviewer.
Slope	Slope of the plot (1 if highly sloped, 0 otherwise). This was also subjectively determined by the interviewer.
Sorghum	Crop grown (1 if sorghum is grown, 0 otherwise). Sorghum is an indicator of soil type.
Farm size	Area of cultivated land (hectares)
Household income	Total household agricultural income (CFA Francs)
Access to credit	Total non agricultural income (Proxy, CFA Francs)
Land tenure	Property rights of the plot (1 if owned, 0 if leased)
Neighborhood Effects	Neighbor influence measured by % of use of a technique within a village
Age	Age of the head of household (years)
Gender	1 if the household head is female 0 if the household head is male
Education	Literacy of household head (1 if household head knows how read or write, 0 otherwise)
Household size	Number of persons per household

Using the background literature on soil and water conservation technique adoption, relevant explanatory variables were chosen from the data set. Descriptions of the variables are given in Table 3.1. Table 3.2 provides a summary of the expected effects of household characteristics on adoption.

We expect physical factors such as slope, location of field in relationship to the household, and the type of crop planted to affect the adoption decision. In areas that are highly sloped, we would expect more adoption of all of the techniques. Close proximity of the field to the homestead will negatively affect the adoption of stone bunds and zaï because those fields receive household waste and dung and thus do not need additional land-enhancing measures and positively affect the adoption of manure enrichment. Because of economies of scale and greater investment capital, we expect the larger the area of the farm, the higher the likelihood to adopt any soil technique, particularly manure, since larger farms are more likely to farm and graze simultaneously.

Sorghum is an indicator of soil type: it is a drought resistant crop grown in semi-arid areas. Although drought resistant, sorghum requires more moisture than millet. According to Slingerland and Stork, farmers consider zaï suitable for sorghum and millet but not for groundnuts and peas and this may be due to the fact that groundnuts and peas are mainly cultivated on house fields (near the homestead) which receive household waste and livestock droppings. Thus those fields do not need implementation of additional conservation measures. Zaï requires 300 hours of labor per man per hectare and 2 to 5 tons of fertilizer (inorganic such as nitrogen, manure or compost) per hectare to produce yields of 1000 to 1600 kg/ha that is 10 to 50% surplus compare to yields without application of zaï (Tiemtoré). For example, yields of millet and sorghum under traditional farm practices in the semi-arid areas of Burkina Faso rarely exceed 600 to 750 kg/ha in normal years (Savadogo et. al.).

Household income (agricultural and nonagricultural) is likely to affect the household’s ability to invest in manure and zaï techniques using manure, but negatively affect adoption of stone bunds that involve principally manual labor.

In Burkina Faso, land ownership is still governed mostly by traditional arrangements (Sourabi), so farmers take into account the opinion of the community in their adoption decision. Moreover, when neighbors' adoption pays off, farmers are more likely to adopt. Therefore, we expect that the *neighbor* variable should positively affect adoption of all techniques because farmers feel community pressure to conserve soil. Furthermore, land tenure security encourages soil conservation investment because the farmer knows he or she will benefit from his/her investment sooner or later.

Demographic characteristics of the household will also affect SWC measures' adoption. Men in Burkina Faso have a better chance to hire labor or work out arrangements to get help from peers farmers and greater access to credit than women so we expect a negative relationship between being female and adoption. Moreover, under the customary land rights system women cannot own land (Bandré and Batta); therefore they are less likely to implement SWC techniques. If the household head has a higher level of education (here we measure this as literate or illiterate), we expect that household will have a greater willingness to try new methods and capacity to apply them. As in the previous literature, we hypothesize that the relationship between age of the household head and SWC adoption is negative because older farmers have less time to benefit from their investment. Larger households (Hhsize) are expected to be more likely to adopt SWC technique due to labor availability; however, this effect is also ambiguous since the ages of the household members were not available. Households that have large proportions of very young children and elderly may in fact be less productive and unable to implement SWC techniques.

Table 3.2: Summary of the Expected Effect on Adoption

Variable	Measure	Expected effect on adoption
Location	1 if near homestead 0 otherwise	+ The closer the plot the higher the likelihood to adopt manure. -The closer the plot the smaller the likelihood to adopt zaï and stone bunds.
Slope	1 if highlands 0 otherwise	+ Highlands are more prone to erosion because they receive more water and are subject to runoff.
Sorghum	1 if sorghum is grown 0 otherwise	+ Sorghum is grown on same soils where practices can be implemented.
Farm size (AREA)	Hectares	+ Because of economies of scale and greater investment capital.
Agricultural Income (AGINC)	CFA Francs	+The wealthier the household, the higher the likelihood to adopt.
Access to credit (NONAGINC)	CFA Francs	+The greater the access to credit, the higher the likelihood to adopt. -Negative effect is expected for stone bund because its implementation involves labor rather than capital investment.
Land tenure (LDTENURE)	1 if owned 0 leased	+ If owned - If leased
Neighborhood Effects (NEIGHBOR)	% of adoption within village	+ If neighbor adoption pays off, it will increase the likelihood of adoption.
Age	Years	-Older farmers have less time to benefit from erosion control investments.
Gender (FEMHEAD)	1 if female 0 if male	- If female because women have smaller access to labor and credit.
Education (LITERACY)	1 if literate 0 otherwise	+ Higher levels of education leads to greater willingness to try new methods
Household size (HHSIZE)	Numerical	+/-The greater the labor availability, the higher the likelihood to adopt. The greater the number of young children the smaller the likelihood to adopt.

Sample data characteristics

As expected, farms in the survey tended to be small and emphasized subsistence farming with relatively low incomes. Table 3.3 provides descriptive statistics. The average farm size is less than 2 hectares, indicating that small, subsistence farms are common in the country. The average age for household head is high, 52 years compared to a country-wide life expectancy of 54 years in 2000. In the sample used, only 10 households are female headed and 19 household heads are literate which is consistent with the fact that in some regions women are not allowed to own land and literacy level is low in Burkina Faso. Household size averages 5.31 people. On average, farmers earn 531,320 FCFA ($ US 794.035) (the average for 2000 was 260 thousand CFA Francs, FAO) as agricultural income and 213,520 FCFA ($ US 319.10) as nonagricultural income. The adoption of SWC measures is low, 14 out of 190 farmers adopted zaï, 13 out of 129 farmers adopted stone bunds and 58 out of 187 farmers adopted manure. The differences in sample sizes among conservation techniques are due to missing values. About 54% of the farmers surveyed own the land they are farming. The neighborhood effects variable (percentage of adoption within a village) has been computed excluding household *i* so that a particular farmer observes the adoption of techniques by his neighbors.

Table 3.3: Descriptive Statistics

Variable	N[a]	Mean	Std. Dev.	Min	Max	Count
TECHNIC (%)	187	0.166	0.269	0	0.986	
ZAI	190	0.074	0.262	0	1	14.00
SBUND	129	0.101	0.302	0	1	13.00
MANURE	187	0.310	0.4641	0	1	58.00
LOCATION	186	0.280	0.450	0	1	52.00
SLOPE	186	0.156	0.364	0	1	29.00
SORGHUM	186	0.351	0.479	0	1	65.00
AREA (ha)	187	1.699	1.952	0.002	16.57	
AGINC [b] (1000 FCFA)	187	531.318	530.541	2.133	3063.254	
NONAGINC[b] (1000 FCFA)	190	215.787	628.249	107.5	6216.725	
LDTENURE	190	0.537	0.500	0	1	102.00
NEIGHBOR (technic)	178	0.464	0.298	0.07	0.935	
NEIGHBOR (zaï)	162	0.024	0.032	0	0.850	
NEIGHBOR (stone bunds)	190	0.068	0.037	0.032	0.125	
NEIGHBOR (manure)	190	0.125	0.093	0.024	0.265	
NEIGHBOR (%)	190	0.164	0.095	0.056	0.333	
AGE (years)	189	51.852	15.869	20	93	
FEMHEAD	190	0.0526	0.224	0	1	10.00
LITERACY	190	0.1	0.301	0	1	19.00
HHSIZE	190	11.126	8.654	1	64	

[a] N=number of observations

[b] In September 1st 2002, the exchange rate between US dollar and CFA franc was $1 for 669.139.

Chapter 4

RESULTS AND IMPLICATIONS

Logit results

Table 4.1 gives the estimated coefficients and their significance for the three soil and water conservation adoption equations using STATA 8.2 (1984-2003). For the estimation of determinants that affect adoption of the zaï technique, households which were reported to be headed by those who could not read and write or were female headed were not included in the model. These two variables were dropped since these characteristics perfectly predicted the failure to adopt the zaï technique. The equation for the stone bund adoption represents a smaller sample than the other two techniques because there were multiple missing values for households using these techniques.

Farm physical characteristics such as location near the compound proved to have a significant effect on adoption, positively affecting manure enrichment and negatively affecting adoption of the zaï techniques, at the 99% and 90% confidence levels. Location was not significant for stone bunds. The sign of *location* for manure is as expected because manure is easy to apply and transport, and thus farmers prefer to apply it on distant plots and to use compost on the ones near the homestead. Highly sloping land has a significant and positive effect on the probability of manure application to land. While consistently positive, slope is not significant for stone bunds and zaï. Growing sorghum significantly increases both the adoption of zaï and manure at greater than 90% confidence level. This effect is expected since sorghum requires more moisture and hence more effort to provide that moisture; millet requires less moisture than sorghum and hence the lesser is the use of conservation measures on millets fields.

The capacity to invest factors are consistent in sign with our expectation but significance varies across conservation techniques. The coefficient for *area,* the size of the farm, is significant, showing that it positively affects adoption of manure and stone bunds at 99 and 90% confidence levels respectively, holding all other characteristics constant, but is not significant for zaï. For manure and stone bund adoption, *nonaginc,* non-agricultural income, significantly affects the likelihood of the adoption of manure enrichment but adversely affects the adoption of stone bunds. Agricultural income, however, was only significant for the adoption of manure application at the 99% confidence level. Although insignificant, the negative sign on agricultural income for stone bunds is as expected because creation of stone bunds primarily involves labor rather than capital investment. Furthermore, there may be an endogeneity issue where low income farmers are unable to afford manure or livestock and thus have low incomes.

Across all three equations, the *neighbor* variable was significant at greater than a 90% confidence level holding the other determinants constant. This variable indicates that community pressure or prevalence of use of a technique in the village positively affects the probability of adoption of these three techniques.

Surprisingly, having land tenure is not significant for any of the adoption techniques and the negative signs of the coefficients of zaï and stone bunds are not consistent with theory. This may be due to the fact that if borrowers do not expect land to be taken back without warning, they may not care about tenure when investment is annual (manure).

Table 4.1: Logit Estimates for Zaï, Stone bunds, and Manure

Variables	Zaï	Stone bunds	Manure
Intercept	-7.9437***	-2.2719	-4.1062***
	(2.9355)	(2.2300)	(1.1752)
Location	-2.755**	-0.5135	1.5316***
	(1.4000)	(1.0071)	(0.4490)
Slope	2.7299	1.4991	1.8284***
	(2.0220)	(1.4784)	(0.5650)
Sorghum	4.5406**	0.4199	1.3571***
	(1.9816)	(0.8218)	(0.5048)
Area	0.5882	0.9689**	0.5282***
	(0.3955)	(0.4012)	(0.1943)
Aginc	0.0014	-0.0009	0.0012**
	(0.0016)	(.0010)	(0.0006)
Nonaginc	0.0006	-0.0028*	0.0008*
	(0.0021)	(0.0016)	(0.0004)
Ldtenure	-0.6141	-0.8075	0.2272
	(1.0689)	(0.9500)	(0.5370)
Neighbor	0.5426***	0.2304**	0.0851**
	(0.1805)	(0.0981)	(0.0364)
Age	-0.0079	-0.0442	-0.0056
	(0.0285)	(0.0307)	(0.0147)
Femhead		0.4954	0.2637
		(1.5269)	(1.3436)
Literacy		-0.7397	-0.5733
		(1.3835)	(0.6737)
Hhsize	-0.1032	0 .0375	-0.0563
	(0.1210)	(0.0744)	(0.0413)
N	155	123	182
LR Chi^2	45.24	22.79	65.22
Prob Chi^2	0.0000	0.0296	0.0000
Log likelihood	-19.60	-27.93	-81.30
Pseudo R^2	0.5357	0.2898	0.2863

*, **, *** represent confidence levels of 90, 95, and 99% respectively.
Standards errors are in parentheses.

Household head demographic variables, *age*, *gender* and *literacy* do not play a significant role in the adoption of manure or stone bunds; nor is age significant for the adoption of zaï techniques. Household size, *hhsize* was insignificant for all three techniques; the positive coefficient for stone bunds is consistent may be explained by the fact that active household members would be able to provide more labor for implementing SWC. But for zaï and manure, the negative signs may indicate a large number of young children in the household. The logit models were estimated to get intuition about adoption of the techniques. However these are naïve models because they do not allow to tradeoff between all possible techniques.

Multinomial Logit Results

The estimated coefficients and log odd ratios for multinomial logit are summarized in Table 4.2 below. Because of missing values for stone bunds and deletion of observations for *femhead* and *literacy*, the sample size for this estimation has been reduced to 148 observations. When the choice of techniques to be adopted is jointly estimated using multinomial logit, a theoretically more sound choice, far fewer of the determinants prove significant.

Neighborhood effects as measured by the percentage of use of the techniques within the village have been proved to significantly affect the adoption of stone bunds and manure. Everything else held constant, a one unit increase in the percentage of neighbors adopting stone bunds and manure will increase the odds by respectively 1.44

times and 1.59 times as opposed to not adopting any technique with 95% confidence level.

Among the physical incentives to invest variables, only *sorghum* is significant for adoption of stone bunds and manure at the 90 and 95 % confidence levels respectively. Holding other variables constant, if a household grows sorghum, there is an increase in the odds that the household will adopt stone bunds and manure as opposed to non-adoption of 14.73 times and 4.67 times more likely to adopt stone bunds and manure respectively. According to Slingerland and Stork, cash crop producers who grow crops such as cotton are able to purchase inorganic fertilizer. However the survey villages (Woure, Silguey, Kobila, Ouonon, Koho, and Sayero) in our data set were predominantly engaged in subsistence agriculture. It may be that in the presence of yield information and physical information on the response of sorghum yields to these techniques that sorghum responds well to available techniques in Burkina Faso (Tiemtoré).

In terms of capacity to invest, only *aginc* is significant for zaï and manure but not for stone bunds, at the 90 and 95% levels, respectively. The odds ratio shows that the probability of change from non-adoption to zaï with a one unit increase in agricultural income is 1.0041times greater for zaï. For the same variable (*aginc*), the probability of changing from non-adoption to manure with a one unit increase in agricultural income is 1.0019 times greater for manure.

As in the logit estimation, land tenure status is insignificant for all the techniques. Household demographic characteristics, *age* and *hhsize* do not play a significant role in the adoption of the techniques in the multinomial logit specification.

Table 4.2: Multinomial Logit Estimates and Odd Ratios for Zaï, Stone Bunds and Manure as Compared to Non-adoption

	Zaï		**Stones bunds**		**Manure**	
Variables	Coefficients	Odd ratios	Coefficients	Odd ratios	Coefficients	Odd ratios
Intercept	-84.5247		-7.5198**		-7.2762***	
Location	-0.2535	0.7761	-0.9901	0.3715	0.4794	1.6152
Slope	-28.5629	3.9E-13	1.9427	6.9776	1.6632	5.2762
Sorghum	35.3463	2.2E+15	2.6901*	14.7325	1.5407**	4.6678
Area	0.2429	0.7844	0.2162	1.2413	0.4744	1.6070
Aginc	0.0041*	1.0041	0.0004	1.0004	0.0019**	1.0019
Nonaginc	-0.0042	1.0042	0.0006	1.0006	-0.0006	0.9994
Ldtenure	31.1687	3.4E+13	-1.2314	0.2919	-0.4750	0.6219
Neighbor	1.2460	3.4765	0.3660***	1.4419	0.4635***	1.5897
Age	-0.0041	0.9959	-0.0138	0.9863	-0.0166	0.9835
Hhsize	-0.1671	0.8461	-0.0076	0.9924	-0.0664	0.9358
N			148			
LR Chi^2			135.93			
Pr Chi^2			0.0000			
Log likelihood			-67.8563			
Pseudo R^2			0.5004			

(Outcome Non-adoption is the comparison group)
*, **, *** represent confidence levels of 90, 95, and 99% respectively.

Because the coefficient of determination, R^2 is not a good measure of how well the model fits the data in the multinomial logit specification, we test the ability of the estimated model to correctly "predict" or reproduce the technique actually chosen. Table 4.3 provides the results of correctly predicted adoption (Y=1) outcomes by technique based on the multinomial logit results shown in Table 5. The percentage of correctly predicted outcomes for each technique is calculated at two thresholds: greater than 10% and 50% probability that the specified model will predict the adoption of each technique by observation. At both thresholds, the model more accurately predicted the cases in which manure was adopted, 98% at 10% or greater probability that the observation would predict manure was adopted, 98% of the predictions were correct. At the 10% threshold, 57% of the zaï adoptions were predicted correctly, whereas stone bunds were only predicted correctly 40% of the time. Naturally at the higher threshold of prediction of 50% probability that the respective technique resulted in adoption, the percentage of "correct" predictions fell.

Table 4.3: Sample Multinomial Logit Prediction Results

SWC Technique	*Actual % in multinomial logit sample*	*Correctly Predicted adoption Y=1 (10% threshold)*	*Correctly Predicted adoption Y=1 (50% threshold)*
Zaï	8.64	57	14
Stone bunds	9.09	40	10
Manure	30.63	98	29

Tobit results

To restate the model, the dependent variable is the percentage of cropland of farmer *i* improved using any of the three SWC techniques. Unless the latent variable is the variable of interest, the Tobit coefficients cannot be interpreted directly. Therefore the coefficients and marginal effects (which can be interpreted) are summarized in Table 4.4 below. The marginal effects are decomposed according to equation 3.11 into the expected response of current adopters ($\partial E(Y^*)/\partial X_k$) and the expected response of non-users ($\partial F(z)/\partial X_k$). Those two effects sum up to the total effect ($\partial E(Y)/\partial X_k$). Among the nondiscrete variables, only *neighbor* and *nonaginc* are significant at 99% and 90% confidence level respectively. The interpretation of marginal effects of continuous variables for the Tobit model is a follows. Using the marginal effects for the neighbor variable as an example, a 1% increase in the percentage of cropland covered by SWC techniques will result in a 109.29 % increase in the probability of being and adopter (expected response of non-users), in a 36.36% increase in the intensity of use by current adopters and a 46.27% increase in the total probability of adoption. If nonagricultural income increases by 1000 FCFA, the probability of being an adopter will increase by 0.012%, current users will increase conservation techniques acreage by 0.004% and the total probability of adoption will increase by 0.005%. All the binary variables (*location, slope,* and *sorghum*) are intercept shifters.

Table 4.4: Parameter Estimates and Marginal Effects of the Tobit Model

Explanatory Variables	*Normalized Coefficients*	*Marginal Effects* *Adoption*	*Intensity of use*	*Total effect*
		$\frac{\partial F(z)}{\partial X}$	$\frac{\partial E(Y^*)}{\partial X}$	$\frac{\partial E(Y)}{\partial X}$
Intercept	-1.0060 (0.2480)	-0.9307	-0.3096	-0.3940
Location	0.2585*** (0.0884)	0.2423	0.0872	0.1158
Slope	0.5062*** (0.1074)	0.4544	0.2022	0.2778
Sorghum	0.3024*** (0.1019)	0.2805	0.1001	0.1315
Aginc	0.0001 (0.0001)	0.00011	0.00004	0.00005
Nonaginc	0.0001* (0.00007)	0.00012	0.00004	0.00005
Ldtenure	0.1980* (0.1124)	0.1800	0.0600	0.0754
Neighbor	1.1814*** (0.2084)	1.0929	0.3636	0.4627
Age	-0.0026 (0.0028)	-0.0024	-0.0008	-0.0010
Femhead	0.0887 (0.1994)	0.0837	0.0289	0.0380
Hhsize	-0.0008 (0.0081)	-0.0007	-0.0002	-0.0003
Literacy	0.0876 (0.1326)	0.0825	0.0284	0.0372

N=173, Log-likelihood = -84.81, LRchi2 (11) = 75.17 p-value = 0.0000, E(Y) = 0.1711, E(Y/Y>0) = 0.3015, F(z) = 0.3931.
*, **, *** represent confidence levels of 90, 95, and 99% respectively.
Standards errors are in parentheses.

Table 4.5 provides the three components of elasticity according to the decomposition of McDonald and Moffit: elasticity of adoption, elasticity of intensity of use and total elasticity calculated for the significant variables. If the percentage of neighbor's land covered by conservation technique increases by 1%, the expected response of non-users is a 0.8940% increase in adoption, the expected response of current users is a 0.3879% increase in the conservation techniques acreage and the expected total change in elasticity is 1.2819% increase. A 1% increase in off-farm income (*nonaginc*) will result in a 0.0454% increase in the probability of being an adopter, a 0.0202% increase in the intensity of use and a 0.0656% increase in the total elasticity of adoption. The estimated elasticities imply that neighbor contributes the most to motivate the adoption and intensity of use of SWC techniques which is consistent with the multinomial logit results. This suggests that institutional mechanisms should be implemented to support the diffusion of indigenous knowledge through extension and education using local communities' organizations as frameworks. Unfortunately, although we know through background on Burkina Faso and past literature (Baidu-Forson) that NGOs intervene in education and diffusion of SWC techniques in Burkina Faso, there was no measure of the amount of extension education and intensity of these education efforts and contact in the data set.

The main difference between the multinomial logit model and the Tobit results is that tenure status significantly and positively affects conservation decisions for the latter. All other significant variables belong to the same category, physical incentives to invest (*location* and *slope* were significant for Tobit only, *sorghum* for both models), capacity to invest (*aginc* was significant for multinomial logit and *nonaginc* for Tobit), and community pressure (*neighbor* was significant for both models). The difference between Tobit and multinomial logit results may be due to the smaller number of explanatory variables used per technique in the latter and the specification of the two models. Indeed, the farm size (*area*) being the basis of the dependent variable computation is not used in the Tobit model to avoid collinearity with the dependent variable. In addition, *femhead* (female headed households) and *literacy* (knowing how to read and write) have been omitted from the multinomial logit model because of collinearity with zaï.

Table 4.5: Elasticities Calculated at the Mean of Significant Variables

Explanatory variables	Elasticity components Adoption $\eta F(z)$	 Intensity of use $\eta E(Y^*)$	 Total $\eta E(Y)$
Location	0.1195	0.0561	0.1756
Slope	0.1248	0.0724	0.1972
Sorghum	0.1737	0.0808	0.2545
Nonaginc	0.0454	0.0202	0.0656
Ldtenure	0.1704	0.0740	0.2444
Neighbor	0.8940	0.3879	1.2819

Chapter 5

SUMMARY AND CONCLUSIONS

Summary

This study examined the factors affecting the adoption of three prevalent conservation techniques in Burkina Faso using farm-level data. Logit, multinomial logit and Tobit models were used to conduct the analysis. Understanding the willingness to adopt natural resource conservation practices may be useful to public policy decision makers in addressing property rights issues (land tenure is still mostly managed by community leaders), targeting education programs, or subsidizing conservation practices. Physical factors such as location and slope proved significant in influencing adoption in the logit and Tobit specifications. Growing sorghum as opposed to other crops proved to positively affect the odds of adopting stone bunds and manure enrichment in the multinomial logit model and to also positively affect the conservation decision in the Tobit model. This result for sorghum may occur because of self-selection on the part of farmers who are aware of the limitations of their land to grow other crops. Cash crop producers, who grow crops such as cotton, are able to purchase inorganic fertilizer, whereas these villages were predominantly in subsistence agriculture (Slingerland and Stork). Also, it may be true that in the presence of yield information and physical information on the response of sorghum yields to these techniques, that they know sorghum responds well to available techniques in Burkina Faso (Tiemtoré).

Across all models, community prevalence or pressure to adopt conservation practices significantly affected the adoption of two or more of the techniques. This result suggests economies of scale in changing attitudes and prevalence of adoption of techniques through education and extension. Unfortunately, although we know that local non-governmental organizations such as 6S (Se Servir de la Savane et Saison Sèche et au Sahel) engage in education on SWC techniques, no measure of household contact was available in the data set.

The main difference between the Tobit results and the other specifications is that land ownership significantly increases the adoption and intensity of use of any conservation measure rather than an individual measure as estimated in the multinomial logit model. This may be due to the fact that different explanatory variables have been used for each model because of collinearity issues. The findings on literacy and zaï adoption also show that education in general and extension education about the techniques, in specific, may improve farmer's willingness and capacity to better manage the soil fertility.

Finally, since both agricultural income (logit and multinomial logit) and non-agricultural income (logit and Tobit) increase farmer's likelihood of investing in conservation techniques, this suggests that there is a role for subsidization of SWC or expanding access to credit. As for the techniques that are labor intensive, access to transportation for materials may prove to aid in adoption of stone bunds.

Limitations of the study and suggestions for further research

Future studies should be designed carefully so that the decision to adopt and the intensity of use may be estimated sequentially. First the Tobit analysis treats adoption and intensity of use decisions as joint. This may not be the case in the sense that farmers may first decide to invest in conservation (adoption) and then determine how much to invest (intensity of use). To distinguish between factors affecting the two decisions, a double hurdle model proposed by Cragg or a two-stage Heckman's model are needed. The double hurdle model consists of fitting a probit model using all observations then a truncated regression is done the non-zero observations. For this study, the initial values for stone bunds were not feasible for the truncated regression due to the large number of missing values. Hence, a double hurdle model could not be used. For Heckman's procedure the estimation of a probit model of the adoption decision is followed by the computation of the sample selection bias. This bias is then incorporated into a model of effort estimated using OLS. However Heckman's model does not allow for the decomposition of elasticities as it is the case in the Tobit model. Elasticities are needed to draw policy recommendations. Therefore the Tobit analysis was chosen over the two others. Further research should investigate conservation decisions by estimating both Tobit and double hurdle model which treats adoption and intensity of use decisions as separate and likelihood ratio test should be conducted as done in Gebremedhin and Swinton's article.

Future studies may also improve upon these measures by refining the variables that measure household characteristics such as land tenure status and exposure to education about SWC techniques. The data available to this study did not allow distinguishing between short and long term tenure status effects on adoption and there was no measure of extension education effects on adoption. In addition, short/long term tenure status and extension impacts should be addressed. The sample percentage of adoption of zaï (8.64%), stone bunds (9.09%) and manure (30.63%) are low. Gathering data on more areas with relatively high adoption of SWC techniques may provide more insight in conservation decisions. Future surveys should collect data on expenditures on implementation of SWC practices, number of extension agents present in the area, NGOs education intensity, distance of plots from homestead, plot slope characteristics (length, steepness), mechanized implementation of labor demanding SWC techniques (zaï and stone bunds), farmer's perception of erosion problem and perceived attitude of community toward SWC techniques non-adopters.

BIBLIOGRAPHY

Adesina, A.A., and M.M. Zinnah. "Technology Characteristics, Farmers' Perceptions and Adoption Decisions: A Tobit Model Application in Sierra Leone." *Agricultural Economics* 9(1993): 297-311.

Anim, F. D. "A Note on the Adoption of Soil Conservation Measures in the Northern Province of South Africa." *Journal of Agricultural Economics* 50(1999): 336-345.

Baidu-Forson, J. "Factors Influencing Adoption of Land-enhancing Technology in the Sahel: Lessons from a Case Study in Niger." *Agricultural Economics* 20(1999): 231-239.

Besley, T. "Property Rights and Investments Incentives: Theory and Evidence from Ghana." *Journal of Political Economy* 103(5): 903-937.

Bandré, P. and S. Batta. "Soil and Water Conservation (SWC) in Burkina Faso." Overseas Development Institute, October 1998.

Boserup, E. "The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure." Aldine Publishing Co., Chicago, 1965.

Bultena, G. L., and E. O. Hoiberg. "Factors Affecting Farmers' Adoption of Conservation Tillage." *Journal of Soil and Water Conservation* 38 (3): 281-284.

Cleaver, M., and W. G. Donovan. "Agriculture, Poverty, and Policy Reform in Sub-Saharan Africa." World Bank Discussion Paper No 280, Africa Technical Department Series, 1995.

Dejene, D., E. K. Shishira, P.Z. Yanda, and F. H. Johnsen. "Land Degradation in Tanzania, Perspective from the Village". World Bank Technical Paper No 370, Washington D.C., 1997.

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

Food and Agricultural Organization (FAO). Internet site: http://www.fao.org/giews/french/basedocs/bkf/bkfgen1f.stm#I4, Accessed January 18, 2004.

Featherstone, A. M., and B. K.Goodwin. "Factors Influencing a Farmer's Decision to Invest in Long-Term Conservation Improvements." *Land Economics* 69 (1993): 67-81.

Feder, G., R. E. Just, and D. Zilberman. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33 (1985): 155-98.

Gebremedhin, B., and S. M. Swinton. "Investment in Soil Conservation in Northern Ethiopia: The Role of Land Tenure Security and Public Programs." Department of Agricultural Economics, Staff Paper No 2002-13, Michigan State University, 2002.

Greene, W. *Econometric Analysis*.3rd ed. New Jersey: Prentice Hall Co., 1997.

Hayes, J., M. Roth, and L. Zepeda. "Tenure Security, Investment and Productivity in Gambian Agriculture: A Generalized Probit Analysis." *American Journal of Agricultural Economics* 79(1997): 369-382.

Heckman, J.J. "Sample Selection Bias as a Specification Error". *Econometrica* 47(1979): 153-161.

Kambou, N. F., S. J-B. Taonda, R. Zougmoré, D. Kaboré, and J. Dickey. "Evolution of Sedimentation, Surface micro-morpohology, and Millet Production in Response to Soil Conservation Practices on an Eroded Site at Yilou, Burkina Faso." In J. Lowenberg-DeBoer, J.M. Boffa, J. Dickey, and E. Robins (eds), Integrated Research in Agricultural Production and Natural Resource Management. Purdue University, INERA and WINROCK INt., West Lafayette, IN, 1994, pages 43-54.

Kazianga, H., and W. Masters. "Investing in Soils: Fields Bunds and Microcatchments in Burkina Faso." Selected Paper at the American Agricultural Economists Association Annual Meeting, August 5-8 2001.

Kessler, J.J., and C.Geerling. "Profil Environmental du Burkina Faso." Wageningen University of Agronomics, Netherlands, March 1994.

Lal, R. "Methods and Guidelines for Assessing Sustainable Use of Soil and Water Resources in the Tropics. Soil Management Support Services. USDA Soil Conservation and USAID, SMSS Technical Monograph No 21, 1994.

Lapar, M.L.A., and S. Pandey. "Adoption of Soil Conservation: The Case of the Philippine Uplands." *Agricultural Economics* 21(1999): 241-256.

Lee, L.K. "The Impact of Landownership Factors on Soil Conservation." *American Journal of Agricultural Economics* 62 (1980): 1070-1076.

Lee, L.K. and W.H. Stewart. "Landownership and the Adoption of Minimum Tillage." *American Journal of Agricultural Economics* 65(1983): 256-264.

Li, G., S. Rozelle, and L. Brandt. "Tenure, Land Rights and Farmer Investment Incentives in China." *Agricultural Economics* 19(1998): 63-71.

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

McDonald, J.F., and R.A. Moffit. "The Uses of Tobit Analysis." *Review of Economics and Statistics* 62(1980): 318-321.

Ministère de l'Action Coopérative Paysanne. "Rapport de fin de campagne 1989/90 du projet expérimental zaï. " Secrétariat Géneral, Direction de l'Éducation et de la Formation Coopérative, Ouagadougou, Burkina Faso, March 1990.

Nkonya, E., A. Barkley, S. Hamilton, and D. Bernardo. "Environmental and Economic Impacts of Soil Erosion and Fertility Mining in Northern Tanzania." Selected Paper at the American Agricultural Economists Association Annual Meeting, Nashville, Tennessee, August 8-11 1999.

Norris, P.E., and S.S. Batie. "Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis." *Southern Journal of Agricultural Economics* 19(1987): 79-90.

Pender, J. L., and J. M. Kerr. "Determinants of Farmers' Indigenous Soil and Water Conservation Investments in Semi-arid India." *Agricultural Economic*s 19(1998): 113-126.

Place, F., and P. Hazell. "Productivity Effects of Indigenous Land Tenure Systems in Sub-Saharan Africa." *American Journal of Agricultural Economics* 75(1993): 10-19.

Population Reference Bureau. Internet site: www.prb.org, Accessed on January 23, 2005.

Rahm, M. R., and W. E. Huffman. The Adoption of Reduced Tillage: "The Role of Human Capital and Other Variables." *American Journal of Agricultural Economics* 66 (1984): 405-413.

Roose, E., V. Kaboré, and C. Guenat. "Zai Practice, a West African Traditional Rehabilitation System for Semi-arid Degraded Lands: A Case Study in Burkina Faso." In Arid Soil Research and Rehabilitation, vol. 13(1999): 343-355.

Savadogo, K., C.A. McCracken and T. Sakurai, 2002. "Socioeconomic Determinants of Soil and Water Conservation in Burkina Faso." Edited Proceedings of CGER/NIES Conference on "Integration and Regional Research Activities to Combat Desertification -Present State and Future Prospect", Tsukuba, Japan.

Shiferaw, B., and S. Holden. "Resource Degradation and Adoption of Land Conservation Technologies in the Ethiopian Highlands: A Case Study in Andit Tid, North Shewa." *Agricultural Economics* 18 (1998): 233-247.

Slingerland, M.A. and V.E. Stork. "Determinants of the Practice of Zaï and Mulching in North Burkina Faso." *Journal of Sustainable Agriculture* Vol. 16 (2) 2000.

Sourabi, N. "Land Tenure Systems and the Management of Soil Fertility in the Sahel: The Case of Burkina Faso." *Linking Soil Fertility Management to Agricultural Input and Output Market Development*. S. K. Debrah and W.G. Foster, eds., Lome, Togo: IFDC-Africa, 1999.

Tiemtoré, Justin. "Zaï: Les Trous de l'abondance." Le Grenier. No 9: June 2000.

United Nations Development Program (UNDP). Human Development Reports, Internet site: http://hdr.undp.org/statistics/data/cty/cty_f_BFA.html, Accessed on February 17, 2005.

Wang, H. H., D.Young, and O. M. Camara. "The Role of Environmental Education in Predicting Adoption of Wind Erosion Control Practices." Selected paper at the Western Agricultural Economics Association Annual Meetings, British Columbian, June 29-July 1, 2000.

World Bank. Internet site: www.worldbank.org/data/countrydata/countrydata.html, Accessed on February 17, 2005.

Zougmoré, R., D. Kaboré, and J. Lowenberg-DeBoer. "Optimal Spacing of Soil Conservation Barriers: Example of Rock Bunds in Burkina Faso." *Agronomy Journal* 92(2000): 361-368.

Appendix I

Zaï (left) versus manure (right) adoption

Photo 7. Cowpea on termite plus cattle dung plots. Note that the termites had consumed all the cattle dung applied as a mulch without negative effects on the growing crop.

Photo 8. Cowpea on non-termite cattle dung plots. Note that 7 months after the lay out of the experiment, the cattle dung is still not decomposed and that the crop did not perform well, despite cattle dung application.

Source: Food and Agricultural Organization

Appendix II

Contour stone bunds in Burkina Faso and Mali

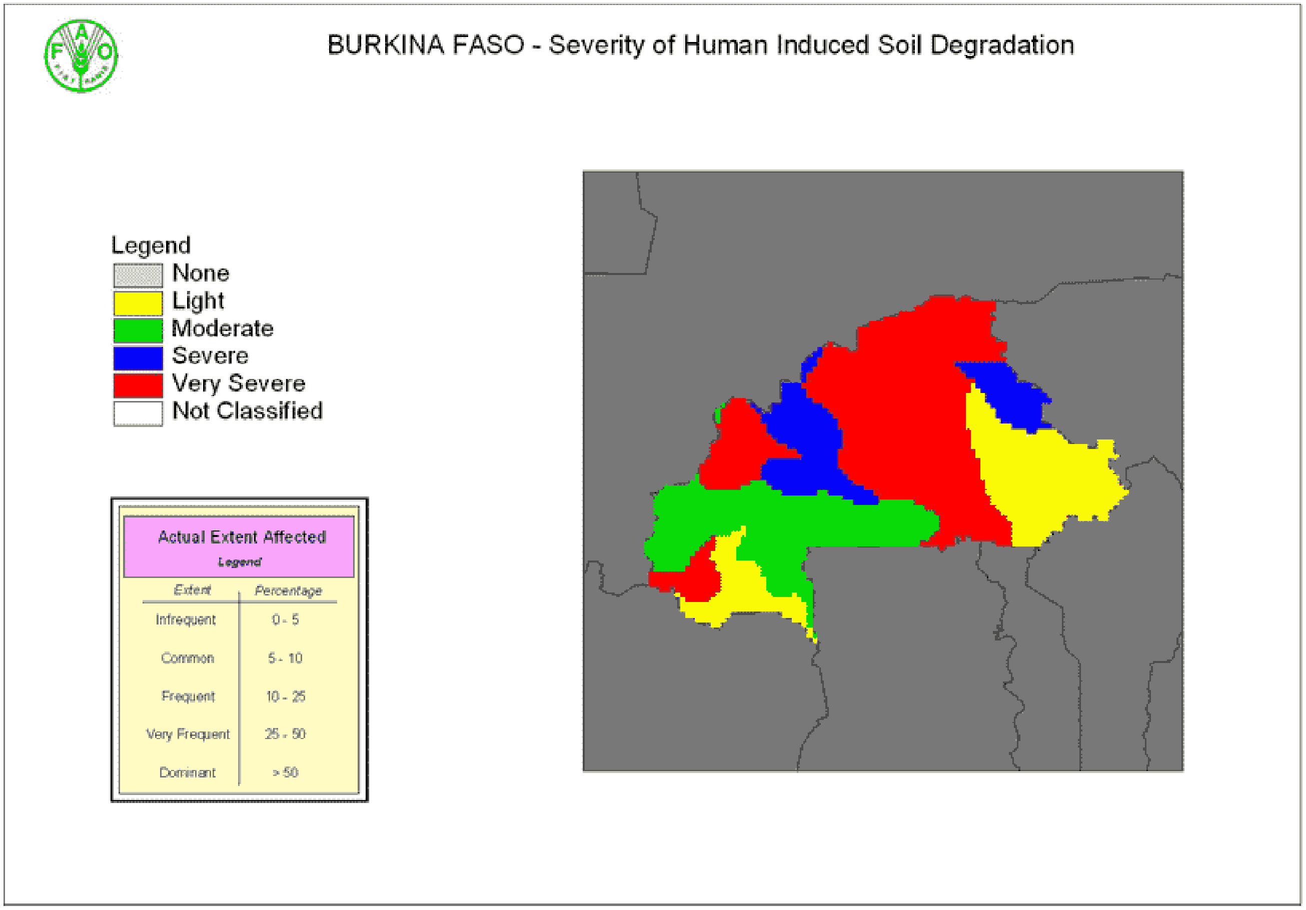
Plate 4.26 Stone lines set out on the contour near Onahigoua, Burkina Faso (OXFAM)

Plate 4.27
Increased moisture and deposited soil improve the grass growth near stone lines, Mali (G. Hallam)

Source Food and Agricultural Organization

Appendix III

Soil degradation map



Source: Food and Agricultural Organization, country information

Appendix IV

Stata Codes

Neighborhood effect variable computation

For stone bunds

```
sort vill by vill:gen n_vill=_N
egen totalsb=sum(disrel), by (vill)
gen neibsb=(totalsb-disrel)/(n_vill-1)
```

For manure

```
sort vill
by vill:gen n_vill=_N
egen totalmanu=sum(manu), by (vill)
gen neibmanu=(totalmanu-manu)/(n_vill-1)
```

For zaï

```
sort vill
by vill:gen n_vill=_N
egen totaltech=sum(prac), by (vill)
gen neibtech=(totaltech-prac)/(n_vill-1)
```

Descriptive statistics

```
summarize tech location slope sorghum area aginc nonaginc ldtenure neighbor age hhsize

summarize technic location slope sorghum aginc nonaginc ldtenure neighbor age femhead hhsize literacy
```

Logit models

```
logit  disrel location slope sorghum area aginc nonaginc ldtenure neighbor age  femhead literacy hhsize

logit  manure location slope sorghum area aginc nonaginc ldtenure neighbor age femhead literacy hhsize

logit  zairel location slope sorghum area aginc nonaginc ldtenure neighbor age hhsize
```

Multinomial logit model

Regression

```
mlogit tech location slope sorghum area aginc nonaginc ldtenure neighbor age hhsize
```

Prediction (correct predicted probabilities at the 10% and 50% threshold)

```
predict pzai if e(sample), outcome (2)
```

```
predict psbund if e(sample), outcome (3)
predict pmanure if e(sample), outcome (4)
generate zai9=1 if pzai<.10
generate zai10=1  if pzai>=.10
generate zai49=1  if pzai<0.5
generate zai50=1 if pzai>=.5
generate sbund9=1 if psbund<.1
generate sbund10=1 if psbund>=.10
generate sbund49=1 if psbund<0.5
generate sbund50=1 if psbund>=.5
generate manure9=1 if pmanure<0.1
generate manure10=1 if pmanure>=.1
generate manure49=1 if pmanure<.5
generate manure50=1 if pmanure>=.5
summarize zai49 zai50 sbund49 sbund50 manure49 manure50
summarize  zai9 zai10 sbund9 sbund10 manure9 manure10
```

Tobit model

Regression

```
tobit technic location slope sorghum aginc nonaginc ldtenure neighbor age femhead
hhsize literacy,ll
```

McDonald and Moffit decomposition of elasticities

```
dtobit
```

Vita

Eugenie W. H. Maiga

Candidate for the Degree of

Master of Science

Thesis: DETERMINANTS OF ADOPTION OF SOIL AND WATER CONSERVATION TECHNIQUES IN BURKINA FASO

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Ouagadougou, Burkina Faso, February 1, 1980, the daughter of Desiré and Martine Maiga.

Education: Graduated from Lycée Bogodogo, Ouagadougou, Burkina Faso, in July of 1997; received Bachelor of Science Degree in Economics from the University of Ouagadougou in July 2002; completed the requirements for the Master of Science Degree at Oklahoma State University in May, 2005.

Name: Eugenie W. H. Maiga Date of Degree: May, 2005

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: DETERMINANTS OF ADOPTION OF SOIL AND WATER CONSERVATION TECHNIQUES IN BURKINA FASO

Pages in Study: 59 Candidate for the Degree of Master of Science

Major Field: Agricultural Economics

Scope and Method of Study: This study examines the determinants of soil and water conservation (SWC) practices adoption and use in three agro-ecological zones in Burkina Faso. Our study uses farm-level data that have been collected on 254 households in three agro-ecological zones in Burkina Faso over the period 1999-2003. Logit, Multinonomial logit, and Tobit models are used to examine the factors affecting adoption of Zaï structures (water and silt catchments), stone bunds and manure soil amendment.

Findings and Conclusions: Across all three models, community prevalence or pressure to adopt conservation practices significantly affected the adoption of two or more of the techniques. This result suggests economies of scale in changing attitudes and prevalence of adoption of techniques through education and extension. The findings on literacy and zaï adoption also show that education in general and extension education about the techniques, in specific, may improve farmer's willingness and capacity to better manage the soil fertility. Since both agricultural and non-agricultural income increases farmer's likelihood of investing in manure and zaï techniques, this suggests that there is a role for subsidization of SWC or expanding access to credit. As for the techniques that are labor intensive, access to transportation for materials may prove to aid in adoption of stone bunds.

Advisor's Approval: Tracy Boyer