Effects of Participation in Organic Markets and Farmer-based Organizations on the Adoption of Soil Conservation Practices among Small-scale Farmers in Honduras

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Abstract

Conservation agriculture is often perceived to provide “win-win” outcomes for farmers leading to reduced erosion and off-site sedimentation, as well as improved soil fertility and productivity. However, adoption rates for conservation agriculture in many regions of the world remain below expected levels. This paper looks at the effect of organic markets in providing incentives for farmers to adopt soil conservation practices. Farmer-based organizations may link farmers to these markets by helping them overcome information deficiencies with respect to production standards and consumer preferences. Based on original survey data from 241 small-scale farm households in Honduras, we find that both participation in organic markets and farmer-based groups have positive effects on the number of soil conservation practices adopted on the farm. The results indicate that besides supply-oriented policy measures, such as the provision of technical assistance and extension, demand-related factors are likely to play an important role in sustainable soil management. Demand-oriented policy measures can include support for labeling initiatives and consumer education to facilitate value-added product differentiation and market segmentation.

Key words: soil conservation, technology adoption, organic markets, farmer organizations

Introduction

Poor farmers in developing countries often depend on marginal or “less-favored” lands with limited agricultural potential to make a living. Less-favored rain-fed lands, which account for approximately 54 percent of the total agricultural area worldwide, are predominantly found in hillside and dryland areas and are characterized by resource degradation and low agricultural productivity due to poor climate, soils and topography (Kuyvenhoven et al. 2004; Ruben and Pender, 2004; World Bank, 2008). Due to their geographical location, these lands are often both highly susceptible to land degradation and at the same time extremely critical for protecting natural resources, such as watersheds (Kuyvenhoven et al. 2004). In addition, many less-favored areas are characterized by poor market access and elevated transportation costs resulting from low infrastructural development and remoteness from population centers, which hampers their integration into functioning markets (Ruben and Pender, 2004). Estimates are that these lands account for nearly two-thirds (62 percent) of rain-fed land in developing countries and are home to about one-third of the rural population (FAO, 2003; World Bank, 2008). Thus, raising their productivity and improving the livelihoods of the people who depend on them are critical steps to rural poverty reduction.

In the past, extension services have often focused on increasing crop yields without paying adequate attention to maintaining soil functions. But, in many cases, resource-poor farmers lack the capital to purchase adequate fertilizers and other inputs necessary to obtain consistently high yields. As a result, farmers find themselves trapped in a downward spiral of poverty, low investment capacity, soil degradation and low agricultural productivity (Ruben and Pender, 2004). Breaking out of this “poverty trap” is commonly viewed as a key goal for agricultural and rural development efforts (Pender, 2004; World Bank, 2008).

Conservation agriculture (CA) is widely considered as a promising approach to break this cycle (FAO, 2008). Conservation agriculture relies on soil conservation practices to maintain and improve soil functions, using on-farm inputs, and keeping purchased inputs to a minimum (Lee, 2005). Notwithstanding its advantages and widespread promotion for many years, adoption rates of CA practices among small-scale farmers often remain lower than expected (Shiferaw and Holden, 2000; Jansen et al., 2006a;). Given that land degradation can irrevocably destroy the resources needed for food production and agricultural income generation, it is critical to identify the factors and policies that promote farm-level adoption of CA in these areas.

For this reason, a substantive body of literature has emerged examining the factors that determine the adoption of conservation practices at the farm level (Guerin and Guerin, 1994; Lee, 2005; Doss, 2006). A recent review of the literature concluded that seldom, if ever, can universal factors be identified that uniformly affect adoption across different studies and locations (Knowler and Bradshaw, 2007). Most empirical studies include farm and household characteristics and capital endowments among the factors assumed to influence technology uptake, but have generally neglected demand factors that may equally shape farmers incentives for adoption. Staal et al. (2002) suggest that the location of a farm – defining not only its natural resource base, but also its position in a rural-urban continuum – is a critical factor determining not only the value of land, but also the technologies applied in production. On account of this, some studies have included distance variables measuring the distance from the farm to the nearest market, in some cases accounting for qualitative differences in the road structure (Staal et al., 2002, Jansen et al., 2006a). However, results are not unambiguous, revealing both positive (Dimara and Skuras, 2003) and negative (Neill and Lee, 2001), as well as insignificant (Amsalu and de Graaff, 2006) effects of market access on adoption. These diverse results can be explained by the fact that the distance to the nearest town can influence farmers' decision-making in various ways. Besides its impact on land values and on the availability of technology, proximity to an urban center will influence the access to agricultural output and input markets, the availability of information and support organizations, including lending institutions, as well as the labor pool and the opportunity costs of labor. As a result, those factors that are not explicitly included in the analysis but proxied by the location of the farm may confound the results. In this paper we argue that participation in markets that specifically remunerate farmers for using sustainable production techniques is likely to influence farmers' decisions to allocate scarce resources to soil conservation tasks.

The main contribution of this paper is thus to analyze the effect of participation in organic niche markets on the adoption of soil conservation practices. To the best of our knowledge, no previous studies have explicitly looked at the potential role of organic markets in providing incentives for farmers to adopt soil conservation techniques. In addition, we examine the effect that membership in farmer-based organizations has on adoption as well as on market participation. Farmer-based groups can significantly reduce transaction costs associated with smallholder production and marketing, which are especially high in less-favored and remote areas. In the current debate about farmers' integration into high-value and certified markets, much emphasis is placed on producer organizations and their potentially critical role in linking farmers to markets and providing them with technical assistance to meet market requirements.

The following section will discuss these hypotheses in further detail. After describing the study area and empirical data in section three, the estimation procedure will be detailed in section four. In the econometric analysis, we account for potential bias that may result from the simultaneity of farmers' decision-making, which, if ignored, would confound the statistical results. Based on the empirical findings presented in section five, we derive recommendations for policy measures that provide support and incentives for the adoption of conservation agriculture. These policy implications together with some concluding remarks are presented in chapter six.

The Adoption Decision

The decision to apply soil conservation practices is a function of the net benefits that the farmer expects to gain from adoption as compared to non-adoption of a technology or practice. The additional costs associated with adoption stem from various sources. Often, they result from higher input and labor requirements of the new technology or practice – for example, higher labor costs in the establishment of terraces and other physical conservation measures or in more intensive crop, pest and weed management activities (Amsalu and de Graaff, 2006). Lee (2005) documents the very high range of labor costs associated with sustainable agriculture technology adoption. In addition, information costs are involved in the acquisition of new technology and the learning process itself. Given high transactions costs in less favored areas, the costs of information gathering can be non-trivial, especially for small-scale farmers. Moreover, the risks associated with a farmer's adopting a new technology and the unknown climatic, biological and economic factors that may influence yields and returns (Baerenklau, 2005) can be substantial in an environment characterized by uncertainty.

These costs have to be weighed against the expected benefits. Benefits may include potential labor and input savings as well as increases in output resulting from improved soil fertility (Knowler and Bradshaw, 2007). In addition to on-farm benefits, there are environmental benefits that extend beyond the boundaries of the farm. These can be substantial. They include the prevention of erosion and irrigation leakage resulting in reduced downstream sedimentation and contamination, as well as more regularized river flow and reduced flooding (Knowler and Bradshaw, 2007, World Bank, 2008). Furthermore, studies have shown the positive effect of conservation agriculture, especially conservation tillage, on carbon sequestration (Lal and Kimble, 1997, Allmaras et al., 2000). By retaining fertile and functioning soils, conservation agriculture can also have positive impacts on food security and biodiversity. It is clear that while most of the costs associated with the adoption decision accrue at the farm level, benefits are gained not only by farmers but also by the society as a whole. Not being able to capture the full benefits of adoption, farmers have less of an incentive to adopt, and adoption rates will typically remain below socially desirable levels (Shiferaw and Holden, 2000). This gap between actual and desired adoption levels can be narrowed through incentive programs that compensate farmers for the services that they provide to society (FAO, 2007; Knowler and Bradshaw, 2007). However, while compensation programs can be a promising tool to remunerate farmers for the provision of environmental services and to internalize the benefits generated through adoption, they are rarely found in developing countries due to their high costs and administrative complexity (FAO, 2007; World Bank, 2008).

Organic Markets and Sustainable Agricultural Practices

Over the last years, consumers have shown an increasing interest in the environmental and health-related aspects of food production, as reflected in a substantial growth of markets for organic products (FAO, 2000; Hobbs et al., 2001). Especially in major North American and European markets, annual growth rates of organic product segments have been as high as 20 percent (Raynold, 2004). This growth trend in consumer demand has led to increasing procurement of organic agricultural produce in developing countries. Raynold (2004) documents the increasing internationalization of the organic product trade and the expansion of organically farmed land in developing countries. If farmers are able to comply with the production standards applied in organic agriculture, this development opens up new marketing opportunities. Given that organic production standards prohibit the use of synthetic fertilizers, farmers must recur to alternative agricultural practices in order to maintain soil fertility, such as organic manure applications. Conservation practices that restore soil functions and build up soil organic matter also help to prevent gradual productivity decline in organic production systems (IFOAM 2006). Therefore, organic agriculture is likely to encourage the adoption of soil conservation practices. For example, Bolwig et al. (2009) find in their study of organic smallholders in Uganda that certified organic farmers are more likely to apply various soil management techniques including mulching and manure applications.

Many consumers in organic markets are willing to pay a price premium for the added value of environmentally produced products. Giovannucci and Ponte (2005) note that these price premiums could potentially have a positive influence on the farmer's decision to invest in soil conservation. In less-favored areas, low agricultural productivity often forces farm households to supplement their agricultural income with non-farm income in order to make a living. In many rural areas, the development of infrastructure has improved access to urban centers, where more off-farm jobs are available. Previous studies have found that in regions where off-farm employment plays a major role, farmers are less likely to divert labor to conservation practices if the economic returns from off-farm labor are higher than the perceived benefits from investing scarce labor in soil conservation (Neill and Lee, 2001; Moser and Barrett, 2003; Jansen et al., 2006b; Lee, Barrett, and McPeak, 2006). In this context, the role of price premiums paid in organic market segments in increasing the profitability of sustainable agricultural production is important and may induce the allocation of scarce labor resources toward conservation activities.

Farmer-based Organizations and Transaction Costs

Small-scale farmers in less-favored areas often face multiple constraints in technology adoption decisions, including limited financial resources, and limited access to information, education, and extension. The latter can prove critical, especially in the context of knowledge-intensive technologies such as many of the practices involved in conservation agriculture. The application of conservation practices and integrated soil management techniques requires farmers to learn new skills and understand biophysical processes that determine the functioning of the soil and impact agricultural yields. Previous studies have documented a positive effect of extension services (Martin and Taylor, 1995; Somda et al., 2002; Jansen et al., 2006b), education (Rahm and Huffman, 1984), and information availability (Feather and Amacher, 1994; Bekele and Drake, 2003) on the adoption of conservation practices. However, the cost of gathering information regarding a new technology and the associated market opportunities can be prohibitive for individual farmers.

While small-scale farmers will often be unable to bear the high transaction costs themselves, cooperatives and farmer-based organizations can exploit economies of scale in the provision of services (Deininger, 1995; Holloway et al., 2000; Weaver and Wesseler, 2004). These organizations can collect information about production technologies and consumer preferences and provide it to their members in the form of extension visits and demonstration sessions. While the cost of obtaining this information would exceed the benefits to an individual farmer, members can benefit collectively from the information collected at the cooperative level (Shaffer, 1987). Different authors have pointed out the important role of cooperatives and farmers' organizations in providing farmers with access to differentiated market segments (Bacon, 2005; Sick, 1999; Verhaegen and van Huylenbroeck, 2001; Varangis et al., 2003). Narrod et al. (2007) stress that farmer groups can reduce the transactions costs involved in contracting between agribusinesses and small-scale farmers and increase the bargaining power on the side of the farmers. Kaganzi et al. (2008) list situations in which collective action is more and less effective, respectively. They claim that collective action can be very useful in cases where products are differentiated, price premiums are paid for specific standards, and market access for small-scale farmers is relatively poor (Kaganzi et al., 2007). In a study of Costa Rican coffee farmers, Wollni and Zeller (2007) show that cooperatives link farmers to specialty coffee markets and obtain higher producer prices for their members. Similarly, there is evidence in the literature that farmer groups have been successful in fostering the adoption of conservation practices (Smit and Smithers, 1992; Swinton, 2000; Rodriguez and Pascual, 2004). Thus, by reducing information search costs, farmer-based organizations can potentially help farmers overcome information deficiencies related to production technology and market access.

Research Area and Data

This study is based on original survey data collected from 241 small-scale farmers in Honduras. The goal of the survey was to elicit views and information from farm households regarding their adoption of conservation agriculture technologies and practices, the extent of their participation in organic markets, their involvement in farmers' associations, and the interlinkages among these behaviors. The survey was implemented in the state of La Paz, which is located in the southwestern part of the country. Six municipalities and twenty villages were selected in a multi-stage random sampling procedure; and in each village, twelve households were randomly selected. A standardized questionnaire was used to collect data on soil conservation practices, access to information and institutions, demographic and socio-economic household data, plot characteristics, and market participation. In addition, the geographic location of households was recorded using GPS, thus allowing the households to be matched with geographically-referenced data on soil types and distance to the nearest major town (CIAT 2001).

The study area is characterized by hillside agriculture, mostly basic grains (corn and beans) and coffee cultivation. The sloping terrain is highly susceptible to soil erosion and degradation. As a result, agricultural productivity is low, households pursue diverse livelihood strategies to fulfill their basic needs, and poverty is widespread (Jansen et al, 2006a). According to the 2001 Poverty Reduction Strategy Paper prepared by the Honduran government, almost 50 percent of the households in the La Paz area are unable to satisfy their basic needs on a day to day basis.

A large number of NGOs and foreign donors have worked on improving the living conditions in the area. Over time, they have helped to create farmer groups and associations, which in some cases have developed into independent, farmer-led organizations and cooperatives that serve their members and receive financial and technical assistance from bilateral and multilateral donors. Besides social functions, the major aim of these farmer-based organizations is to integrate their members into input and output markets and to take advantage of potential income opportunities through collective action. Some of the organizations engage in active negotiations with buyers on behalf of their members and search for new market outlets. In addition, they often provide credit (in cash or kind) as well as technical assistance to their members. Farmers can join as many organizations as they like, but in practice they face time constraints, because they usually can only benefit from an organization's activities if they attend group meetings.

Soil conservation is promoted by the farmer-based organizations themselves as well as by NGOs and through bilateral and multilateral technical cooperation projects. From the traditional "training and visit" approach, the methodological focus of technical assistance and extension has shifted to more experimental and participatory methods such as farmer field schools, where participants collectively farm a designated plot and experiment with different cultivation practices (van den Berg and Jiggins, 2007). The idea behind this approach is that farmers experiencing the benefits of a technology first-hand are more likely to later adopt it on their own plots. In the study area, 23 percent of the sampled farmers have participated at least once in a farmer field school. The greatest challenge in this approach is to obtain farmers' commitment to carry out maintenance activities on the experimental plot, when labor needs on the own farm are pressing.

The soil conservation practices most extensively applied among the households in the study sample are live barriers (vetiver grass, aloe vera) and crop residue mulching. In addition, about one-third of the households plant along contour lines and apply organic manure. All other conservation practices including terraces/stone walls, drainage ditches, cover crops and crop rotations, are used by only 10 percent or less of the households in the sample. Table one reports chi-square test statistics for a number of tests exploring the relationships between participation in farmers' groups and the adoption of the soil conservation practices most frequently applied in the study area. The test results show a strong relationship between participation in local farmer-based groups and the adoption of selected conservation techniques. Group members are more likely to adopt live barriers, to plant along contour lines, and to apply organic manure. Overall, group members use a more diverse set of conservation practices on their farms. Member households of farmer-based groups use an average of 2.4 different techniques as compared to 1.6 different practices used by non-member households on the average[1].

As regards farmers' market orientation, about one-fifth of the households in the sample produce exclusively for home consumption and do not participate in market transactions at all. However, the majority of the households sell part or all of their agricultural output in the market. For approximately one-fourth of those households that sell in the market, this merely refers to the local village market. The vast majority of the remaining households sell their products in Marcala, the local town, where coffee traders and a village market serving local farmers are located. Overall, 20 percent of the households in the sample sell their products in the organic market segment. Table two contains the results of several chi-square tests that examine the relationship between participation in organic markets and farmers' groups as well as the adoption of different soil conservation practices. The test results confirm that farmers who are members of a farmer-based group are more likely to participate in the organic market. In addition, there is a positive and significant relationship between organic marketing and the use of live barriers and organic manure on the farm.

Estimation Procedure

Conservation agriculture is a complex system that involves many different conservation measures and sustainable soil management practices. Consequently, when analyzing the adoption of conservation agriculture researchers face the problem of defining a cut-off point

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[1] Independent samples t-test is significant at 1% probability of error ($p < 0.01$).

for dividing farmers into adopters and non-adopters. In practice, many farmers will adopt only part of the package applying some conservation practices on their farm, but not others. To circumvent this problem, we choose the number of conservation practices adopted as the dependent variable in our model. The ordinal nature of the dependent variable motivates the use of an ordered probit model (Daykin and Moffatt 2002, Greene, 2008). While Poisson regression models are explicitly designed for count data, the underlying assumption is that all events have the same probability of occurrence. However, the probability of adopting the first conservation measure is different in this application from the probability of adopting a second or third measure, given that the farmer has already gained some experience with soil conservation and has been exposed to information about the technology.

The adoption decision is modeled in a random utility framework. The ordinal dependent variable indicates whether farmers adopt zero ($C_i = 0$), one ($C_i = 1$), two ($C_i = 2$), three ($C_i = 3$), or more than three ($C_i = 4$) different conservation practices. We assume that farmers decide to adopt a certain number of conservation practices based on the maximization of an underlying utility function

$$U_i = V_i(\beta' x_i) + u_i \quad \text{for } i = 1, \ldots, n \tag{1}$$

where V_i, the observed portion of the farmer's utility function, is expressed as a function of a vector of exogenous household and plot related variables, x_i, and a vector of parameters to be estimated, β, and is assumed to be equal to the mean of the random variable U_i. The unobserved portion of the utility framework is represented by an i.i.d. random error term u_i with mean zero. The farmer will choose to adopt an additional conservation measure if the utility gained from adopting it is greater than the utility of not adopting it. The utility level of each individual farmer U_i is unobserved, but we observe that

$$C_i = 0 \text{ if } U_i \leq \alpha_1 , \tag{2}$$

$$C_i = 1 \text{ if } \alpha_1 < U_i \leq \alpha_2 ,$$

$C_i = 2$ if $\alpha_2 < U_i \leq \alpha_3$,

$C_i = 3$ if $\alpha_3 < U_i \leq \alpha_4$,

$C_i = 4$ if $U_i > \alpha_4$,

where $\alpha_1 < \alpha_2 < \alpha_3 < \alpha_4$ are unknown threshold parameters to be estimated with β [2]. Assuming that u_i follows a normal distribution, we obtain the following probabilities (subscripts i are suppressed):

$$Prob(C = 0|x) = Prob(U \leq \alpha_1|x) = Prob(\beta'x + u \leq \alpha_1|x) = \Phi(\alpha_1 - \beta'x) \tag{3}$$

$$Prob(C = 1|x) = \Phi(\alpha_2 - \beta'x) - \Phi(\alpha_1 - \beta'x)$$

$$Prob(C = 2|x) = \Phi(\alpha_3 - \beta'x) - \Phi(\alpha_2 - \beta'x)$$

$$Prob(C = 3|x) = \Phi(\alpha_4 - \beta'x) - \Phi(\alpha_3 - \beta'x)$$

$$Prob(C = 4|x) = 1 - \Phi(\alpha_4 - \beta'x)$$

where $\Phi(.)$ is the standard normal cumulative distribution function. Parameter vectors α and β are estimated by maximum likelihood.

In addition to various household and plot-related variables, vector x_i in (3) includes two dummy variables that reflect farmers' participation in organic markets and in farmer-based groups, respectively. As discussed in previous sections, participation in organic markets and in farmer-based groups are both expected to be positively associated with farmers' decision to adopt conservation measures. Direct estimation of the effects of participation on adoption, however, is likely to be subject to endogeneity bias. If farmers self-select into farmers' groups, their unobserved household characteristics will systematically differ from non-participants. Endogeneity bias arises if these unobserved household characteristics are also correlated with the error term in the adoption model. Similarly, farmers participating in

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[2] β does not contain an intercept term, because the intercept term is normalized to zero in order to allow all threshold parameters to be free parameters (Daykin and Moffatt 2002). Alternatively, one of the threshold parameters can be normalized (Greene 2008).

the organic market segment are likely to have unobserved characteristics that differ from non-participants and are also correlated with adoption behavior, such as their attitude towards environmental and health issues. This potential source of bias is often mentioned in the adoption literature but rarely controlled for in the empirical analysis. To control for endogeneity bias, we estimate the model in two stages. In the first stage, a bivariate probit model is used to determine the factors influencing participation in farmers' groups as well as in organic markets. From the first-stage model we obtain the predicted values for participation in farmer groups and in organic markets; these, instead of the original values, are then inserted in the right hand side of the second-stage ordered probit model explaining the number of soil conservation practices adopted.

Participation in organic markets is modeled as a function of household and farm related variables, including demographic and socio-economic variables as well as crop choices. Crop choices are represented by major crop activity categories, i.e., whether the household grows vegetables, fruit or coffee reflecting the major cropping systems in the area. As an instrument we include the share of households in the district who participate in organic markets. Finally, we include a dummy variable that assumes one if the household is a member of a farmer-based organization. As discussed earlier in this paper, membership in farmers' groups is expected to have a positive effect on participation in niche markets.

Similarly, the equation explaining *participation in farmer-based organizations* includes demographic, socio-economic, and farm-related variables as potential explanatory factors. Here again, we include the share of households in the district who participate in farmer-based organizations as an instrument. Furthermore, we use the number of groups of which the household is a member (other than farmers' organizations) as a proxy for willingness to cooperate. Finally, an index is constructed reflecting the farmer's attitude towards cooperation, extension groups, and towards neighbors and other farmers within the community. The score of the index ranges between one (meaning that the farmer is open-minded and keen to cooperate) and three, meaning that the farmer is skeptical about cooperation and extension (see footnote to Table three).

In the second-stage ordered probit model, the *number of soil conservation practices applied* on the farm is modeled as a function of participation in farmer-based groups and organic markets as well as a number of exogenous household and plot-related variables. In order to identify indicators for inclusion in the model and their respective hypotheses, we draw on the empirical literatures on the adoption of innovations and program participation. With respect to socio-demographic variables, we include the age of the household head, the maximum education (in years) of household members, and the number of adult household members. Education is assumed to enhance the farmer's ability to access and process information and is therefore expected to have a positive effect on the adoption of new and knowledge-intensive technologies (Rahm and Huffman, 1984). The number of adult household members reflects the availability of family labor that could potentially be used on the farm and is therefore expected to be positively related to the number of conservation activities performed on the farm (Neill and Lee, 2001). In addition we include a dummy variable that equals one if the household has other income generating activities besides farming. The impact of this variable on adoption is ambiguous. Most likely, other income activities will deviate time and effort away from the farming activities leading to lower investments in soil conservation. On the other hand, farmers working off-farm often have better access to information about new technologies.

Assuming that the farming activity is given priority if the household head is involved with it, we include a variable that reflects whether the household head works on the farm, which is expected to have a positive effect on adoption. Furthermore, we add a dummy equaling one if a household member has participated in a farmer field school before. Given that the aim of farmer field schools is the transfer of knowledge about new farming practices, we expect these households to be more likely to adopt soil conservation measures. Based on the assumption that an ownership title of the land gives the household security and thus incentives for investment, we include a dummy variable expecting a positive impact of formal land ownership on soil conservation (Neill and Lee, 2001). Finally, we include a variable representing the number of livestock owned by the household. The hypothesized effect of this variable is ambiguous. On one hand, livestock may compete with plots for crop residues (nutrients) and labor and will thus have a negative effect on soil conservation; on the other hand, studies have also found synergies between livestock and soil management (Kristjanson et al., 2005; Marenya and Barrett, 2007).

Various plot-related variables are included in the model, most of which are expected to have a positive effect on the number of soil conservation practices applied on the farm. Previous studies have found plot slope, altitude and farm size to be a positive and significant determinant of soil conservation (Neill and Lee, 2001; Bekele and Drake, 2003; Amsalu and de Graaff, 2006; Marenya and Barrett, 2007). Access to irrigation as well as having a river bordering the plot is assumed to increase the value of the land, thus motivating its conservation. Moreover, the likelihood of soil fertility management is expected to increase with the number of years that the household has owned and cultivated the land. With respect to the type and quality of the soil, we include three dummy variables that represent different soil types that were classified based on their agricultural suitability (Simmons and Castellanos, 1968). Soil type MI is characterized by high productivity and the need for moderate soil conservation due to its location in hilly terrain. Soil type CR is rated as being susceptible to erosion resulting in soil conservation and tree cover being highly recommended. Soil type CO is only suitable for pastures and forest use. The soil type excluded from the model (to avoid multicollinearity) is the soil of the valley bottomlands, characterized by high productivity and mostly flat terrain. Finally, we include a variable measuring the distance of the farm to the nearest town (Marcala). Table three presents descriptions and summary statistics of all variables included in the first and second-stage models.

Model Results

The estimation results of the bivariate probit and ordered probit models are shown in Tables four and five. The signs of the exogenous variables in the bivariate probit model explaining participation in farmers' groups and organic markets are largely as expected. Households are more likely to *participate in farmer-based groups* if they are literate and female-headed. The latter is a result of female-headed households being specifically targeted by some of the farmers' organizations in the area. Similarly, coffee farmers are more likely to participate in farmers' groups that help them to market their coffee. Most of the coffee produced by small-scale farmers in the area is marketed through cooperatives and farmers' associations. Moreover, households are less likely to participate in farmers' groups if they have salaried employment or are a member of other groups or local organizations suggesting that these households are facing time constraints. On the other hand, households are more likely to participate in farmer-based groups if a household member migrates to Marcala for work. As the main offices of the farmers' groups are also located in the town, this reflects the households' greater mobility and access to information sources. As expected, the share of households in the district who are member of a farmers' group has a positive effect on participation. Finally, the attitudinal index has a negative sign indicating that farmers who have a positive attitude towards cooperation and extension are more likely to join a farmers' group.

The bivariate probit model further shows that households who participate in farmers' groups are also more likely to *participate in organic niche markets*. This is an important finding confirming the role of farmers' groups in linking farmers to specialized markets. With respect to demographic variables, the age of the household head and the size of the family both have a positive effect on participation in the organic market segment. In addition, if households have salaried employment, they are also more likely to sell their products in organic markets. Households pursuing off-farm work usually have better access to information about alternative agricultural technologies and new market opportunities. Moreover, this finding may reflect that organic agriculture often does not represent the main income source of farmers, who rely on a variety of income activities to make a living. With respect to crop choices, coffee and fruit farmers are more likely to participate in organic niche markets as compared to other major crops including basic grains and vegetables. Finally, the share of households in the district who sell in organic markets has a positive effect on a household's likelihood to sell organic products indicating spill-over effects of organic agriculture adoption at the local level.

Results of the ordered probit model reveal that participation in both farmer-based groups and organic markets have a positive effect on the *number of soil conservation practices* adopted. With respect to socio-demographic characteristics, the analysis shows that the number of soil conservation practices adopted increases with the maximum educational level attained by the household members. An unexpected result is that the number of adult family members has a negative impact on adoption. Apparently, households with more adults also pursue more off-farm activities, such that these household members are not available for farm work. This interpretation is supported by the fact that the variable on other income generating activities has a negative sign, although it is not statistically significant in the model. Furthermore, the analysis shows that households that have participated in a farmer field school are more likely to apply multiple practices. Thus education and training seem to be critical for the adoption of conservation agriculture. In addition, tenure security positively influences investment in soil conservation. Farmers that own a land title tend to apply more soil conservation practices to their fields. Finally, the distance of the farm to the nearest town has a negative impact on adoption. This reflects the difficulty of remote households to access and implement new technologies. Plot-related variables such as slope, access to irrigation and rivers, and the number of years that the plot has been cultivated by the household have a positive effect on the number of soil conservation practices applied. Similarly, soil type is found to be an important predictor for the use of soil conservation practices. Soil type CR, which is susceptible to erosion, has a positive and significant coefficient indicating that households apply significantly more soil conservation practices as compared to households located in areas with soil type SV (the soil type excluded from the model, which is rated most suitable for agriculture).

The magnitude of the coefficients of the ordered probit model are of limited interest and not readily interpretable. Instead we are interested in the marginal effects of changes in the regressors on the response probabilities, which for continuous variables are calculated as follows:

$$\frac{\partial\, Prob(C=0|x)}{\partial x} = -\beta\phi(\alpha_1 - x'\beta) \tag{4}$$

$$\frac{\partial\, Prob(C=1|x)}{\partial x} = \beta[\phi(\alpha_2 - x'\beta) - \phi(\alpha_1 - x'\beta)]$$

$$\frac{\partial\, Prob(C=2|x)}{\partial x} = \beta[\phi(\alpha_3 - x'\beta) - \phi(\alpha_2 - x'\beta)]$$

$$\frac{\partial\, Prob(C=3|x)}{\partial x} = \beta[\phi(\alpha_4 - x'\beta) - \phi(\alpha_3 - x'\beta)]$$

$$\frac{\partial\, Prob(C=4|x)}{\partial x} = \beta\phi(\alpha_4 - x'\beta)$$

Marginal effects are presented in Table six. Households who participate in farmers' groups are 24 percent more likely than non-participants to apply more than one conservation practice on their land. Furthermore, households who participate in organic niche markets even have a 50 percent higher probability to adopt two or more conservation practices. Participation in farmer field schools has a slightly lower impact on farmers' adoption behavior: participation increases the probability of adopting more than one conservation method by 11 percent. Experiences with farmer field schools in the area have been mixed and in some cases farmers' support has been limited resulting in the abandonment of experimental plots as soon as labor requirements on farmer-owned plots became pressing. Also, most farmer field schools focus on integrated pest management techniques (see e.g. van den Berg and Jiggins, 2007), but not explicitly on conservation agriculture.

Land ownership security plays an important role for investment in soil conservation as confirmed by the data. In the study area, farmers that have a land title are four percent more likely to adopt more than one soil conservation measure. The effect of this variable might have been even more important, if there was more variability in the data. Land tenure initiatives have led to a favorable situation where 81 percent of the households now hold a title for their land. Similarly, the value of the land influences farmers' adoption decision. If a river borders the land, the probability of adopting two or more conservation measures increases by 10 percent. Similarly, if households have access to irrigation, they are 25 percent more likely to adopt two or more conservation practices. Given the remoteness of the villages, access to the nearest town is critical for observed adoption behavior. For every km that a farm is located further away from Marcala, the probability of applying more than one conservation practice decreases by two percent. Finally, farmers who are located on soil type CR, which is susceptible to erosion, are 23 percent more likely to adopt two conservation practices, 24 percent more likely to adopt three practices, and overall 57 percent more likely to adopt more than one practice on their lands.

Conclusions and Policy Implications

In this study, we have analyzed farmers' decisions to adopt various soil conservation methods in Honduras, given the interactions of their membership in farmers' groups and participation in organic niche markets, and the resultant impacts on sustainable soil management. In the two-step model we used to analyze the data, we first estimated the probability of a household to participate in farmers' groups and organic markets, respectively, and in the second stage, we used an ordered probit model to identify the factors that determine the number of soil conservation practices adopted on the farm.

Most importantly, we found that membership in farmer-based organizations and participation in organic markets foster the adoption of multiple soil conservation techniques. In addition, farmers who participate in local farmers' groups are more likely to sell their output in organic markets indicating that group membership indeed facilitates access to these niche markets. Furthermore, the use of soil conservation practices is associated with higher educational attainment of the household members and participation in extension projects, such as farmer field schools. Thus, additional investments in education and training can be expected to have positive impacts on sustainable soil management. Reflecting the importance of tenure security, we found that households who have a land title tend to adopt more soil conservation practices on their land. Finally, controlling for a range of plot related variables we found evidence that farmers' decision to adopt soil conservation techniques is also guided by the natural conditions (such as slope and soil quality) and the potential (such as access to irrigation) of the land.

In the research region, farmers' groups fill an important gap since state agencies have privatized public agricultural extension services in Honduras. Given the remoteness and topographical exposure of the area, it does not easily lend itself to large-scale commercial agriculture and markets have been slow to develop. In the presence of multiple market failures, farmers' groups that have been established, in part, by NGOs and international cooperation projects play a critical role in providing farmers with inputs, information, and technical assistance. The results of the analysis indicate that there is significant potential payoff from improved design and provision of "supply side" mechanisms including extension and NGO programs, and supportive policies that help farmers overcome information deficiencies related to conservation technologies. These measures should include the support of local organizations that can effectively provide farmers with extension and information reducing the transaction costs faced by small-scale farmers.

The results further suggest that demand-related factors play an important role in sustainable soil management decisions. Organic and sustainable niche markets that remunerate farmers for using conservation practices can provide significant incentives for adoption. Facilitating access to these markets is therefore critical to provide farmers in remote areas with alternative income sources and at the same time promote the sustainable use of natural resources. For example, Aldy et al. (1998) suggest that one mechanism to promote sustainable agricultural practices would be for policymakers to facilitate the certification and labeling of sustainable agricultural produce to inform consumers and legitimize price premiums. Giovannucci and Ponte (2005) point out that there might be a tendency of shrinking price premiums in the organic segment – a development, which would undermine the incentives given to farmers to adopt conservation agriculture. However, given the potential that current price premiums for organic products and the continuing growth in organic markets, in general, offer to farmers in less-favored areas, we believe the results of this study are promising.

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Table 1: Participation in farmer-based groups and adoption of conservation practices

		Member in farmer-based group?		Chi-square test
Conservation practices		yes	no	statistic
Living barriers	yes	103	33	13.25**
	no	56	49	
Mulching	yes	81	37	0.73
	no	78	45	
Plant along contour lines	yes	62	16	9.38**
	no	97	66	
Organic manure	yes	59	8	20.16**
	no	100	74	
Terraces / stone walls	yes	21	4	4.04*
	no	138	78	
Drainage ditches	yes	16	5	1.07
	no	143	77	
Cover crops	yes	13	7	0.01
	no	146	75	
Crop rotations	yes	8	2	0.91
	no	151	80	

*(**) significant at 5%(1%) probability of error

Table 2: Participation in organic markets, farmers' groups and adoption of conservation practices

		Participates in organic market?		Chi-square test
Farmers' groups		yes	no	statistic
Member in farmers' group	yes	43	116	14.88**
	no	5	77	
Conservation practices				
Living barriers	yes	35	101	6.63**
	no	13	92	
Mulching	yes	25	93	0.23
	no	23	100	
Plant along contour lines	yes	20	58	2.37
	no	28	135	
Organic manure	yes	35	32	60.78**
	no	13	161	
Terraces / stone walls	yes	4	21	0.27
	no	44	172	
Drainage ditches	yes	4	17	0.01
	no	44	176	
Cover crops	yes	4	16	0.00
	no	44	177	
Crop rotations	yes	5	5	5.92*
	no	43	188	

*(**) significant at 5%(1%) probability of error

Table 3: Summary statistics

Variable		Mean	Std. Dev.	Min	Max
Number of soil conservation practices	Soil	1.47	1.26	0	4
Membership in farmers groups	Group	0.66	0.47	0	1
Participation in organic markets	Organic	0.20	0.40	0	1
Number of adults	Adults	3.41	1.48	1	9
Share of hh in the district who are member of farmers‘ organization	Ag_group	0.66	0.07	0.60	0.83
Share of hh in the district who sell in the organic market	Ag_organic	0.20	0.11	0.04	0.50
Age of hh head	Age	46.48	13.42	20	91
Altitude (in km)	Altitude	1.97	1.12	0.74	5.96
Cultivated land area (in ha)	Area	24.40	26.67	0	196
Attitude toward cooperation (index)*	Attitude	1.62	0.23	1	2.17
Nr. of cattle owned	Cattle	0.39	1.25	0	11
hh grows coffee	Coffee	0.58	0.50	0	1
interaction term coffee*fruit	Coffee*fruit	0.47	0.50	0	1
Hh sells coffee	Coffee_sell	0.54	0.50	0	1
Hh member commutes to Marcala	Commute	0.36	0.48	0	1
Distance to Marcala in km	Distance	14.01	8.29	0.34	32.21
Hh has participated in farmer field school	F_f_s	0.23	0.42	0	1
Hh head works on the farm	Farm_hh	0.81	0.39	0	1
Female-headed hh	Female	0.22	0.42	0	1
hh grows fruits	Fruit	0.56	0.50	0	1
Nr. of other group memberships	Group_nr	0.46	0.69	0	4
Nr. of hh members	Hh_size	5.63	2.16	1	14
Access to irrigation	Irrigation	0.29	0.45	0	1
Hh head can write	Literacy	0.80	0.40	0	1
Household pursues other income activities	Off_farm	0.71	0.45	0	1
farm is located within one km of paved road	One_road	0.56	0.49	0	1
River borders the land	River	0.38	0.48	0	1
Hh has salaried employment	Salary	0.11	0.32	0	1
Max schooling (years)	School	7.05	2.31	1	14
Slope (of steepest plot)#	Slope	1.82	0.81	1	5
Soil type CO°	Soil_co	0.15	0.35	0	1
Soil type CR°	Soil_cr	0.04	0.20	0	1
Soil type MI°	Soil_mi	0.44	0.49	0	1
Hh holds land title	Title	0.81	0.39	0	1
hh grows vegetables	Veggy	0.14	0.34	0	1
Years hh has farmed the land	Years_farm	14.88	11.99	1	76

* attitudinal index: includes 4 variables scaled from 1 to 3. Scores are added up and total score is divided by 4. Interpretation: 1 = open-minded, cooperative, 3 = conservative, skeptical about cooperation. Questions regard the farmer’s attitude towards cooperation, extension services, and opinion about his/her neighbors’ attitude.

Slope is categorized into 5 levels: 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%

° Local soil classification based on agricultural suitability according to Simmons and Castellanos (1968). Geo-referenced map is available at http://gisweb.ciat.cgiar.org (The Mitch Atlas).

Table 4: Results of the bivariate probit model

	Participation in farmers organizations			Participation in organic markets		
	Coefficient	Robust Std. Err.		Coefficient	Robust Std. Err.	
Group				2.010	0.245	***
Age	0.009	0.008		0.019	0.010	*
Literacy	0.568	0.270	**	0.176	0.223	
Hh_size	0.005	0.023		0.077	0.025	***
Female	0.655	0.177	***	0.029	0.178	
Salary	-0.804	0.312	**	0.441	0.264	*
Farm_hh	0.354	0.317		0.003	0.475	
Commute	0.756	0.256	***	-0.268	0.274	
Area	0.008	0.005		-0.005	0.005	
One_road	0.117	0.124		0.188	0.169	
Coffee_sell	0.168	0.158				
Attitude	-0.673	0.162	***			
Group_nr	-0.443	0.073	***			
Ag_group	1.836	0.838	**			
Veggy				-0.170	0.163	
Fruit				1.537	0.306	***
Coffee				0.488	0.114	***
Coffee*fruit				-1.235	0.231	***
Ag_organic				1.813	0.435	***
Constant	-1.266	0.967		-4.593	0.872	***
/athrho	-20.652	5.267	***			
rho	-1	0				

Wald test of rho = 0: chi2(1) = 15.3733***
N = 241
Log pseudo likelihood = -210.07307

*(**)[***] The null-hypothesis is rejected at a level of significance of p=0.10 (0.05) [0.01]

Standard errors are adjusted for 6 clusters.

Table 5: Results of the ordered probit model

Number of soil conservation practices adopted			
	Coeff.	Robust Std. Err.	
Groups (predicted)	0.614	0.272	**
Organic (predicted)	1.266	0.245	***
Age	-0.003	0.005	
School	0.076	0.036	**
Adults	-0.090	0.030	***
Off_farm	-0.063	0.045	
Farm_hh	0.192	0.144	
F_f_s	0.277	0.107	***
Distance	-0.048	0.018	***
Area	0.003	0.003	
Title	0.103	0.057	*
Cattle	-0.024	0.033	
Years_farm	0.013	0.008	*
Slope	0.246	0.044	***
River	0.230	0.087	***
Irrigation	0.643	0.151	***
Altitude	0.037	0.029	
Soil_MI	0.110	0.409	
Soil_CR	1.462	0.258	***
Soil_CO	-0.287	0.334	
Cut-off 1	0.742	0.349	
Cut-off 2	1.769	0.344	
Cut-off 3	2.588	0.366	
Cut-off 4	3.435	0.337	
Number of obs	240		
Wald chi2(5)	363.5		
Prob > chi2	0.000		
Pseudo R2	0.161		
Log pseudo likelihood	-306.165		

*(**)[***] The null-hypothesis is rejected at a level of significance of p=0.10 (0.05) [0.01]

Predicted and observed probabilities

	Number of soil conservation practices adopted				
	0	1	2	3	>4
Observed prob.	0.2697	0.2988	0.2116	0.1328	0.0871
Predicted prob.	0.2052	0.3756	0.2660	01225	0.0308

Table 6: Marginal effects of the ordered probit model

	Number of soil conservation practices adopted									
	Prob(C=0|x)		Prob(C=1|x)		Prob(C=2|x)		Prob(C=3|x)		Prob(C=4|x)	
	dy/dx		dy/dx		dy/dx		dy/dx		dy/dx	
Groups (predicted)	-0.175	**	-0.065	*	0.095	**	0.103	**	0.043	*
	0.072		*0.036*		*0.041*		*0.048*		*0.022*	
Organic (predicted)	-0.360	***	-0.135	***	0.195	***	0.212	***	0.088	***
	0.067		*0.035*		*0.036*		*0.049*		*0.028*	
Age	0.001		0.000		0.000		-0.001		0.000	
	0.001		*0.000*		*0.001*		*0.001*		*0.000*	
School	-0.022	**	-0.008	***	0.012	*	0.013	**	0.005	*
	0.011		*0.003*		*0.006*		*0.005*		*0.003*	
Adults	0.026	***	0.010	***	-0.014	***	-0.015	***	-0.006	**
	0.008		*0.004*		*0.004*		*0.004*		*0.003*	
Off_farm	0.018		0.007		-0.010		-0.011		-0.005	
	0.013		*0.004*		*0.008*		*0.007*		*0.003*	
Farm_hh	-0.057		-0.017	**	0.031		0.031		0.012	
	0.046		*0.007*		*0.025*		*0.019*		*0.009*	
F_f_s	-0.074	***	-0.036	**	0.039	***	0.048	***	0.022	*
	0.027		*0.016*		*0.014*		*0.019*		*0.012*	
Distance	0.014	***	0.005	**	-0.007	***	-0.008	**	-0.003	**
	0.005		*0.002*		*0.002*		*0.003*		*0.002*	
Area	-0.001		0.000		0.001		0.001		0.000	
	0.001		*0.000*		*0.000*		*0.000*		*0.000*	
Title	-0.030	*	-0.010	*	0.016	*	0.017	*	0.007	*
	0.017		*0.006*		*0.009*		*0.010*		*0.004*	
Cattle	0.007		0.003		-0.004		-0.004		-0.002	
	0.010		*0.003*		*0.005*		*0.006*		*0.002*	
Years_farm	-0.004	*	-0.001	*	0.002	*	0.002	*	0.001	
	0.002		*0.001*		*0.001*		*0.001*		*0.001*	
Slope	-0.070	***	-0.026	***	0.038	***	0.041	***	0.017	***
	0.011		*0.008*		*0.008*		*0.009*		*0.005*	
River	-0.065	***	-0.024	**	0.035	***	0.038	**	0.016	***
	0.023		*0.012*		*0.014*		*0.017*		*0.006*	
Irrigation	-0.183	***	-0.068	***	0.099	***	0.107	***	0.045	***
	0.036		*0.024*		*0.014*		*0.032*		*0.017*	
Altitude	-0.010		-0.004		0.006		0.006		0.003	
	0.008		*0.003*		*0.005*		*0.005*		*0.002*	
Soil_MI	-0.031		-0.012		0.017		0.018		0.008	
	0.117		*0.043*		*0.064*		*0.068*		*0.028*	
Soil_CR	-0.416	***	-0.156	***	0.225	***	0.244	***	0.102	***
	0.065		*0.044*		*0.042*		*0.058*		*0.027*	
Soil_CO	0.082		0.031		-0.044		-0.048		-0.020	
	0.095		*0.036*		*0.053*		*0.056*		*0.023*	

*(**)[***] The null-hypothesis is rejected at a level of significance of p=0.10 (0.05) [0.01]

Marginal effects (dy/dx) are calculated at the mean for continuous variables and for a discrete change from 0 to 1 for dummy variables.

Standard errors are in *italics*.