# ADOPTION AND IMPACT OF SOIL CONSERVATION PRACTICES ON FARM INCOME: EVIDENCE FROM NORTHERN HAITI

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**Abstract**

Soil conservation practices (SCP) play a fundamental role in reduction of soil loss due to soil erosion and improvement of soil fertility. In this paper we assess the adoption and the impact of SCP on Farm income in Northern Haiti as a consequence agricultural productivity increase. Based on data collected from 483 farmers in six watersheds --- Borgne/Limbé, Haut-du-Cap, Grand-Rivière-du-Nord, Marion/Trou-du-Nord, Jassa and Grisongarde --- in Northern Haiti, this study investigates the impact of adoption of SCP on farm income using Heckman two steps selection model. The results from the probit model reveal adoption of SCP is influenced by gender, group membership, land ownership, access to credit, the interaction between education and group, the size of the plot and the interaction between slope and the size of the plot. The outcome model of the Heckman selection shows household size, access to credit and off-farm activities improve farmers' income.

**Key words**: Soil conservation practices, propensity score, Northern Haiti

## Introduction

In developing countries, agriculture remains a key activity for providing people the capacity to feed themselves by producing their own food or the source of employment and income to access to food supplies (Andzo-Bika and Kamitewoko, 2004; Kokoye et al., 2013). It represents the major subsistence activity for rural Haitians, (WEF, 2011; Bargout and Raizada, 2013) and contributes to 25 per cent of the gross domestic product of Haiti (Singh and Cohen, 2014). However, Haitian agricultural sector is facing serious soil erosion that widely impacts agricultural land fertility (Bayard et al., 2003; Jolly et al., 2006). In Haiti, reduction in soil fertility leading to the decrease of agricultural productivity was listed as a major cause of soil erosion (Bayard et al., 2007). Given that agricultural productivity is critical determinant in developing countries' ability to meet food security and economic development objectives in times of rapid population growth (Wiebe et al., 2001; Kokoye et al., 2013); the implication for food security and livelihoods of Haitian farmers is obvious. In face of the current global challenge of increasing and stabilizing farmers' income to achieve poverty reduction and environmental

management, adoption of sustainable practices become inevitable (FAO, 2012a; Arslan et al., 2014).

Soil conservation techniques have been largely popularized by development projects over the years as sustainable solution to soil loss and decrease of agricultural productivity in Haiti. These techniques include *bann manje* (crop bands), rocks wall, hedge rows and *rampaye*. Most of these primarily address soil erosion, soil fertility improvement and farm income diversification.

However, despite the proven benefits of soil conservation practices farmers are still reluctant to adopt them. Reasons for that are various and related to farmers' socio-economics characteristics, production factors and geo climatic factors (Bayard et al., 2006). Several studies have been done to investigate on factors affecting the adoption of soil conservation practices. Most of these studies have been done in China, Africa and other developing countries where soil erosion is a serious problem. In China, while Wang et al., (2010) focused their study on farmers' adoption of conservation agriculture, Liu and Huang (2013) studied the adoption and continued use of contour cultivation in the highlands of southwest China. Both studies gave an insight on how farmers' socio economics characteristics affect their decision to adopt soil conservation practices and conservation agriculture. In most African countries, land degradation has led to severe soil erosion and the use of soil conservation practices become an inevitable option for farmers. Agbamu (1995) has investigated on farmers' characteristics that guide adoption of soil management practices in the Ikorodu area of Nigeria. Arslan et al., (2014) analyzed the determinants of farmer adoption of conservation farming practices in Zambia using panel data. Adesina et al., (2000) studied adoption of alley farming by farmers in the forest zone of southwest Cameroon. Ng'ombe et al., (2014) investigate on factors affecting adoption of Conservation Farming Practices by Smallholder Farmers in Zambia. Kassie et al. (2012) analyzed determinants of adoption of sustainable agricultural practices including terracing and plant barriers in Tanzania. Chiputwa et al., (2011) used tobit model to study the adoption of Conservation Agriculture Technologies by Smallholder Farmers in the Shamva District of Zimbabwe. In Ethiopia, Amsalu and de Graaff (2007) studied the factors affecting adoption and continued use of stone terraces. Tesfaye et al. (2013) also analyzed adoption of

three soil conservation practices -- soil bunds, stone bunds and fanya juu bunds (terraces) --- in Ethiopia. These studies used various methodologies to identify determinants of soil conservation practices.

In Haiti, Bayard et al., (2003) and Jolly et al., (2006) have investigated the factors affecting adoption of soil conservation techniques such as alley cropping, rock walls, gully plugs and crop band in Southern Haiti. Furthermore, Jolly et al, (2006) have studied the impact of some of these techniques on net income of farmers. However, conditions for adoption might be different for each, or set of practices and vary from one location to the next. To our knowledge there is no study in northern Haiti on factors affecting choice of soil conservation practices and their impact on farmers' income. Given the agricultural potential of the Northern corridor, it is important to evaluate the practices that reduce soil erosion and influence crop yields. Therefore, this study contributes to the previous literature by empirically identifying factors affecting the adoption of selected soil conservation techniques in Northern Haiti and their impact on farmers' income.

The impact evaluation may suffer from selection bias as the process of adoption of soil conservation techniques by farmers might not be random. So identify causal effect of soil conservation techniques is quite difficult as adoption process tend to be endogenous. Two main reasons are behind these difficulties: 1) we cannot observe the counterfactual, that is, what income or revenue would look like in the absence of adoption, 2) as the process of adoption is seldom random it is very difficult to isolate the true causal impact of soil conservation techniques adoption. Using data from individual farmers in Northern Haiti, this paper applies the Heckman two-stage procedure to address self-selection problems in nonexperimental data.

The remainder of the paper is organized as follows. The second section provides a theoretical framework, the third section describes the data collection procedures, and the fourth section presents the results and discussions, and the last section concludes and summarizes the paper.

## 2. Theoretical Model and Empirical Specification

Impact evaluation involves the use of experimental and non-experimental approaches. Experimental approach consists of having a group of persons or individuals or any other measurement unit that have the same characteristics and accept to participate in the experiment and assign them randomly to two groups: treatment group and control group. Since in this experiment participants were chosen randomly, any difference with non-participant is attributed to the treatment. Therefore sample selection bias was not considered a problem in randomized experiments because randomization renders selection effects irrelevant (Guo and Fraser, 2014). For these reasons the experimental approaches are considered as more accurate (unbiased estimates) and gives results that easy to interpret (Cochrane et Rubin, 1973; Bassi, 1984). However this approach is difficult to implement in social science.

Economist and social scientist uses the non-experimental approach by using economic and econometric theories for guiding the analysis and minimize the potential error that might occur in the estimation of impact (Diagne, 2003). Indeed this approach is used when it is impossible to select control or comparison group. One can compare the participant to the project or program with the non- participant by using statistical method to control the observed difference between both groups. It is possible with a regression analysis to control for age, revenue, gender and other characteristics of the participant. This approach is less difficult and easy to apply but the results might be less accurate.

In this paper we use the Heckman two step selection models to evaluation the impact of the adoption of soil conservation techniques on farmer net income. This model has been used to address selection bias when the correlation between the two error terms is greater than zero (Hoffman and Kassouf, 2005; Adeoti, 2009; Johannes et al., 2010; Siziba et al., 2010; Ibrahim et al., 2012). The Heckman slection model involves two equations: (1) The regression equation considering mechanisms determining the outcome variable here income and (2) the selection equation considering a portion of the sample whose outcome is observed and mechanism determining the selection process (Heckman, 1978, 1979).

The regression can be written as follows:

$$Y_i = \beta_0 + \sum_j \alpha_j X_{ij} + \delta_i W_i + \varepsilon_i \quad [1]$$

With: $\beta_0$ the constant term, $\alpha_j$ the parameters to be estimated, $X_{ij}$ is the set of independent variables, $W_i$ is a dummy variable for adoption of SCP and $\varepsilon_i$ the error term

The election equation can be written as follows:

$$W_i^* = \gamma_0 + \sum_j \alpha_j X_{ij} + \mu_i \quad [2]$$

$$W_i = \begin{cases} 1 \text{ if } W_i^* > 0, \\ 0 \text{ otherwise} \end{cases} \quad [3]$$

where $W_i^*$ is a latent variable denoting the difference between utility from adopting SCP and the utility from not adopting SCP. The table 1 summarized the variable used in the models.

## 3. Materiel and methods

*Study area and data collection*

Haiti, with a total area of 27,750 square kilometers is located in Caribbean island and lies between the Caribbean Sea and North Atlantic Ocean and has a latitude of 19° 00' N and a longitude 72° 25' W. Data used in this study were collected in North Haiti (figure 4) by the USAID/AVANSE project as part of a baseline survey. The area covers 6 watersheds in North Haiti. These include Marion, Trou du Nord, Grande riviere du Nord, Haut du Cap, Jassa and Limbe. The average annual rainfall is about 1,200 mm in the plain and 1,780 mm in the high mountains. Annual rainfall decreases from West to East, with precipitation varying from 800 mm to 1,900 mm in the East and from 1,500 to over 2,000 mm in the West. The two rainy seasons are September to January and April to June (DAI, 2014).

Farmers participating in this study are those who were registered by the project in the opening phase of implementation. From September 2013 to January 2014, the project registered 6,400 farmers. Four hundreds eighty three (483) farmers were randomly selected from the list of farmers who registered with the project. Table 1 shows the number of households surveyed in each watershed.

A survey instrument composed of open-ended and closed-ended questions was used. Information collected are related to farm households socio-economics and demographics data – age, location, type of household, education, off-farm activity—agricultural activities from October 2012 to September 2013 and household use of soil conservation techniques.

## 4. Results

The table 1 presents the descriptive statistics of variables used in the Heckman selection model. The control group comprises farmers who do not adopt the soil conservation techniques (204 farmers) and farmers who adopted (279 farmers). Given the socio-economics characteristics, farmers in the treated group in the treated group are different from their counterpart in the control groups. We used the log of net income as variable of interest for the outcome model. Adoption of SCP is influenced by gender, group membership, land ownership, access to credit, the interaction between education and group, the size of the plot and the interaction between slope and the size of the plot. Men are more likely to adopt SCP than women. Similar results were found by Adesina et al., (2000) in their study on factors affecting adoption of alley farming in Cameroon. As it was the case in Cameroon, men in Haiti might have more access to resources including contact with international projects that popularize these techniques. Fabiyi et al. (1991), cited in Adesina et al., (2000) also found that in southwest Nigeria men farmers were more likely to use alley farming than women. Studies of Liu and Huang (2013) in China indicate that households with female decision makers are less likely to use contour cultivation. The limited access to resources by women might prevent them to adopt agricultural technologies. Doss and Morris (2001) found that access to inputs is the main factor that justifies the difference in adoption of agricultural technology between men and women in Ghana. Unexpectedly group membership has negative impact on hedge rows adoption. This result is in contrast with many studies (Lapar and Pandey, 1999; Adesina et al., 2000, Yegbemey et al., 2013) that found farmers groups and associations to be an asset for agricultural technology adoption. Land ownership positively influences the adoption of SCP. This results confirm previous studies (Lapar and Pandey, 1999; Soule et al., 2000; Schuck et al., 2002; Kabubo-Mariara, 2006; Yegbemey et al., 2013) that demonstrated that ownership of the land has positive effect on adoption of any technology especially SCP. Adesina et al., (2000) have found a

positive relation between adoption of alley farming and the possession of right over three in Cameroon. Land ownership defines the property right on the land and could consequently determine the type of investment – including establishment of SCP for soil fertility improvement--- farmers will put on the land for agriculture. Thus unsecure property rights expose farmers to expropriation, which reduces their incentive to enhance the value of the property (Kokoye et al., 2013). The interaction between education level and group membership positively influences famers decision to adopt SCP. The results show that there is a marginal increase in the probability of adoption for those who belong to local groups and have some measure of education. The size of the plot has positive effect on the adoption of SCP. Liu and Huang (2013) in their study in China found that households with larger plots are more likely to use contour cultivation. The interaction between slope and the size of the treated plot has negative effect on the adoption of SCP. One plausible explanation of this result is that it is recommended that the farmer reduces the space between each row whenever the slope is high but farmers are reluctant to that; thus reducing their chance of adopting SCP whenever the size of the field and the slope are high.

In the outcome model (second stage) the inverse Mills ratio (IMR) has been incorporates. The IMR (lambda) was not significant implying that adoption of SCP does not necessarily increase farmer's income. Three variables significantly influenced farm income, household size, access to credit and off-farm activities.

## Conclusions

This paper investigates the impact of soil conservation adoption techniques on farmers' net income using Heckman two steps selection. The treatment group consists of farmers who adopted soil conservation techniques and the control group of farmers who did not. Results show that adoption of SCP is influenced by gender, group membership, land ownership, access to credit, the interaction between education and group, the size of the plot and the interaction between slope and the size of the plot. From the outcome model, three variables significantly influenced farm income, household size, access to credit and off-farm activities.

**Table 1: Explanatory variables considered in the models**

| Variables | Types[a] | Definition |
|---|---|---|
| Age | C | Number of years from birth |
| Gender | D | 0=Female ; 1=Male |
| Schooling level | D | No = 0 ; Yes = 1 |
| Per capita income | C | Level of per capita income |
| Off farm activity | D | No = 0 ; Yes = 1 |
| Household's size | C | Number of people living in the household |
| Access to credit | D | No = 0 ; Yes = 1 |
| Group membership | D | No = 0 ; Yes = 1 |
| Size of plot treated | C | Area in hectare of plot treated |
| Crop dependency[1] | C | Agricultural income share |
| Slope | D | No = 0 ; Yes = 1 |
| Land ownership | D | No = 0 ; Yes = 1 |

[a] Types : D = Discontinuous variables ; C = Continuous variables

**Table 2**: Distribution of household surveyed by watershed

| Watersheds | Frequencies | Percentage |
|---|---|---|
| **Marion** | 65 | 13.46 |
| **Trou du Nord** | 60 | 12.42 |
| **Grande Rivière du Nord** | 81 | 16.77 |
| **Jassa** | 68 | 14.08 |
| **Limbé** | 138 | 28.57 |
| **Haut du Cap** | 71 | 14.70 |
| **Number of observations** | **483** | **100** |

[1] Crop dependency is a ration between agricultural income and total income of the household

**Table 3: Descriptive statistics of the variables used for estimation**

| | | Treatment group (N=279) | | Control group (N=204) | |
|---|---|---|---|---|---|
| **Variables** | **Description** | **Mean** | **Stdev[1]** | **Mean** | **Stdev[1]** |
| **Age** | Age of respondent | 50.92832 | 11.59642 | 53.30392 | 13.07371 |
| **Gender** | Sex of respondent | 0.842293 | 0.365120 | 0.8676471 | 0.339707 |
| **School** | If the respondent went to school or not | 0.587813 | 0.493112 | 0.5098039 | 0.5011337 |
| **Net income** | Net income | 26311.97 | 11172.9 | 34301.09 | 18762.5 |
| **Person** | Number of persons | 4.978495 | 1.958078 | 4.97549 | 1.963807 |
| **Credit** | Access to credit | 0.107526 | 0.310338 | 0.0882353 | 0.2843345 |
| **Age^2** | Square of age | 2727.688 | 1200.544 | 3011.392 | 1415.207 |
| **Ownership** | Ownership of the land | 0.100358 | 0.301017 | 0.0882353 | 0.2843345 |
| **Crop dependency** | Share of Agricultural income | 0.437570 | 0.835051 | 0.432066 | 0.6100604 |
| **Group membership** | Farmer belong to a group | 0.078853 | 0.269993 | 0.068627 | 0.253441 |
| **Off farm activity** | Has off farm activity | 0.473118 | 0.500174 | 0.495098 | 0.5012059 |

Note: 1. Stdev means standard deviation

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