Adoption of Soil Conservation Practices and Farmers' Willingness to Pay for Soil Testing in Northern Haiti

by

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Abstract

This dissertation is organized in three chapters that deal with issues on agricultural development in Haiti. The first chapter presents results from adoption of soil conservation practices in Northern Haiti. Using data from 483 farmers, we investigate factors influencing adoption of soil conservation practices (SCP) in Northern Haiti. Four selected soil conservation techniques -*bann manje* (contour crop bands), rock wall, hedgerows and *rampaye* (contour bands of plant residues)-were evaluated using a multivariate probit model. The results reveal that educational level, crop dependency, access to credit and field size significantly affect rock wall adoption whereas gender, age of the farmer, land ownership, crop dependency, access to credit, interaction between educational level and group membership and the size of the treated plots had a statistically significant effect on adoption of hedgerows. Field size, the existence of slope and the interaction between slope and field size influence adoption of *rampaye* while age of the farmer, access to credit and the field size significantly influenced the adoption of *bann manje.* Policy makers who seek to encourage the use of SCP in North Haiti should consider those factors. Particular attention should be given to access to credit, extension education, training in soil conservation practices, and access to production resources.

The second chapter investigates factors affecting farmers' willingness to pay for soil testing in Northern Haiti. Using data collected from 452 farmers in 17 localities in Northern Haiti, the interval regression was applied. The findings reveal that 90% of farmers have never tested their soils and have little knowledge of soil testing benefits. However, the explanation of soil testing benefits, led to a large number of farmers (93%) willing to pay on average 503 HTG, an equivalent of 7 USD per test. The models reveal that various factors affect the amount to be paid for soil testing services. These factors include: the type of crops grown, group membership, farmers' educational level, access to credit, gender, contact with extension services or any institution, type of soils, income level, participation in soil testing program and farm size. Two major policy implications can be derived from this study. The training module on soil testing benefits should be designed and supported by extension services and NGOs. Second, the financial support in form of subsidies or access to credit should help low income farmers to pay for soil testing services.

The third chapter uses a structural equation model, to investigate factors affecting farmers' perceptions and knowledge of soil testing benefits and fertilizer use in Northern Haiti. The soil testing benefits are based upon the following assumptions: insufficient fertilization reduces plant growth; excess use of fertilizer leads to money loss; insufficient fertilization reduces crop yields; soil tests help the producer to apply the right amount of fertilizer that will generate profits and too much fertilizer pollute the environment. Knowledge about these items was collected using Likert scale. Data were collected from 452 farmers within 17 localities in Northern Haiti. The findings reveal that farmers currently have no or little knowledge of soil testing benefits and know better about fertilizer use. Factors such as farm size, participation in project, rice, banana, and cocoa growers, affect farmers' perceptions and knowledge of soil testing benefits. Factors affecting willingness include group membership, type of crops grown, whether farmer' land is on the slope, his farm size and whether he participates in the USAID project. Knowledge on fertilizer use is influenced by rice and banana growers, fertilizer use, participation in soil testing program and support from AVANSE/USAID. The effects of both latent variables are found to be positive but non-significant. As policy implication; is that farmers need a training module on soil testing to improve their understanding.

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List of Abbreviations

SCP	Soil conservation practices
USAID	United States Agency for International Development
AVANSE	Appui à la Valorisation du potentiel Agricole du Nord, à la Sécurité Economique et Environnementale
WTP	Willingness to pay
MIMIC	Multiple Indicators Multiples Causes
FAO	Food and Agriculture Organization of the United Nations
MVP	Multivariate probit
HDM	Hybrid Discrete Model

Chapter 1:

Economics of Soil Conservation Practices in Northern Haiti

Abstract

Using data from 483 farmers, we investigate factors influencing adoption of soil conservation practices (SCP) in Northern Haiti. Four selected soil conservation techniques -*bann manje* (contour crop bands), rock wall, hedgerows and *rampaye* (contour bands of plant residues)-were evaluated using a multivariate probit model. The results reveal that educational level, crop dependency, access to credit and field size significantly affect rock wall adoption whereas gender, age of the farmer, land ownership, crop dependency, access to credit, interaction between educational level and group membership and the size of the treated plot had a statistically significant effect on adoption of hedgerows. Field size, the existence of slope and the interaction between slope and field size influence adoption of *rampaye* while age of the farmer, access to credit and the field size significantly influenced the adoption of *bann manje.* Policy makers who seek to encourage the use of SCP in North Haiti should consider those factors. Particular attention should be given to access to credit, extension education, training in soil conservation practices, and access to production resources.

Key words: Soil conservation, Adoption, Haiti, Multivariate probit,

1.1. Introduction

In developing countries, agriculture remains a key activity for enabling people to feed themselves by producing their own food (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 soil fertility (Bayard et al., 2003; Jolly et al., 2006). Soil erosion in Haiti was estimated at 36 million metric tons, or 1,319 metric tons /km^2/year in Haiti in 1999 compared to 9 tons/km^2/year in UK in 2004 (Bargout and Raizada, 2013). According to several studies, (Halcrow et al., 1982; Miranowski, 1983; Lovejoy and Napier, 1986; Swanson et al., 1986; Napier, 1991), the loss of future productive capacity of agricultural land; reduction in water quality; reduced economic value of land; and the increased cost of agricultural production are among the most important damages caused by soil erosion.

In Haiti, reduction in soil fertility leading to the decrease of agricultural productivity was listed as a major consequence of soil erosion (Bayard et al., 2007). Given that agricultural productivity is a 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); Haitian farmers must try to manage their soils to maintain soil fertility for improved crop production. In the face of the current global challenge of increasing and stabilizing farmers' income to attain poverty reduction and environmental management, adoption of sustainable practices become inevitable (FAO, 2012a; Arslan et al., 2014). The livelihood system is impacted by adoption of soil conservation practices through different components such as environmental management, agricultural productivity and poverty reduction, food security as shown in figure 1.1.

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-economic characteristics, production and geo climatic factors (Bayard et al., 2006). Several studies have been done to investigate 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 economic 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) investigated 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. They found that extension services, rainfall variability, agro ecological and socio-economic constraints are the strongest determinants of adoption.

Adesina et al., (2000) studied adoption of alley cropping by farmers in the forest zone of southwest Cameroon. Their results showed factors such as farmers’ gender, contact with extension services, group membership, population pressure, and fuel scarcity affect adoption of alley cropping. Ng’ombe et al., (2014) investigated factors affecting adoption of Conservation Farming Practices by Smallholder Farmers in Zambia. They found that the age of the household head, access to loans, labour availability, in-kind income and location of the households in agro-ecological regions significantly increase the odds of adoption of Conservation farming. Kassie et al. (2012) analyzed determinants of adoption of sustainable agricultural practices including terracing and plant barriers in Tanzania. Chiputwa et al., (2011) used a tobit model to study the adoption of Conservation Agricultural 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. Their study revealed that adoption of stone terraces is influenced by farmers' age, farm size, perceptions on technology profitability, slope, livestock size and soil fertility, while the decision to continue using the practice is influenced by actual technology profitability, slope, soil fertility, family size, farm size and participation in off-farm work. Tesfaye et al. (2013) also analyzed adoption of three soil conservation practices -- soil bunds, stone bunds and fanya juu bunds (terraces) --- in Ethiopia. The findings revealed that farmers need adequate cash to invest in soil conservation measures and they would implement soil conservation if they have larger areas of cropland. These studies used various methodologies to identify determinants of soil conservation practices.

In Haiti, Bayard et al., (2003) and Jolly et al., (2006) investigated the factors affecting adoption of soil conservation techniques such as alley cropping, rock walls, gully plugs and crop band in Southern Haiti. Their results showed that institutional factors, such as membership in a local peasant organization and training in soil conservation practices, and socio-economic factors such as gender, per capita income, and interaction between education and per capita income also significantly influenced adoption of alley cropping in 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 as well as their impact on 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 using Multivariate probit (MVP) analysis. The MVP is increasingly used to analyze adoption of technologies or agricultural practices for the purpose of accounting for correlation between different practices (Nhemachena and Hassan, 2007; Teklewold, Kassie and Shiferaw, 2013; Yegbemey et al., 2013; Asfaw et al., 2014 and Zuluaga et al., 2015).

The remainder of the paper proceeds by (1) providing a theoretical framework in the second section; (2) describing the data collection procedures in the third section, (3) presenting the results and discussions in the fourth section, and (4) presenting some conclusions and implications in the last section.

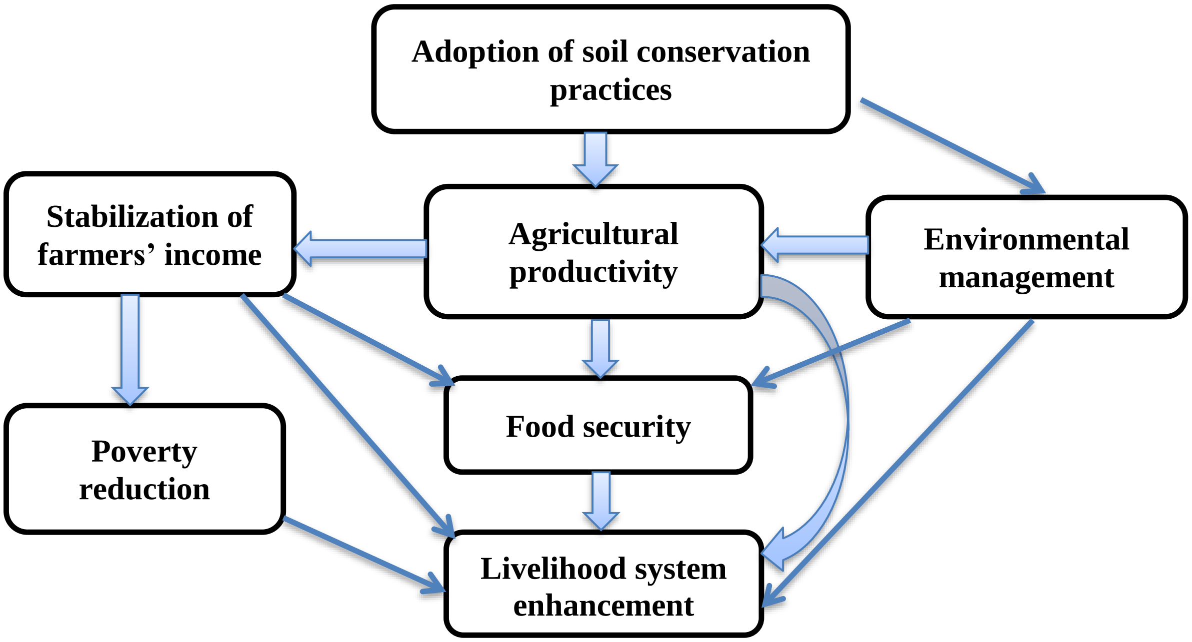

Figure 1.1. Conceptual framework

1.2. Theoretical framework

In the literature several studies have documented models of farmer's decision to adopt agricultural technologies particularly soil conservation techniques (Arslan et al., 2014; Yegbemey et al., 2013; Kassie et al., 2012; Bayard et al, 2007; Bayard et al., 2006; Adesina et al., 2000; Napier; 1991; Ervin and Ervin 1982). These studies used a choice model based on consumer theory. Adoption of any technology by farmers is guided by their rationality that soil conservation practices generate short and/or long term benefits. Therefore, farmers' decision to adopt any technology is motivated by utility maximization as indicated by several studies (Mc Fadden, 1973; 1974; Train, 1998, Ben- Akiva et al., 1993; Jumbe and Angelsen, 2011). The farmer is considered an economic agent whose decision to adopt any agricultural technology is subject to the perceived utility derived from the benefit generated by the technology (Fernandez-Cornejo et al., 1994). Thus, the farmer adopts the technology if the expected utility or benefit is greater than the expected cost (Bayard et al., 2006) of any other alternative. This decision is modeled as such: let us consider Y as a decision variable which takes on 1 if farmer adopts one of the soil conservation techniques and 0 if he does not, and *U* is the expected utility.

The farmer chooses alternative *j* if the technique generates the maximum utility compared to alternative *i* that is, if $U_j > U_i,\ i \neq j$ or when the unobserved latent variable $y^* = U_j - U_i > 0$. These levels of utility cannot be observed. Suppose that the utility level of the farmer i who chooses alternative j is:

$$U_j = X_j\beta_j + \varepsilon_j \qquad [1]$$

with, X_j a vector of household characteristics, β_j a vector of coefficients associated with X_j and ε_j is the unobserved error term. From this assumption the probability that farmer i adopts an alternative q is given by:

$$prob(y_j = q) = prob\ (U_q > U_j) = prob[\varepsilon_1 - \varepsilon_q > (x_q - x_1)\delta, \ldots, \varepsilon_j - \varepsilon_q > (x_q - x_j)\delta] = F(\delta_j' Z_j) \qquad [2]$$

More specifically in the case of binary choice $prob\ (Y = 1) = F(\delta_j' Z_j)$. With F being the cumulative distribution function and the Z_j is the vector of independent variables. When the farmer faces several alternatives, the use of logit or probit separately for each alternative or Multinomial logit or probit, is common. However, the binary logit or probit might generate biased and inefficient estimates as the factors identified might be correlated to unobserved factors contained in the error terms (Nhemachena and Hassan, 2007; Teklewold, Kassie and Shiferaw, 2013; Yegbemey et al., 2013; Asfaw et al., 2014 and Zuluaga et al., 2015). Following Yegbemey et al, (2013), Teklewold, Kassie and Shiferaw, (2013) and Zuluaga et al., (2015), we assume that farmers respond to soil loss by adopting different soil conservation options, therefore adoption of one given option or strategy might be correlated with the adoption of another option. To account for this issue and assuming that the error components are independent and identically normally distributed we use the multivariate probit (MVP) as previous authors to determine factors that drive the adoption of different strategies. The multivariate probit (MVP) simultaneously models the impact of the explanatory variables on each of the different practices, while allowing the error terms to be freely correlated (Belderbos et al. 2004; Lin et al. 2005; Kassie et al., 2012). The correlation may be complementarity (positive correlation) and substitutability (negative correlation) between different practices (Belderbos et al. 2004; Kassie et al., 2012; Zuluaga et al., 2015). We hypothesize farmers' adoption decision could be affected by socio-economic, geo-climatic and production factors (figure 1.2). These variables are included in the vector Z_j.

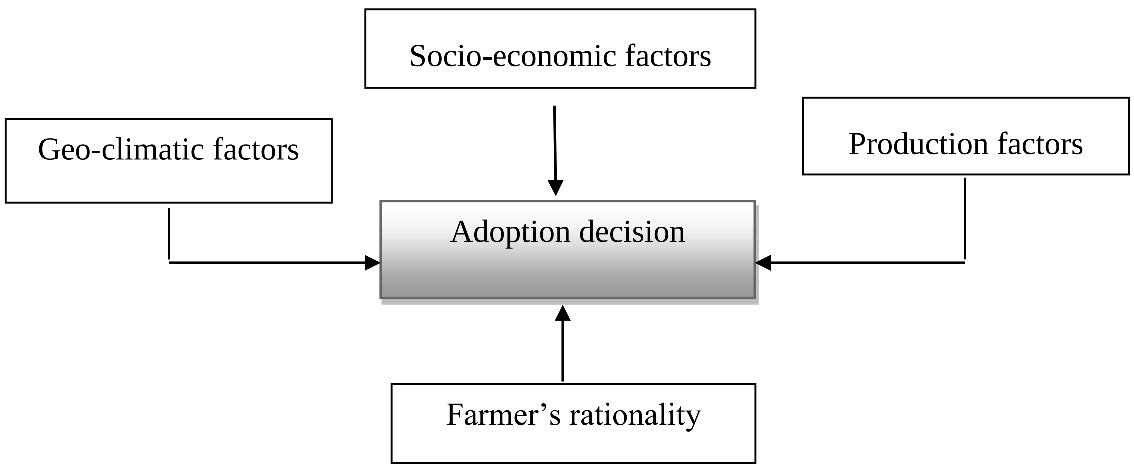

Figure 1.1. Theoretical framework (adapted from Kokoye et al., 2013)

1.3. Soil conservation practices (SCP)

<u>Rock walls:</u> Rock walls are mechanical structures constructed with rocks across contours. This practice exists in most parts of Haiti. It is labor intensive and requires some maintenance after installation. This makes the adoption of this practice difficult as farmers are reluctant to invest in it. Availability of rocks is the determinant in using this practice. In areas where the bedrock is limestone it is advantageous for farmers to use this practice as rocks are readily available on the field (Shannon et al., 2003). About 12.84% of farmers interviewed indicated that they adopted rock walls on their fields.

<u>Hedge rows</u>: Alley cropping between hedgerows is an agroforestry practice consisting of closely planted and regularly spaced rows of fast growing trees, usually -- *Leucaena leucocephala* – planted on contours with agricultural crops grown between the hedgerows. The hedgerows allow the reduction of runoff generation and intercepts eroded sediment from the upper slope so that soil fertility can be conserved (Lal, 1989, Leug Ng et al., 2008). Soil accumulation behind the hedge rows, provide an area of improved soil conditions immediately uphill from the hedgerows

(Bannister and Nair, 1990; Shannon et al., 2003). About 16.77% of farmers interviewed stated that they adopted hedge rows as a soil conservation technique on their fields.

Rampaye: Crop residues are used on contours to harvest water and hold the soil and prevent erosion. This is a well-known traditional used by farmers. It is a low cost technology and that requires a minimum amount of labor. In the region of Maissade in Haiti *rampaye* has been found to be the most profitable conservation technique compared to Rock walls (Lutz et al., 1994). Shannon et al., (2003) argued that even though "Rampaye" is effective in retaining the soil, it is a temporary measure as the barrier decomposes over time and need to be built again the following season. About 22.15% of farmers in the sample adopted "rampaye" as a soil conservation practice (SCP).

Bann manje: are rows of perennial or long duration food crops interspersed with other soil conserving crops such as sisal that are planted on contours to form barriers that provide protection to the soil. Crops used include plantain, banana, Malanga (*Xanthosoma*), sugar cane, pineapple, and cassava. About 12.01% have adopted "Bann manje". Detailed cost and revenue of Rock walls and Rampaye are placed in Appendix.

Table 1.1: Estimated relative costs, benefits, and risk of Soil conservation practices

SCP	Cost of installation	Cost of management	Amount of benefits	Timing of benefits	Risk of loss
Rock walls	High	Low-med	Low-med	Short	Med
Hedgerows	Varies	Med.-High	Varies	Med.-Long	Med.-High
Rampaye	Low	Low-med	Low-med	Short	Med
Bann manje	med.-high	Med.-high	high	short	Med.

Source: Adapted from Bannister, 2000

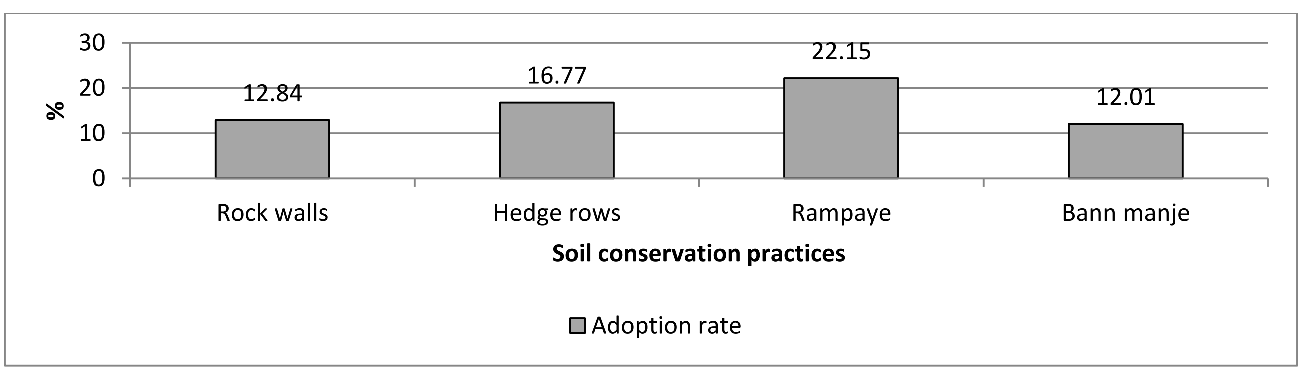

Figure 1.2. Adoption rates of soil conservation practices

1.4. Materiel and methods

1.4.1. 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. Over 90% were registered at implementation sites targeted for crop intensification through the transfer of improved agricultural technologies, and 10% in critical zones of the upper watersheds targeted for adoption of soil conservation techniques. 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.

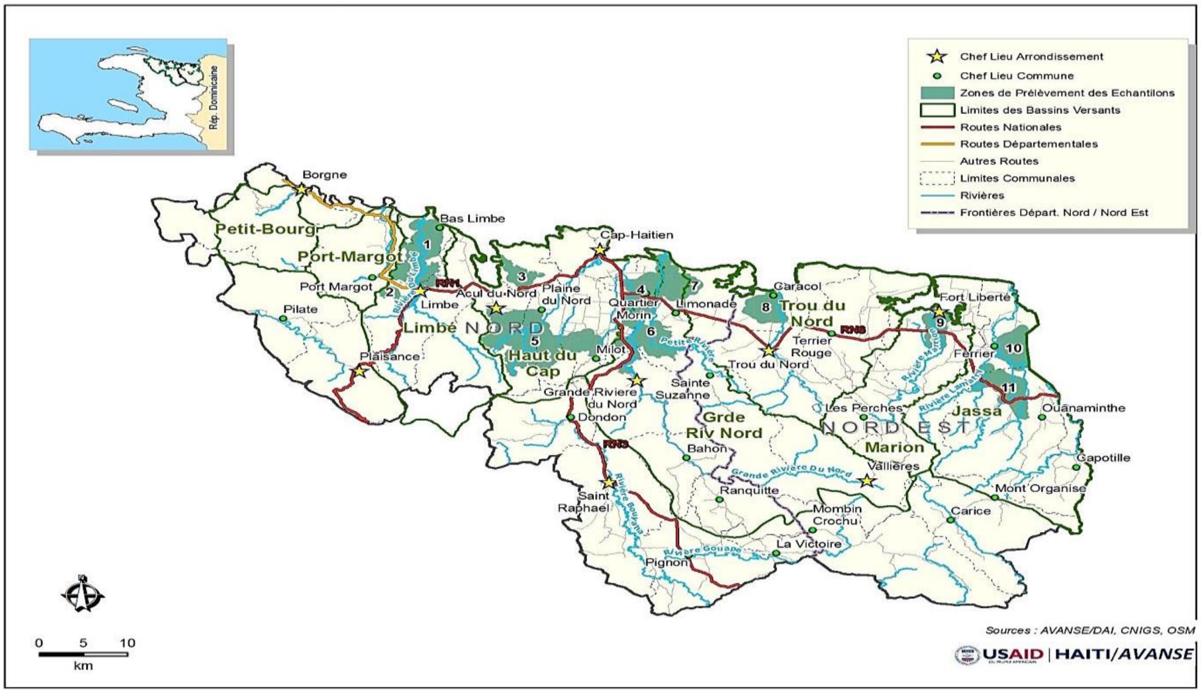

Figure 1.3. Study area

Table 1.2. 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**

1.4.2. Empirical model

Adoption of soil conservation techniques was analyzed using a multivariate probit model (MVP). The specification of the model is based on the following equation which is the basic form of probit or logit model often used for technological adoption decision.

$$Y_i = \beta_0 + \sum_j \alpha_j X_{ij} + \varepsilon_i \qquad [3]$$

With: β_0 the constant term, α_j the parameters to be estimated, $\mathrm{X_{ij}}$ is the set of independent variables and ε_i the error term. In the MVP used which models the adoption of each soil conservation technique simultaneously, equation (1) might be divided in n separate equation, each representing a binary adoption of each alternative. It is characterized, for each observation, by M pairs of equations, one describing each latent dependent variable and the other describing the corresponding binary observed outcome (Cappellari and Jenkins, 2006). Then the equation [1] becomes:

$$\begin{cases} \mathrm{Y_{1i}} = \beta_1 + \sum_{\mathrm{j}} \alpha_{\mathrm{1j}} \mathrm{X_{ij}} + \varepsilon_1 \\ Y_{\mathrm{2i}} = \beta_2 + \sum_{\mathrm{j}} \alpha_{\mathrm{2j}} \mathrm{X_{ij}} + \varepsilon_2 \\ \vdots \\ \vdots \\ \mathrm{Y_{mi}} = \beta_{\mathrm{m}} + \sum_{\mathrm{j}} \alpha_{\mathrm{kj}} \mathrm{X_{ij}} + \varepsilon_{\mathrm{m}} \end{cases} \qquad [4]$$

For each soil conservation option m, let us define the latent variable as:

$Y_{mi}^{*}=\beta_{\mathrm{n}} + \sum_{\mathrm{j}} \alpha_{\mathrm{j}} \mathrm{X_{ij}} + \varepsilon_m$, with m= 1, …., M

$$\mathrm{Y_{mi}} = \begin{cases} 1 \text{ if } Y_{mi}^{*} > 0 \\ 0 \text{ otherwise} \end{cases} \qquad [5]$$

ε_m are error terms distributed as multivariate normal, each with a mean zero, and variance-covariance normalized matrix. Following Cappellari and Jenkins (2006) the Log-likelihood function of the model in equation (3) is written as follows:

$$L = \sum_{i=1}^{N} \log \Phi_M \left(\mu_i; \Omega\right) \qquad [6]$$

Where $\Phi_M(\mu_i; \Omega)$ is standard multivariate normal cumulative distribution function with arguments μ_i and Ω, where $\mu_i = q_{i1}\beta_1' X_{i1}, q_{i2}\beta_2' X_{i2}, \dots, q_{iM}\beta_M' X_{iM}$ with $q_{ik} = 2y_{ik} - 1$, for each $i, k = 1, \dots., M$. q_{ik} = 1 if the binary variable $y_{ik} = 1$ and q_{ik} = - 1 if $y_{ik} = 0$. Ω has constituent elements $\Omega_{jk} = 1 \; if \; j = k \; or \; \Omega_{jk} = \Omega_{kj} = q_{ik} q_{ij} \rho_{kj}$. The models were estimated using method of Simulated Maximum Likelihood (SML) in STATA. The empirical model is written as follows:

$$\text{ADOPT} = \beta_0 + \beta_1 AGE + \beta_2 GEND + \beta_3 EDUC + \beta_4 GROUP + \beta_5 OWN + \beta_6 CROPDEP + \beta_7 CAPINC + \beta_8 CREDI + \beta_9 EDUC * GROUP + \beta_{10} SIZEPLOT + \beta_{11} SLOPE + \beta_{12}\, SIZEPLOT * SLOPE + \varepsilon_i \quad [7]$$

The following table presents the explanatory variables used in adoption model and their expected signs used in the models.

Table 1.3: Explanatory variables considered in the models

Variables	**Types[a]**	**Definition**	**Expected signs**
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	+
Valley	D	No = 0 ; Yes = 1	±
Land ownership	D	No = 0 ; Yes = 1	+

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

1.5. Results and discussions

1.5.1. Farmers' socio-economic and farming characteristics

Table 3 summarizes the socio economics and demographic characteristics of farmers. About 45% of farmers have formal education compared to 55% with no formal education. About 85% of farmers interviewed are male and about 48% participates in off-farm activities. It is common practice in Haiti for farmers to diversify their sources of income. Bayard et al., (2007) found that 57% of farmers in the areas of Gaita and Bannate in Southern Haiti devoted their time

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

to off-farm activities. Access to credit is very low (9.94%) and this is due to the absence of financial institutions that provide micro credit to farmers. About 7% of the farmers belong to groups, which is less than Fort Jacques area in Southern Haiti, where 31% of farmers participated in groups (Bayard et al., 2006). Farmers (36%) interviewed do have their land on slope. About 78% of farmers own the land either by inheritance or purchase. The average age of farmers is 51 years old.

Table 1.4. Socio-economic and farming characteristics

Qualitative Variable	Frequency	Percentage
Schooling level	--	--
Formal education	215	44.51
No formal	268	55.49
Gender	--	--
Female	71	14.70
Male	412	85.30
Off-farm activity	233	48.34
Access to credit	48	9.94
Group membership	36	7.45
Slope	174	36.02
Land ownership	380	78.67
Quantitative Variables	**Mean**	**Standard deviation**
Age	51.93	12.28
Crop dependency	0.43	0.74
Household size	4.97	1.95
Per capita income	450	410

Source: Authors' calculates from field study data

1.5.2. Factors affecting adoption of soil conservation techniques

The factors that affect the different soil conservation techniques are presented in table 4. Adoption of rock walls is negatively affected by educational level and positively affected by access to credit, the size of the treated plot and crop dependency. This shows that individuals with formal education are less likely to adopt rock walls as SCP. This result is in contrast with the general perception that formal education increases the probability of adopting agricultural technology. The result makes sense as formal education does not include teaching modules on agricultural technology, especially in the case of Haiti. Studies by Bayard et al., (2006) on adoption of rock walls in Fort Jacques in Southern Haiti also found that educational level has a negative influence on rock wall adoption. The establishment of rock walls is cash intensive (Bayard et al., 2007); this might justify the positive relation with access to credit which could help farmers to initiate the emplacement of the rock walls. Access to credit is limited to farmers in Northern Haiti. Financial institutions are rare and the few present use high interest on farmer loans. Tesfaye et al., (2014) in their study in Ethiopia found that adequate cash is needed by farmers to invest in soil conservation practices. Similarly, Bekele and Drake (2003) underlined the importance of credit in famers' soil and water conservation decision in Ethiopia. The size of the plot shows the expected sign which contradicts the results of Bayard et al., (2006) in Western Haiti (Fort-Jacques). However, Featherstone and Goodwin (1993) found a positive relationship between adoption of soil conservation practices and size of the farm. The results of studies by Amsalu and de Graaff (2007) in Ethiopia showed a positive relation between farm size and adoption of stone terraces, suggesting that farmers who hold large farms are more likely to invest in conservation. Presumably, this might be due their financial means to the cost of installation and management. Crop dependency showed positive relation implying farmers who rely on agriculture tend to invest more in Rock walls to secure their activities.

Adoption of hedge rows is influenced by gender, age of the farmer, crop dependency, 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 hedgerows as 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. In our sample only 14% of women have ownership of the land. The limited access to resources by women might prevent them from adopting 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. Age of the farmer reveal a negative relation with hedgerows adoption. This implies that the younger farmers are more likely to adopt SCP. Land ownership positively influences the adoption of hedge rows. 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 rights over tree 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 property value (Kokoye et al., 2013). Here, as oppose to the case of rock wall adoption, access to credit has a negative influence on hedgerow adoption. Hedge row farming is low cost practice; therefore, credit might be invested in other activities such as rock walls instead of using it for establishment of hedgerows. The interaction between education level and group membership positively influences famers decision to adopt hedge rows. 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. Even though local groups are not formed to discuss soil conservation issue, they might deal with issues concerning agriculture which impact the adoption of hedgerows. As it was the case of rock walls the size of the plot has a positive effect on the adoption of hedge rows. Liu and Huang (2013) in their study in China found that households with larger plots are more likely to use contour cultivation.

Factors affecting *rampaye* include the size of the treated plot, the existence of slope and the interaction between the slope and the size of the treated plot. As the size of the plot increases farmers are more likely to adopt *rampaye* as SCP. This result is in line with the findings of Kassie et al., (2012) who found that the plot size and the plot location are relevant in soil conservation practices adoption in Tanzania. Similarly, Liu and Huang (2013) showed that the size of the plot is a determinant in adoption of contour cultivation. The interaction between the slope and the size of the treated plot negatively affect the adoption of *rampaye*. Since *Rampaye* is a temporary measure and the barriers decompose over time (Shannon et al., 2003), its establishment on slope will not be efficient and durable. This could explain the negative sign of the interaction between the slope and the size of the treated plot.

The adoption of *Bann manje* is positively affected by size of the treated plot and access to credit. Given the benefits of Bann manje, the installation on large area would increase benefit to farmers. This might justify the positive relation. Even though the cost of installation of Bann manje is low, access to credit would help farmers to cover related costs. Age of farmer has negative effect on adoption of *Bann manje.* The age of farmer is negatively related to adoption of *Bann manje*, this suggests that the younger farmers are more likely to adopt *Bann manje*. Adesina et al., (2000) who found similar result in Cameroun explained that younger farmers might be disposed to try new innovations. However, *Bann manje* has this advantage of providing additional income or foods to households which lower risk and become attractive to younger farmers.

Table 1.5: Results of the Multivariate Probit (MVP) model

Variables	Rock walls (1)		Hedge rows (2)		Rampaye (3)		Bann manje (4)	
	Coefficient	P>z	Coefficient	P>z	Coefficient	P>z	Coefficient	P>z
Gender	- 0.13 (0.23)	0.558	0.45*(0.23)	0.052	0.073 (0.218)	0.736	0.319 (0.30)	0.298
Educational level	-0.40**(0.17)	0.020	-0.006(0.18)	0.974	0.0178(0.14)	0.905	-1.158(0.80)	0.151
Group membership	0.001 (0.40)	0.997	-0.896 (0.63)	0.157	-0.45 (0.35)	0.206	0.464 (0.30)	0.182
Age	-0.0044 (0.0068)	0.511	-0.015**(0.007)	0.028	-0.004 (0.006)	0.462	-0.027** (0.012)	0.030
Ownership	-0.052 (0.26)	0.845	0.57**(0.25)	0.023	0.050(0.24)	0.837	0.217 (0.27)	0.429
Crop dependency	0.166*(0.098)	0.090	0.180 * (0.102)	0.078	0.138 (0.10)	0.186	0.094 (0.10)	0.350
Per capita income	1.94e-06 (1.36e-06)	0.155	-2.25 e-05 (3.55 e-05)	0.527	-1.12e-06 (2.53e-06)	0.659	2.67 e-05 (2.09 e-05)	0.201
Access to credit	0.415*(0.22)	0.067	-0.637* (0.36)	0.082	-0.208(0.24)	0.395	0.736 *** (0.23)	0.001
Education*group	-0.055(0.65)	0.932	1.28* (0.0752)	0.087	-0.05 (0.14)	0.699	0.02 (0.24)	0.933
Size of plot treated	2.25***(0.40)	0.000	5.04***(0.63)	0.000	3.621*** (0 .589)	0.000	2.94***(0.63)	0.000
Slope	0.126 (0.17)	0.466	-0.023(0.19)	0.906	0.45*** (0.15)	0.004	-0.151 (0.1783)	0.396
Slope*Size of plot treated	-0.539 (0.56)	0.342	-1.317 (0.83)	0.115	-2.525*** (0.621)	0.000	-1.05 (0.70)	0.137
Constant	-0.810 (0.42)	0.056	-0.91 (0.36)	0.013	-1.06** (0.39)	0.008	-0.503 (0.72)	0.488

/atrho21	0.571 *** (0.18)	0.002
/atrho31	-0.414 * (0.14)	0.004
/atrho41	-0.002 (0.15)	0.985
/atrho32	-0.420* (0.13)	0.002
/atrho42	0.245 *** (0. 18)	0.175
/atrho43	-0.265 (0.14)	0.057

Number of observations = 483; Wald chi2 (48) = 309.59; Log likelihood = -608.6119; Prob> chi2 = 0.0000

NB: The values in bracket are the standard-errors; * p < 0.10, ** p < 0.05, *** p < 0.01, atrho21 indicating correlation between adoption equations (1) and (2)

Source: Authors' estimation

Table 1.6: Covariance of the error terms and Likelihood ratio test

rho	Coefficients	Standard Errors	P>|z|
rho21	0.516	0.134	0.000
rho31	-0.392	0.122	0.001
rho41	-0.002	0.151	0.985
rho32	-0.397	0.116	0.001
rho42	0.240	0.170	0.158
rho43	-0.259	0.130	0.046

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0
Chi2 (6) = 31.87; Prob > chi2 = 0.0000
Source : Authors' estimations

1.6. Conclusions

This study investigates the factors that affect adoption of SCP, such as rock walls, hedge rows, *rampaye* and *Bann manje*. It provides an empirical contribution to the literature on SCP practices and also gave guidance on factors that could be taken into account while looking into SCP adoption in Northern Haiti. Data were collected from 483 farmers in six watersheds --- Marion, Trou du Nord, Grande riviere du Nord, Haut du Cap, Jassa and Limbe – in Northern Haiti. The multivariate probit model reveals that the factors affecting adoption vary across practices. Those factors include educational level, access to credit, field plot location and field size, gender, group membership, land ownership, access to credit, interaction between education level and group membership, the interaction between the existence of slope and size of treated plot, and the age of the farmer. Any policy that seeks to encourage the use of soil conservation practices in North Haiti should take into account those factors. Particular attention should be given to access to credit, extension education, training in soil conservation practices, and increase access to production resources. If one is concerned about increasing adoption of SCP by women, improving their access to resources is an inevitable option. Additionally, secure land tenure has proven to be an important factor for adoption of SCP. The availability of soil conservation material also plays an important role in adoption of each SCP. However, this is not taken into account in this study and could be a limitation of this study. Also the value of crops grown -- value of field to farmer -- and willingness to invest in conservation practice are important aspects to be taken into account for future research. The dataset used for this study were composed of farmers who registered for the project. Therefore, we acknowledge potential selection which might prevent us from generalizing the results to the whole country. However, we believe these results could be used for policy recommendation and project implementation.

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Chapter 2:

Farmers' willingness to pay for soil testing service in Northern Haiti

Abstract

The study uses interval regression to investigate factors affecting farmers' willingness to pay for soil testing services in Northern Haiti. Data were collected from 452 farmers in 17 localities in Northern Haiti. The findings reveal that most farmers (90%) have never tested and have little knowledge of soil testing benefits. However, the explanation of soil testing benefits, led to a large number of farmers (93%) willing to pay on average 503 HTG, an equivalent of 7 USD per test. The models reveal that various factors affect the amount to be paid for soil testing services. These factors include: the type of crops grown, group membership, farmers' educational level, access to credit, gender, contact with extension services or any institution, type of soils, income level, participation in soil testing program and farm size. Two major policy implications can be derived from this study. The training module on soil testing benefits should be designed and supported by extension services and NGOs. Second the financial support in form of subsidies or access to credit should help low income farmers to pay for soil testing services.

Key words: Willingness to pay, Soil testing, Interval regression, CVM, Northern Haiti

2.1. Introduction

Soil fertility and health are determinant factors for increasing agricultural productivity. In most developing countries where soil degradation is prominent, maintaining good soil fertility is important to boost agricultural production. Soil testing was introduced to ascertain the condition of soils and provide recommendations on how to improve the nutrient component and its fertility USA (Jones and Kalra, 1992). The process is a cost-effective means to identify soils where nutrients such as N, P and K are deficient, and must be corrected to attain economically optimum crop yields (Wu and Babcock, 1998). Soil testing is a tool used to ensure that the additional use of fertilizer and lime improves crop performance and economic benefit without excessive waste or possible adverse environmental effects (Zhan et al., 1998). It is also seen as an effective way to reduce nonpoint-source pollution from agriculture (Wu and Babcock, 1998). In the late 1940s soil testing became an important factor in crop production decision making in USA (Jones and Kalra, 1992).

For many years, agriculture in Haiti experienced soil degradation and nutrient depletion that affected crop yields and farmers' income. The direct consequence of soil degradation is a prolonged history of food insecurity in Haiti (Lewis and Coffey, 1985; Bargout and Raizada, 2013). There is a need for new technologies or inputs with novel attributes that can help to increase agricultural production, reduce production costs and increase revenue. Soil testing services to farmers is quite relevant in the context of Haiti where soil conditions are unknown and soil nutrient imbalance exists due to the frequent use of predominant fertilizer formulation 12-12-20 (nitrogen-phosphorus-potassium; NPK) irrespective of soil quality or deficiency (Bargout and Raizada, 2013). Soil testing can help improve soil nutrient management and crop profitability. However, the culture of soil testing to obtain proper fertilization recommendation is quite new in Haiti where farmers seemingly apply fertilizer to their fields. This behaviour may cause loss of money and environmental issues as farmers may apply too little or too much fertilizer to their fields. The other consequences of this behaviour are the reduction of yields, the increase in costs and the decrease in profits. Soil testing services can help farmers apply the required amount and kinds of supplemental nutrients. As mentioned by Zhan (1998), providing farmers with information needed to apply the right amount of nutrients to the soil can save money and protect the environment. Based on this evidence, the US Agency for International

Development (USAID) intended to launch the first soil laboratory in the Northern region of Haiti. This laboratory will provide services to farmers and NGOs in the region.

However, the sustainability of this laboratory will depend on farmers' economic incentives and their ability to pay for the soil testing services. We believe that farmer support is essential for the long term sustainability of the laboratory. Thus, one would be interested to investigate on farmers' knowledge and willingness to pay (WTP) for soil testing services. Following Lui and Zhang (2011), we hypothesize that farmers would be more willing to pay for the soil testing services if they have higher valuation of the services. Additionally, we are interested to find out factors that affect their willingness to pay for soil tests. These factors are important in popularizing the process among farmers. Several studies investigate the willingness to pay for environmental goods and services as well as factors driving the WTP. Using various methods ranging from Choice experiment to contingent valuation method, these studies have focused in most cases on the consumer side of the valuation of goods and services (Huffman et al., 2003; ALFNES et al., 2006, Boys et al., 2014; Xu and Wu, 2009; Sriwaranun et al., 2015; Nandi et al., 2016). However, few studies have focused on producer valuation of goods and services. In the field of agribusiness, Roe and Antonovitz, (1985) studied the estimation of producers' WTP for information under risk while Patrick, (1988) investigated farmers' WTP for crop insurance. Studies by Whitehead et al., (2001), Budak et al., (2010) and Yegbemey et al., (2014) researched farmers' WTP for agricultural extension services. WTP for novel technologies or inputs were also studied by Kenkel and Norris, (1995); Hudson and Hite, (2003); Basarir et al., (2009) and Lillo et al., (2014). These studies have provided background on producers' WTP for acquiring information on agricultural inputs either in developed or developing countries. They also provided methodological guidelines on farmers' valuation of goods and services which were used in our study.

In the literature, we have found two studies that focused on farmers' valuation of soil testing. In 2011, Lui and Zhang examined the factors influencing Chinese farmers' willingness to adopt soil testing technology. Using a double bounded dichotomous choice contingent valuation method, they found that farm size, land distribution pattern and type of crop growing; gender, age and education level and usage of private lending affect farmers' willingness to adopt soil testing technology. Glendenning et al., (2011) focused on farmers' WTP for soil testing in Southern

India. Their results indicated farmers who have tested their soil and followed the advice of the soil testing service provider have a higher valuation of the service. These two studies gave an insight on farmers' willingness to pay for soil testing. Our study followed the previous by providing another evidence of farmers' valuation of soil testing services.

Given the establishment of the soil laboratory in Northern Haiti, the general objective of this study was to generate the demand side information from farmers who are the major users of the laboratory. The specific objectives are two fold, (1) to estimate the mean farmers' WTP in the study area. (2) To identify the determinants that affect farmers' willingness to pay for soil testing.

The remainder of the paper proceeds by (1) providing a theoretical framework in the second section; (2) giving an overview of methods used to measure willingness to pay in the third section (3) describing the data collection procedures in the fourth section, (3) presenting the results and discussions in the fifth section, and (4) presenting some conclusions and policy implications in the last section.

2.2. Theoretical framework

Following Hudson and Hite (2002) we hypothesize that soil testing services –assuming to improve soil quality for better production --- would have an effect on farmer' profit as a result of soil fertility improvement or cost reduction from precision in fertilizer application. The theoretical framework is derived from producer theory. Let us assume that farmers maximize profit and face a perfectly competitive input and output market. The individual farmer produces a product Y to be sold on the market. So he/she faces the following maximization problem:

$$Max\ \Pi = P_y Y - C(Y, r, \boldsymbol{q}) \qquad [1]$$

Where Π is the profit function, P_y is the price of output Y and $C(Y, r, \boldsymbol{q})$ is the cost function of the individual farm. The cost function can be defined as the solution of the following problem:

$$Min\ C = rX \qquad [2]$$

Subject to $Y = f(X, q)$

Where r is a vector of input prices, X is a vector of input quantities, $f(X, q)$ is the production function of Y, and q is a vector of input quality levels—here soil quality due to soil testing service ---. The level of q is fixed exogenously, thus the profit and the cost functions are conditional on q. Given $P_y,\ r\ and\ q$ that produces the optimal level of output, $Y\left(p_y, r, q\right)$, and input, $X(Y, r, q)$, which generate the cost function $\mathrm{C}\,(Y, r, q)$ and the indirect profit function Π (p_y,r,q).

The variation in profit due to change in q from q^0 to q^1 yields the following expression:

$$\mathrm{d} = \Pi\left(p_y, r, q^1\right) - \Pi\left(p_y, r, q^0\right) = F(p_y, r, q^1, q^0) \qquad [3]$$

This expression represents the maximum amount of money a farmer is willing to pay for improvement in soil quality. This amount theoretically depends on output price, input prices and the expectation in soil quality improvement. The equation could be extended to include socio-economic and farm management factors and yields the following model:

$$d_i = F(p_{yi}, r_i, q_i^1, q_i^0, X_i) \qquad [4]$$

where X_i stands for socio-economic and demographic characteristics of the *i*th farmer.

2.3. Measuring farmers' willingness to pay

The value of goods and services is measured based on the importance of the goods and services for consumers, their preferences and choices. Consumer preferences are evaluated by the amount they are willing to pay for the goods or services. Thus, the willingness to pay (WTP) for goods or services are defined as the maximum price people are willing to pay for goods or services (Wertenbroch & Skiera, 2002; Yegbemey et al., 2014). This technique is increasingly used in the absence of real market where consumers reveal how much they are willing to give up getting a good or service (Lofgren et al., 2008).

Methods for valuation included stated preference and revealed preferences. The "stated preference" method estimates the monetary value of goods and services by asking people how much money they are willing to pay for a particular good or service, or how much they are willing to accept as compensation if the services were to be eliminated (Boxall et al. 1996; Birol et al. 2006, Rasul, 2009). Two most common methods are used in this category: contingent valuation method (CVM) and choice experiment model (CE). Revealed preference (RP) methods differ from stated preference (SP) methods in that they use people's actual behavior in real markets, rather than their conjectured behavior in hypothetical markets. The revealed preference method uses information about a marketed commodity to infer the value of a related, non-marketed commodity through a complementary (surrogate or proxy) market (Rasul et al., 2011). Methods used for valuation may depend on time and money constraints.

In this study, the contingent valuation method (CVM) was used. CVM is a survey based methodology that simulates a market in which farmers are exposed to information on the new goods or services and make decision about their willingness to pay (Chee et al., 2004; Zapata and Carpio, 2012). This method was first used by Davis (1963) who designed the market to assess the economic value of recreational possibilities of Maine's forests. CVM is considered flexible and adaptive to some valuation tasks that other techniques cannot handle (Padi et al., 2015). It has been widely used by studies in the fields of environmental economics and health economics (Dafor and Essel-Gaisey, 2015; Cho et al., 2005; Cho et al., 2008; Jin et al., 2016; Whitehead, 2005; Hudson and Hite, 2003; Yegbemey et al., 2014). However, since CVM uses a hypothetical market the main issue is whether people are actually willing to pay what they claim they will pay. The CVM has been criticized for its inability to deliver reliable and accurate estimates of the willingness to pay (Diamond and Hausman, 1994) and for many biases including strategic bias, design bias, hypothetical bias and operational bias (Pearce and Turner, 1990; Padi et al., 2015). Given the fact that no soil testing services exist in Northern Haiti, we decided to use the CVM in this study.

2.4. Material and method

2.4.1. Study area

Haiti is a Caribbean island located between 19° 00' N latitude and 72° 25' W longitude in the western hemisphere. The average annual rainfall in the study area in Northern Haiti is about 1,200 mm in the plains 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).

Data were collected in Northern Haiti within AVANSE/USAID project intervention areas. These areas include Limonade, Plaisance, Acul du Nord, Plaine du Nord, Grand Rivière du Nord, Fort

Liberté, Ferrier, Ounanaminthe, Limbe, Bas Limbe, Trou du Nord. The Northern Corridor of Haiti extends 70 km along the region's Route National 6, and connects about 600,000 people. The project covers a wide area on the Northern Plain. Within the plain are a number of small farmers holding land on degraded soils.

2.4.2. Data collection

Data collection involved three steps. In the first step twenty (20) interviewers who speak Haitian Creole were recruited and trained from March 16-17, 2016 on data collection procedure and questionnaire administration. Interviewers were briefed on objectives of the survey, sample design, the selection of respondents within households, and methods of conducting a survey, respondent bias minimization and survey questionnaire techniques. Participants also received training on basic rules for avoiding the introduction of bias into the survey and measures of soliciting unbiased information from farmers. Interviewers practiced mock interviews among themselves and discussed problems and questions that arise. Trainees did also some testing of the survey instrument with other students involved in agriculture. Trainees received information on the ethical conduct of personal interviews.

The second step consisted of pre-testing the questionnaire with farmers in close by villages to ensure that the questions were well formulated. As a result of the pre-testing some questions were deleted or modified.

In the third step the enumerators went on the fields to collect data. The field work was done from May 16 to June 3, 2016. The field work was supervised by the Auburn Graduate Research Assistant who conducted field visits to observe the data collection and ensure the good quality of the data collected.

2.4.3. Sampling method

A multistage approach was used to select farmers participating in the study. In the first stage we purposefully selected 17 localities within the project intervention areas from a list of AVANSE target zones. In the second stage we randomly selected farmers from the list of enrolled project participants in each zone who are participating in the project. The list was provided by the project officer.

In some instances, when farmers on the excel spread sheet provided by the project officer were not found, a snowball sampling method was employed to add farmers to the sample. Snowball sampling relies on referrals from initial subjects to generate additional subjects or find replacements. Thus farmers on the list made referrals to nearby farmers as replacements for those who were not present or not found. In total, 456 farmers were interviewed.

2.4.4. Survey instrument

A structured questionnaire allowed the collection of information related to farm household socio-economics and demographics data – age, location, type of household, education, —, knowledge and perception on soil testing services and their willingness to pay for soil testing. The questionnaire was translated and administered in Haitian Creole to ensure that farmers understand the content of the questionnaire.

Questionnaires were close ended and were administered through informal interviews. Figure 2.1 shows the structure of the willingness to pay questions. Four questionnaires were dropped from the dataset for inconsistency and incompleteness of information.

Descriptive statistics was used to evaluate farmers' socio-economic characteristics. Interval regression was used to determine the factors affecting the willingness to pay for soil testing services.

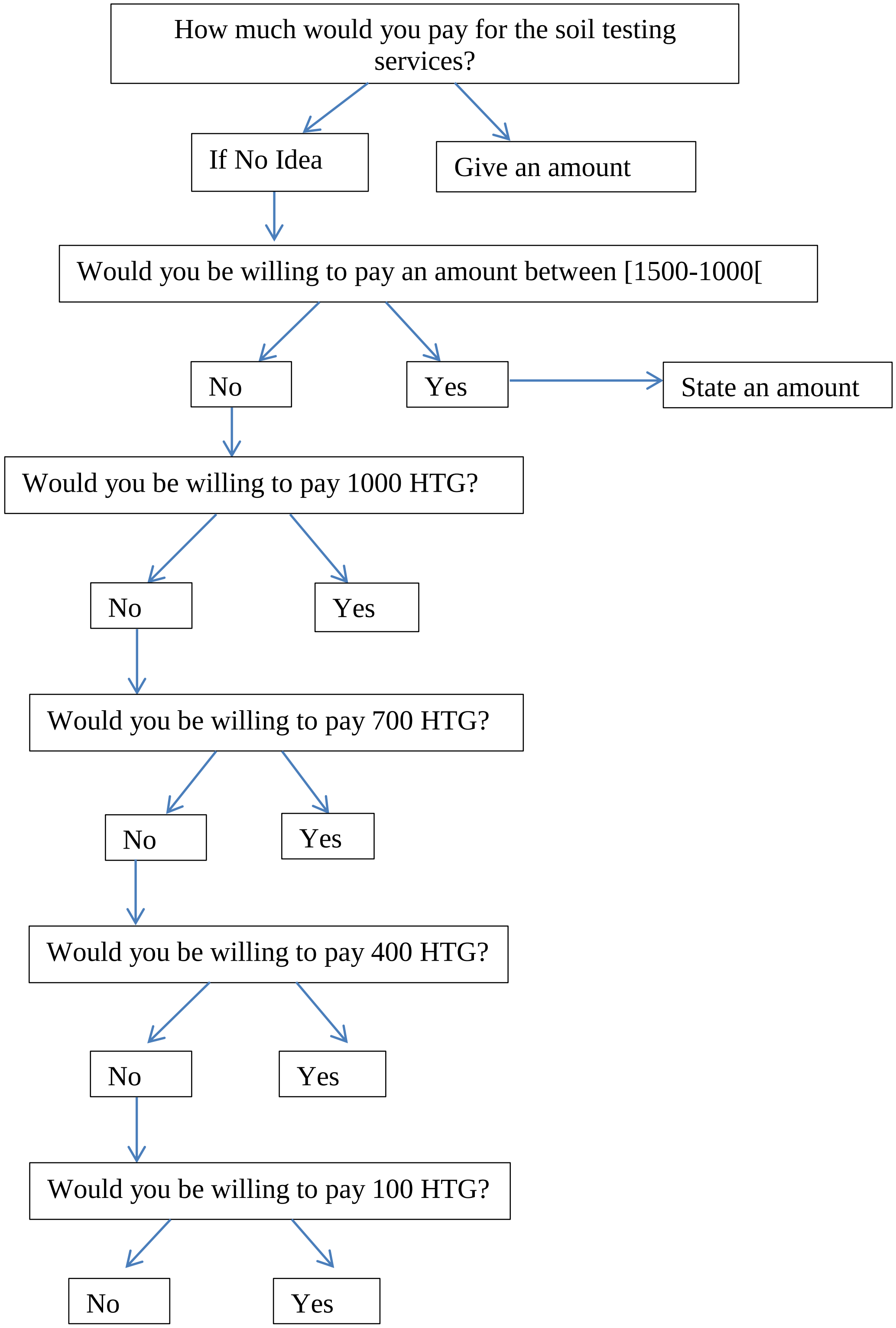


Figure 2.1. Structure of WTP questionnaire

2.4.5. Empirical modelling

Figure 2.2 shows the structure of the WTP responses. An analysis of the responses revealed that (1) the distribution of stated WTP is skewed; (2) some respondents state a zero WTP—around 6% of respondents---; (3) other respondents state a WTP very different from most of the respondents (outliers) --- about 4%--; and (4) respondents' WTP tend to concentrate – "heap" – around certain values---24% of values around 100HTG, 24% of WTP values around 400HTG and 19% are concentrated around 1000HTG. According to Lofgren et al., (2008), these issues arise in many WTP studies. Different methods have been used to deal with these issues. Aristizabal (2012) showed how the log-normal model is used to deal with the skewness. In that case the zero WTP and the outliers are excluded. The heap effect suggests that their stated WTP represents a certain interval, rather than a precise amount (Lofgren et al., 2008). Torelli and Trivelato (1993) have shown that this behavior, if not considered, may disguise true relationships. To account for these issues mentioned above and assuming that the WTP lies between intervals (Lofgren et al., 2008; Shang-Ho et al., 2012) we use the interval regression model. The WTP were grouped in the following interval: [0-100[; [100-400[; [400; 700[; [700-1000[and [1000; +∞ [. Supposing that y_i^* represents the true value of the WTP, which is unobserved, the specification of the model can be written as follows:

$$y_i^* = X_i\beta + \varepsilon_i \qquad [5]$$

β the parameters to be estimated, X_i is the set of independent variables, and ε_i the error term which is assumed to have mean zero and normally distributed. The interval regression estimates the probability that a latent variable y_i^* exceeds one threshold but is less than another threshold, i.e., it estimates the probability of the latent variable lying in a certain interval (Cawley, 2008; Kpade et al., 2016). Therefore, the likelihood contribution of the individual is:

$$L = \prod_{y_i=1} \Phi\left(\frac{\ln 100 - \beta x_i}{\sigma}\right) \prod_{y_i=2} \left[\Phi\left(\frac{\ln 400 - \beta x_i}{\sigma}\right) - \Phi\left(\frac{\ln 100 - \beta x_i}{\sigma}\right)\right] \prod_{y_i=2} \left[\Phi\left(\frac{\ln 700 - \beta x_i}{\sigma}\right) - \Phi\left(\frac{\ln 400 - \beta x_i}{\sigma}\right)\right] \prod_{y_i=2} \left[\Phi\left(\frac{\ln 1000 - \beta x_i}{\sigma}\right) - \Phi\left(\frac{\ln 700 - \beta x_i}{\sigma}\right)\right] \prod_{y_i=2} \left[1 - \Phi\left(\frac{\ln 1000 - \beta x_i}{\sigma}\right)\right] \quad [6]$$

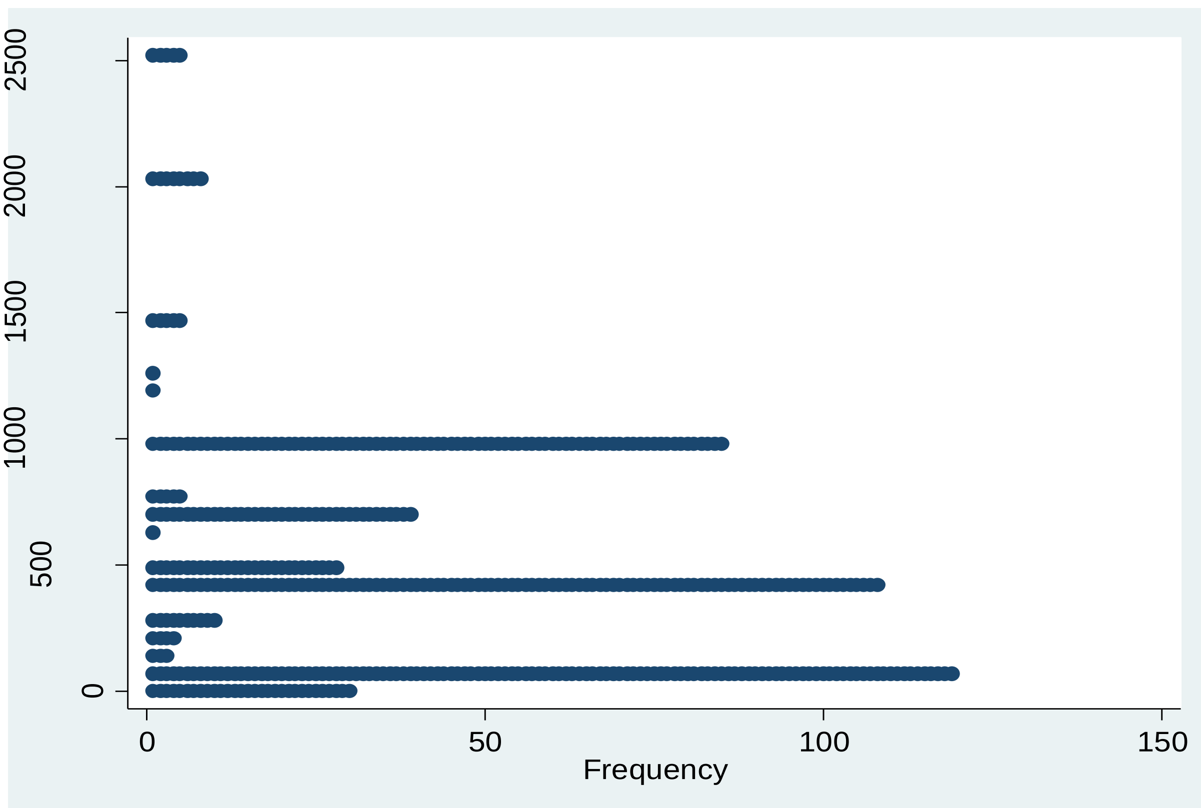


Figure 2.2. Distribution of farmers' WTP for soil testing services, North Haiti farm survey 2016

The empirical models of equation [1] can be written as follows:

$$\text{WTP} = \beta_0 + \beta_1 AGE + \beta_2 GEND + \beta_3 EDUC + \beta_4 GROUP + \beta_5 OWN + \beta_6 COCOA + \beta_7 BAN + \beta_8 RICE + \beta_9 FERT * RICE + \beta_{10} MARCH + \beta_{11} SLOPE + \beta_{12}\ HHSIZE + +\beta_{13} CONTACT + +\beta_{14} FARMSIZE + +\beta_{15} EXP + +\beta_{16} PARTST + \beta_{17} SOILT + \beta_{18} INCOME + \beta_{19} CREDI + \beta_{20} FERT + \varepsilon_i \quad [7]$$

In the literature, several studies use interval regression model to examine factors affecting the willingness to pay for goods and services. Lofgren et al., (2008) applied interval regression to measure people's willingness to pay for health insurance in rural Vietnam. The interval regression has been useful to solve the problems of zero answers, skewness, outliers and the heaping effect present in their dataset. Shang-Ho et al., (2012) also employed interval regression to analyze consumer willingness to pay for Fair Trade Coffee in China. More recently the interval regression serves as method of analysis for Cotton farmers' willingness to pay for pest management services in northern Benin by Kpade et al., (2016).

Prospective explanatory variables included in our model are presented in table 2. Several studies have discussed the factors influencing farmers' willingness to pay for technologies (Hite et al., 2002; Kenkel and Norris, 1995; Hudson and Hite, 2003; Basarir et al., 2009 and Lillo et al., 2014). These factors include: age of farmer, gender, farm size, educational level, income, group membership, access to credit, experience in agriculture, and contact with extension services.

Table 2.1. Prospective explanatory variables

Variables	Types[a]	Definition	Expected signs
Age	C	Number of years from birth	±
Gender	D	0=Female; 1=Male	±
Educational Level	C	Number of years in school	±
Income	D	1= Less than 2000 HTG 2= 2001 - 4000 HTG 3= 4001 - 6000 HTG 4= More than 6000 HTG	+
Soil Texture	D	1= Sandy soils 2=Clay soils 3= Clay and sandy soils 4= Soils with relatively high gravel	±
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	+
Farm size	C	Area in hectare	±
Slope	D	No = 0 ; Yes = 1	+
Cocoa growers	D	No = 0 ; Yes = 1	±
Rice growers	D	No = 0 ; Yes = 1	±
Banana growers	D	No = 0 ; Yes = 1	±
Experience in Agriculture	C	Number of years	±
Participation in AVANSE soil testing program	D	No = 0 ; Yes = 1	±
Access to market	D	No = 0 ; Yes = 1	±
Land ownership	D	No = 0 ; Yes = 1	+
Contact with institution/extension	D	No = 0 ; Yes = 1	+
Fertilizer use	D	No = 0 ; Yes = 1	+

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

2.5. Results and discussions

2.5.1. Socio-demographics characteristics of farmers

Table 3 shows farmers socio-demographics characteristics. Out of 452 respondents 81.86% are male and 18.14% are females with an average age of 47 years. Interviewees had an average of 6 years of schooling, 60.18% had up to primary level education, 18.80% had up to secondary level education, 2.22% had up to tertiary level education, and 18.80% had not attended school before.

The average household size is 6, and the average number of children that has been to high school is 1 per household.

Access to agricultural resources is fundamental for increasing agricultural productivity. We evaluate farmers' access to agricultural resources by gathering information on land tenure, fertilizer use, and access to credit, group membership, farm size and contact with extension service. About 76% of farmers surveyed owned their land. These results are similar to those of the baseline survey conducted the AVANSE M&E team in 2014. As mentioned in several studies (Ghei, 2008; Yegbemey et al., 2013; Kokoye et al., 2013) secure land guarantees to farmers' incentive to invest more on the lands.

About two thirds of Haiti is mountainous. However, in the study only 7% of the lands cultivated by famers in our samples were located on hillsides. Fertilizers remain an important input in agriculture. In Haiti the intensity of fertilizer use is low, given reasons such as lack of supply, financial means and lack of knowledge on soil components and nutrients. Among the farmers surveyed, about 37% apply fertilizers. Majority are rice farmers (95%) as shown in figure 4. It is common practice in the study area to apply fertilizers on rice. This practice is being reinforced with the intervention of AVANSE that facilitates access to fertilizers through its voucher program. The voucher program subsidizes 60% of the fertilizer cost to farmers. Access to credit is quite limited in Northern Haiti as mentioned by several studies (Molnar et al., 2016, DAI, 2014). In our study area only 17.92% of farmers have access to credit to finance their farming activities.

Group membership helps farmers to share information on agriculture and/or other activities they practice. About 56% farmers belong to farmers' group or association that handle issues regarding agriculture. Contact with institutions or extension services are also key resources for agricultural development education. We found out that 60% of farmers have contact with at least one institution or extension services. Nearly 47.7% of farmers have access to market for inputs and to sell their products. The average farm size is 1.03 (± 1.20) hectares per household. Farmers are experienced in agriculture with average of 14 years.

Soil texture refers to the percent by weight of sand (particles between 0.05 to 2.0 mm), silt (0.002 to 0.05 mm), and clay (<0.002 mm) in a soil sample. It indicates how easily a soil can be cultivated. Soils high in sand are easier to cultivate and are termed light, whereas soils that are difficult to cultivate and high in clay are called heavy. Soil texture also affects nutrient holding capacity, with clay soils having more surface area on which to retain plant nutrients. As shown in the table, 13% of farmers believed their soil texture is sandy, 46% as clay, 40% as sandy and clay, and 1% as soil with relatively high gravel.

Looking at the distribution of farmers by categories of income; most of the farmers (48%) earn more than (1.0 USD=63HTG) 6,000 HTG a year.

Table 2.2. Farmers' socio-economics characteristics and agricultural resources

Qualitative Variable	Frequency	Percentage
Soil texture	--	--
Sandy soils	60	13.27
Clay soils	210	46.46
Sandy and clay soils	178	39.38
Soils with relatively high gravel	4	0.88
Income	-	-
Less than 2000 HTG	60	13.27
2001 - 4000 HTG	80	17.70
4001- 6000 HTG	93	20.58
More than 6000 HTG	219	48.45
Crops grown	-	-
Cacao	152	33.63
Banana	323	71.46
Rice	138	30.53
Fertilizer use	166	36.73
Land ownership	343	75.88
Gender	-	-
Male	370	81.86
Female	82	18.14
Access to credit	81	17.92
Participation in AVANSE soil testing	41	9.07
program Group membership	255	56.42
Slope	32	7.08
Contact with institution/extension	272	60.18
Market access	216	47.79
Quantitative Variables	**Mean**	**Standard deviation**
Farm size	1.03	1.20
Age	47.14	13.49
Educational level	6.01	4.22
Experience in agriculture	14.64	12.15
Household size	6.15	2.43
Number of children in high school	1.34	1.80

Source: Survey, Auburn University, 2016

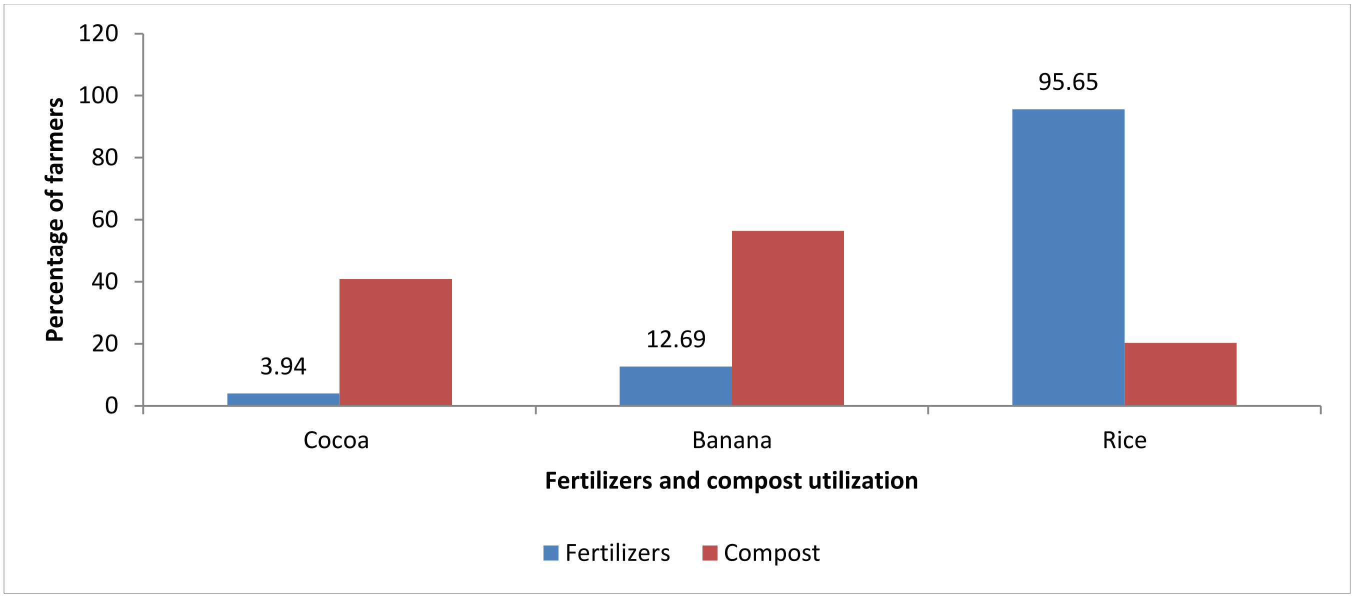


Figure 2.3. Fertilizers and compost utilization, Northern Haiti farm survey, 2016

2.5.3. Factors affecting farmers' willingness to pay for soil testing services

2.5.3.1. Farmers' willingness to pay for soil testing services

We obtained information on farmers' willingness to pay (WTP) by asking how much they were willing to pay for soil testing services if this was available to them. The result shows that farmers are willing to pay an average of 503 gourdes, an equivalent of 7 USD per test for the soil testing services throughout the regions. This value is less than the average amount charged by Oklahoma Soil laboratory which is 10 USD for routine analysis --- pH (1:1), Lime requirement (Sikora Buffer), NO3-N, Soil test P & K by Mehlich 3 ---. The following table shows the willingness to pay for soil testing services in different regions. This value varies from North-east region to North region.

Table 2.3 shows the statistics of respondents who are willing and unwilling to pay for soil testing services. In total 28 (6.0%) farmers stated they were unwilling to pay for soil testing services whereas 94% of farmers are willing to pay for the soil testing services.

Table 2.3. Farmers' willingness to pay for soil testing, North Haiti farm survey 2016

Department	Amount Willing to Pay for Soil Test (gourdes[2])		
	Mean (standard errors)	[95% Confidence Interval]	
North(n=319)	449.5 (23.99)	402.29	496.71
North-east (n=133)	634.2 (44.57)	546.04	722.38
Full sample (n=452)	503.8 (21.75)	461.09	546.60

2.5.3.2. Estimation results from interval regression

We estimate the interval model to determine the factors affecting farmers' willingness to pay for soil testing services. The results shown in table 2.4 revealed that the farmer' educational level, whether he has access to credit, his gender, his belonging to a farmer' group, whether he has contact with extension services or any institution, whether his soils are sandy and clays, his income level, whether he grows rice or banana and rice, if he participates in AVANSE soil testing program, his farm size, are strong predictors of farmers' willingness to pay.

Farmers' educational level is positive and statistically significant at 5% significance level. Farmers who have been to school are willing to pay a positive amount for acquiring information on their soils. Several studies have indicated the importance of education in either agricultural technology adoption decision or willingness to pay for various agricultural inputs. Yegebemey et al, (2014) in their studies on farmers' willingness to pay for extension services found that education plays a determinant role in the amount farmers are willing to pay to acquire information on climate change. Mwaura et al., (2010) results showed that education determine Uganda farmers' willingness to pay for extension services related to crop and animal husbandry. The number of years in school has been revealed to affect farmers' willingness to pay for agricultural extension service in Nigeria, by Ozor et al., (2013). Liu and Zhang (2011) have also identified education as a key factor affecting farmers' willingness to pay for soil testing. However, results from studies by Glendenning et al., (2011) in Southern India revealed that farmers who do not have formal education are willing to pay more for soil testing. In our study educated farmers are willing to pay 540HTG compared to uneducated farmers who are willing to pay 495HTG.

[2] 1USD =62 HTG at the time of the survey.

Access to credit is significant and positive. This means farmers who have access to credit offer more for the soil testing services. The available of funds which provide farmers with greater financial means to decide could justify such result. However, this result is consistent with several studies related to willingness to pay or adoption of novel agricultural inputs. A result from Omondi, et al., (2014) in their studies of WTP for irrigation demonstrated a statistically significant relationship between access to credit and WTP for irrigation water. Yegbemey et al, (2014) have also showed that access to credit is significant in farmers' willingness to pay for agricultural extension services.

Male farmers have higher willingness to pay compared to their female counterparts. Agriculture in Haiti is dominated by male head of households and our sample is composed of about 82% of men. Several studies showed that males have a higher WTP for technologies compared to females (Yegbemey et al, 2014; Lui and Zhang, 2011). This is often justified by the fact that males in most of the developing world have greater access to resources than females.

Farmers who belong to a group are willing to pay less than those who do not. This result contradicts the general opinion according to which group membership is expected to assist farmers to acquire information on technologies and novel inputs (Tiamiyu et al., 2009). Given that soil testing services are not well developed in the region, group membership might create a dependence and readiness to expect a subsidy for soil testing. This might explain farmers' behaviour in this model.

Farmers who have contact with agricultural extension services or any other institutions are willing to pay more than those who do not. The role of extension services is to provide information on agricultural technologies and practices to farmers. It helps farmers to increase their production or living conditions. Arinloye et al., (2016) indicated that contact with extension services is a positive factor in pineapple farmers' willingness to pay for market information received by mobile phone in Benin. Fadare et al. (2014) and Yu, Nin-Pratt, Funes and Gemessa (2011) also found a positive relationship between access to extension services and the adoption of agricultural technology. In the context of Haiti, we would not argue that extension services provide farmers with information on soil testing services since extension institutions do not provide training on soil testing. The plausible explanation for this result is that farmers who have contact with extension or any other institution are already exposed to various knowledge on agriculture which confers to them the ability to comprehend the benefit of soil testing services and being willing to pay more.

Soil texture, particularly farmers whose soils are sandy and clay are willing to pay less than those whose soils are not. Soil texture generally affects growth the root zones, which determine the above-ground growth production, and is determined by the fractions of sand, silt, and clay present in the soils. Sandy clay soils seem to improve soil quality. Therefore, farmers whose soils are sandy clays might not value soil testing as much as those whose soils are not.

The type of household based on the crops they grow or the combination of crops they grow are also determinants of their willingness to pay for soil testing services. Farmers who grow only rice are willing to pay more than those who do not. As shown in figure 2.5 rice farmers are willing to pay 591 HTG compared to cocoa and banana farmers who are willing to pay 348 HTG and 491 HTG respectively. Similarly, farmers who grow rice and bananas are willing to pay more. One of the main benefits we expose to farmers is the ability of the soil testing services to provide information on the appropriate fertilizer to be used for cropping.

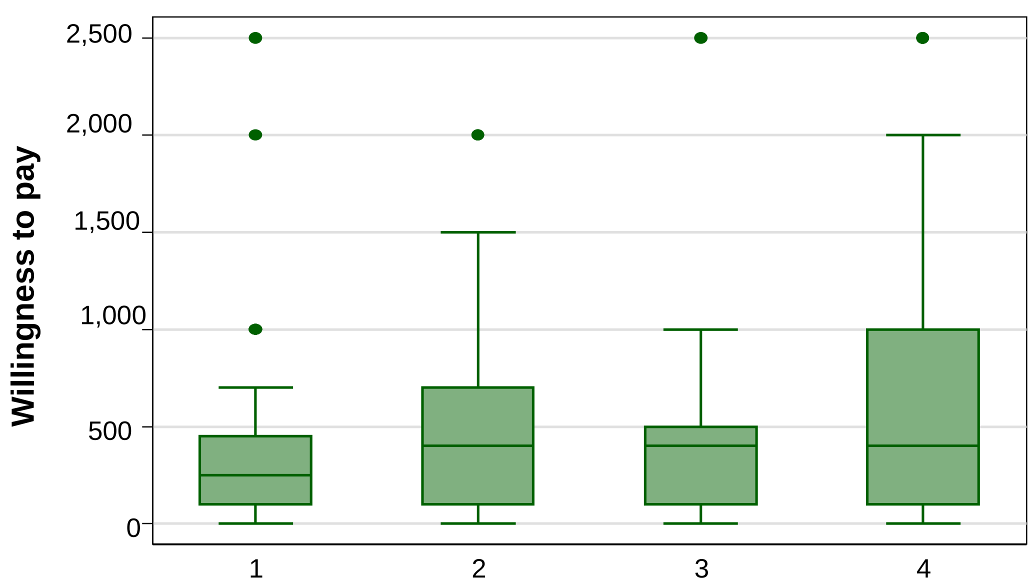
In the case of Haiti, this information is non-existent and farmers apply fertilizer randomly without standard fertilizer requirements. Therefore, given rice farmers apply fertilizers to their fields; they might be interested to know about the fertilizer requirement for their crops.

About 37% of farmers in our dataset use chemical fertilizers. However, among them, 95% of rice farmers use chemical fertilizer (Figure 2.4).

According to our results, farmers who earn income of 2001-4000HTG (category 1) and more than 6000HTG (category 3) are willing to pay a significant and positive amount of money. However, farmers who earn more than 6000HTG are willing to pay more for the soil testing than others. This is understandable as cash is needed to pay the cost of the services. These results suggest that there is an income effect in the decision on the amount of money farmers are willing to pay. In order to cross check this result we use the boxplots and run the Kruskal-Wallis test. Figure 2.5 shows the side by side boxplot of farmers' willingness to pay by income categories. These plots reveal that the average willingness to pay varied across income category. Farmers with high income of more than 6000 gourdes were willing to pay the highest amount (586 HTG). The Kruskal-Wallis test showed that there is a statistically significant difference in the WTP between the four categories of income, $\chi 2=6.8$, $p < 0.0006$. Therefore, income might have an impact on the amount of money farmers are willing to pay for soil testing services. This result is consistent with that of Ulimwengu and Sanyal (2011) who found that the income of a farmer influences the willingness of the farmer to pay for agricultural services. This result suggests that farmers with limited resources will not be able to afford the cost of soil testing services.

As the farm size increase, farmers are willing to pay more for the soil testing. This result suggests two explanations. First farmers with large farms have more income or financial power to afford soil testing services. Second they might be willing to pay more in order to know the status of their soils for efficient production. Positive relation between farm size and agricultural technologies adoption has been proved by the following studies: Liu and Zhang (2011), found that farm size has a statistically significant positive relationship with the willingness to adopt soil testing technology. Norwood and Mask (2005) also found that farm size influences the willingness to adopt and also pay for agricultural technologies.

Farmers who provide their soil samples to AVANSE/USAID suggested greater amounts of money for soil tests. Farmers who provide their soils samples to AVANSE/USAID offer more WTP which might result from the tangible results they got from the experience in providing their soils sample[3].



1= Income less than 2000 HTG
2=2000-4000 HTG
3=between 4001-6000 HTG
4=more than 6000 HTG

[3] We need to mention that during our survey, we handed the results of the soils sample analysis for those who provide the soils sample. So we can assume that this action provide an incentive to offer more WTP for the soil testing services.

Figure 2.4. Willingness to pay and farmers' income, Northern Haiti farm survey, 2016

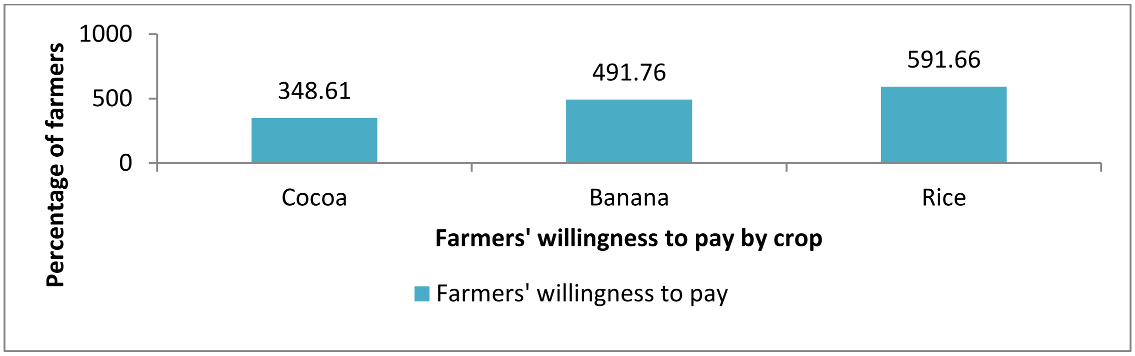


Figure 2.5. Willingness to pay by crop, Northern Haiti farm survey, 2016

Table 2.4. Interval regression model of farmers' willingness to pay for soil testing in Northern Haiti

Variables	*Coefficients*	*Standard Errors*	*P>z*
Age	-2.45	1.59	0.125
Educational level	99.66	49.63	0.045**
Credit	174.63	52.21	0.001***
Gender	113.84	47.78	0.017**
Household size	-7.85	7.67	0.306
Group	-110.23	37.92	0.004**
Ownership	-25.71	45.20	0.569
Contact	68.64	38.91	0.078*
Soil texture	-	-	-
Clay soils	-35.35	62.47	0.572
Sandy and clay soils	-96.20	57.44	0.094*
Soils with relatively high gravel	332.50	231.74	0.151
Crops grown			
Rice	249.02	104.70	0.017**
Banana and Rice	220.00	124.96	0.078*
Cocoa	86.35	123.07	0.483
Cocoa and Banana	36.88	106.58	0.729
Banana	119.67	105.70	0.258
Per capita income	-	-	-
Income 2	127.62	64.75	0.049*
Income 3	109.76	63.75	0.085*
Income 4	196.71	56.99	0.001***
Slope	41.748	72.207	0.563
Experience	0.79	1.71	0.644
Farm size	41.88	18.19	0.021*
Participation in AVANSE soil testing program	260.45	72.67	0.000***
Constant	554.24	178.72	0.002
Log likelihood	-701.45	LR chi2(22)	112.10
Number of observations	452	Prob >chi2	0.000

*, **, *** significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Authors' estimations

2.6. Conclusions

Increasing agricultural productivity in Haiti requires innovative tools to help farmers achieve their goals. Soil testing appears to be one tool that can provide farmers with necessary information to increase the yields of their crops. In prelude to the installation of soil testing laboratory in Northern Haiti, we researched factors that affect farmers' willingness to pay for soil testing services in Northern Haiti. By taking into account zero answers, skewness, outliers and the heaping effect of the data we use interval regression model. This model reveals that various factors affect the amount to be paid for soil testing services. These factors include: farmers' educational level, access to credit, his gender, belonging to a farmer' group, whether he has contact with extension services or any institution, whether the farmer's soils are sandy or clay, income level, whether he grows rice or banana and rice, if he/she participates in AVANSE soil testing program, farm size.

2.7. Policy implications

The study provides information on the existing potential for the establishment of laboratory in the North. However, the sustainability of this laboratory will depend on various factors identified in this study. The first factor that seems to be important and that appears to be significant across models is the income or financial means. Price payment schedule for the soil testing should be designed in such way farmers are able to afford, given that our study reveal that farmers who earn high income or have access to financial resources are able to pay more for the soil testing services. Male farmers are also willing to pay more, given the reason that they have access to more resources than their females' counterparts. Another way to help farmers is to provide subsidy to support the pricing policy that will be put in place or provide credit access to farmers. NGOs might also provide support to their farmers by helping them to pay for soil testing analysis.

One big issue to be solved before designing any pricing policy is to inform farmers on the importance of soil testing service for increasing their yields. From our investigation, farmers are not well informed or educated on soil testing benefits. We suggest that the laboratory include an extension component that will help farmers to better apprehend the usefulness of the soil testing services and also the interpretation of the results. In addition, NGOs and development projects working with farmers should include training module to explain soil testing benefits to farmers to raise awareness.

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Chapter 3:

Modelling farmers' perception and knowledge and willingness to pay for soil testing

Abstract

Soil testing in the prospect of taking relevant action for agricultural sustainability is one of the actions being implemented by the United States Agency for International Development (USAID) project in Northern Haiti. Using a structural equations model and choice model, this study investigates factors affecting farmers' perceptions and knowledge of soil testing benefits and fertilizers use in Northern Haiti. The soil testing benefits and knowledge on fertilizers use included the following: insufficient fertilization reduces plant growth, excess use of fertilizer leads to money loss, insufficient fertilization reduces crop yields, Soil tests help the producer to apply the right amount of fertilizer that will generate profits, Too much fertilizer pollute the environment. Knowledge about these items was collected using Likert scale. Data were collected from 452 farmers within 17 localities in Northern Haiti. The findings reveal that farmers currently have no or little knowledge of soil testing benefits and but know better about fertilizer use. Factors such as farm size, participation in project, rice, banana, and cocoa growers, affect farmers' perceptions and knowledge of soil testing benefits. Factors affecting willingness include group membership, type of crops grown, whether farmer' land is on the slope, his farm size and whether he participates in the USAID project. Knowledge on fertilizer use is influenced by rice and banana growers, fertilizer use, participation in soil testing program and AVANSE/USAID. The effects of both latent variables are found to be positive but non-significant. As policy implication; farmers need training module to be better informed on soil testing benefits.

Key Words: Soil testing benefits, Structural equation model, MIMIC model, WTP, Theory of Planned Behavior, Hybrid Choice Model, Northern Haiti

3.1. Introduction

Agricultural production in the developing world needs innovative technologies that will help to boost the production and feed the growing population. However, the adoption process and farmer's involvement in the process of diffusion have not been an easy task for developers. Many factors such as environmental, culture, socio-economics and demographics play a major role in the success of integrating innovation or novel input in agricultural production. Soil testing is considered as a new input that helps farmers to gather information on the nutrient status of their soils and have appropriate recommendations on how to improve the soil quality. Soil testing is extensively used in developed countries to advance agricultural production. Soil testing services to farmers have recently emerged in developing countries as a means to improve soil quality with the prospect of increasing agricultural productivity. In Haiti, few laboratories have been installed to help farmers to test their soils and provide proper fertilizer recommendations, where recommendations are non-existent and application is done at random. More recently the United States Agency for International Development (USAID) intends to install a soil testing laboratory in Northern Haiti. We believe that to achieve a desirable goal of providing soil testing services to Haitian farmers, it is important to consider the knowledge and perception of farmers who are the potential users of these new inputs and how this guides their decision to pay for the services.

As Wossink and Boonsaeng (2003) observed farmers' perception and knowledge are crucial for successful research and development strategies. According to Meijer et al., (2015) perception and knowledge are prerequisites for adopting new technology and/or for taking any relevant action. Therefore, the success of the management and the operation of this laboratory will depend on the understanding of the socioeconomic and cultural background within which they operate. Several studies have reported knowledge and perception issues in technologies adoption and/or agricultural practices in developing countries. Using factor analysis and linear structural models. Dolisca et al., (2007) investigate farmers' perceptions and the impact of the Forêt des Pins Reserve on the economic, social, and environmental status of local people in Haiti. They found that farmers most value tourism and tree planting activities to promote forestry programs. Ndunda and Mungatana (2013) evaluate farmers' perception and knowledge of health risks in urban wastewater irrigation in Nairobi, Kenya. Their results reveal that factors such as age, gender, household size, education level, farming experience, credit access and farm income are key determinants of farmers' perception on health-related risks due to wastewater irrigation. Mojida et al., (2010) also studied farmers' perceptions and knowledge in using wastewater for irrigation in Bangladesh. Oladele et al., (2013) showed how Farmers' perception and Knowledge are needed for adoption of new cultivars of cassava in Nigeria. These studies showed the importance of integrating perception and knowledge in program design or innovation diffusion and provide interesting results which guide our study.

The purpose of this paper is to investigate farmers' knowledge and perceptions of soil testing benefits and fertilizer use and factors affecting their willingness to pay for soil testing. Specifically, this study has three objectives: (1) to describe farmers' knowledge and perceptions about soil testing benefits and fertilizer use; and (2) to determine whether socio-economic and demographic factors affect farmers' knowledge and perceptions of soil testing benefits and fertilizer use, and (3) to investigate how farmers' knowledge and perceptions on soil testing benefits and how fertilizer use affect their decision to pay for soil testing services.

The Hybrid choice models (HCM) which combine the Multiple-indicators multiples causes (MIMIC)-models and the discrete choice models are used to examine the link between farmers' decisions to pay for the soil testing and the psychological and socio-economics factors. Previous studies using HCM include: Palma et al. (2013) studied consumers' preferences towards wine products by incorporating the effect of consumer psychology through measuring sociability, sophistication and price-quality latent variables in a random parameter logit model. Yangui (2013) also used HCM in his study on consumers' preferences towards extra virgin olive oil in Spain. The application of HCM is scarce in the fields of farmers' valuation of services. The contribution of this study to the literature is twofold: firstly it provides evidence on how perception and knowledge could be integrated in decision making about new inputs—here soil testing services--, and secondly the application of HCM that combine classic choice models with SEM where the inclusion of latent variables improve the model fit through capturing farmers' preference heterogeneity.

The findings from this study can help guide public and private initiatives in developing appropriate strategies to enhance soil testing and fertilizer use in Haiti. These strategies may help to increase agricultural productivity in Haiti.

The remainder of the paper is organized as follow: the theoretical framework, the material and methods, the empirical modeling, the results and conclusions.

3. 2. Theoretical framework

In this study we hypothesize farmers' decision to pay for soil testing is guided by psychological and socio-economic factors. The effects of the psychological factors are described by the theory of planned action (TPA) in figure 3.1. This theory was proposed by Ajzen (1991) and stipulates that the intention to perform a given behavior indicates people's readiness to perform the behavior, and it is a direct predictor of actual behavior (Urban et al., 2012). According to the TPA the behavioral intention is influenced by three components named: attitude, subjective norm, and perceived behavioral control (PBC) (figure 3.1).

In this scheme attitude refers to whether the person is in favor of doing something. Subjective norms show how much the person feels social pressure to do it. Perceived behavioral control alludes to whether the individual feels in control of the action in question (Scagnolari, 2010). The common hypothesis in the majority of studies indicates that a more positive attitude and subjective norm and greater perceived behavioral control should strengthen the individual's intention to perform the behavior under consideration (Ajzen, 1991 and Liebe et al., 2011; López-Mosquera, 2014).

This theory has been extensively used in contingent valuation studies to obtain more accurate results as it allows the inclusion of psychological variables (Harris et al., 1989; Avila-Foucat, 2012). Ajzen and Driver (1992) used the TPA to show the importance of attitude towards paying, perceived behavioral control and the ethical and moral factors in the willingness to pay for recreational activities. Urban et al., (2012) used the TPA to demonstrate that attitudes and norms are the strongest predictors of the intention to purchase organic food in Czech Republic. Pouta and Rekola (2001) used the concepts developed in the Theory of Planned Behavior to predict Willingness to Pay for Abatement of Forest Regeneration. Their results showed that the beliefs concerning forest regeneration play a fundamental role in the attitude formation. López-Mosquera et al., (2014) used the Theory of Planned Behavior to determine their influence on the willingness to pay of visitors for park conservation. The results showed that moral norm was the major factor in predicting behavioral intention, followed by attitudes.

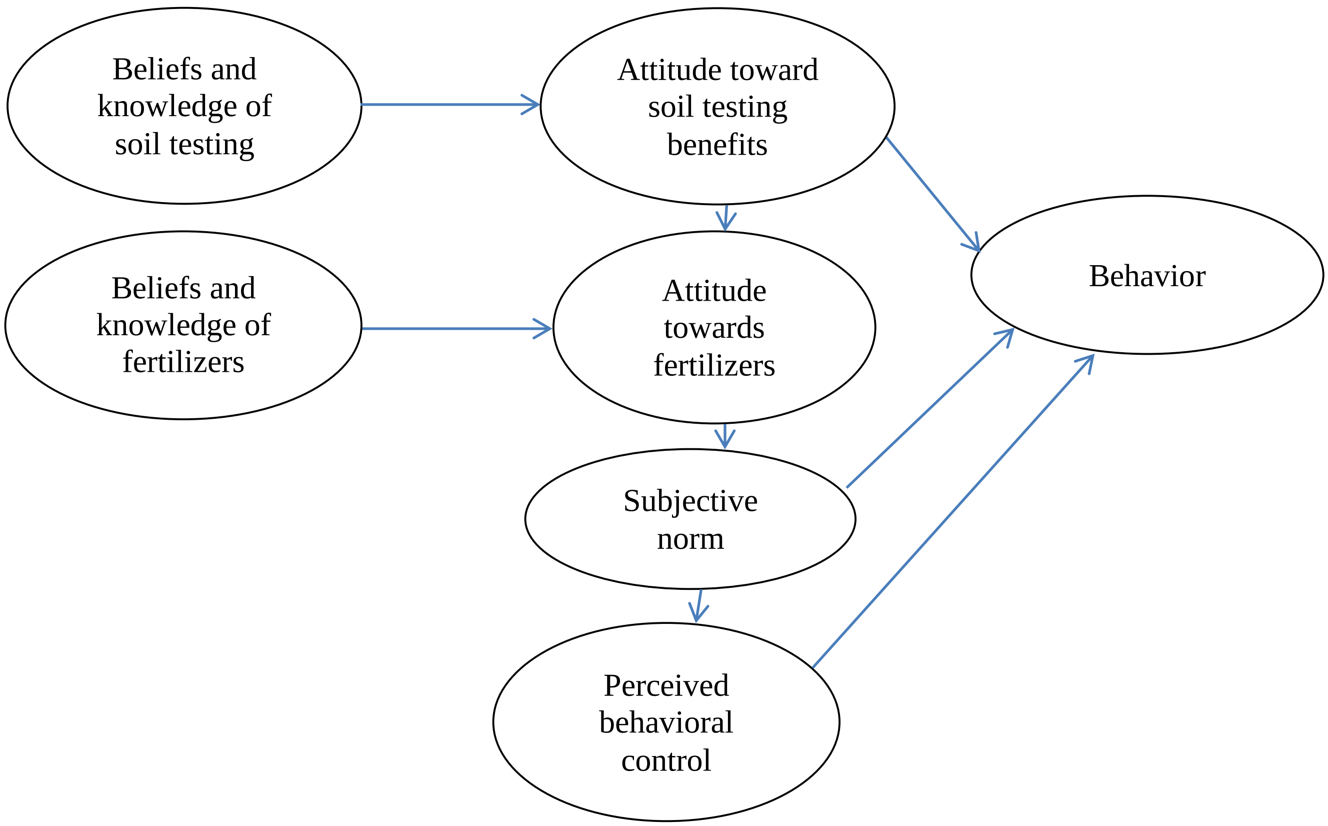

Figure 3.1. Application of the Theory of Planned Behavior (Ajzen, 1991) to soil testing behavior

3.3. Material and method

3.3.1. Study area and data collection

The study was conducted in Northern Haiti and covers 17 Localities across the region (figure 1). Haiti is a Caribbean island located between 19° 00' N latitude and 72° 25' W longitude in the western hemisphere. Data were collected from 452 farmers randomly selected from a list provided by AVANSE/USAID project officer. A structured questionnaire was used to collect farmers' socio-economic and demographics information. Farmers' knowledge and perception were also collected using five point Likert scale. Table 3.1 show the distribution of farmers surveyed during the survey.

Table 3.1. Distribution of respondents by commune, North Haiti farm survey 2016

Department	Commune	Number	Percent
NORTH	Acul du Nord	37	8.2
	Bas Limbe	7	1.6
	Borgne	1	0.2
	Milot	15	3.3
	Plaine du Nord	41	9.1
	Plaisance	7	1.6
	Port Margot	31	6.9
	Quartier Morin	31	6.9
	Camp coq	7	1.6
	Grande riviere	15	3.3
	Limbe	30	6.6
	Limonade	98	21.7
		319	70.6
NORTH-EAST	Ouanaminthe	18	4.0
	Dilaire	2	0.4
	Fort-Liberte	77	17.0
	Ferrier	24	5.3
	Trou du Nord	11	2.4
		133	29.4
	Total	452	100.0

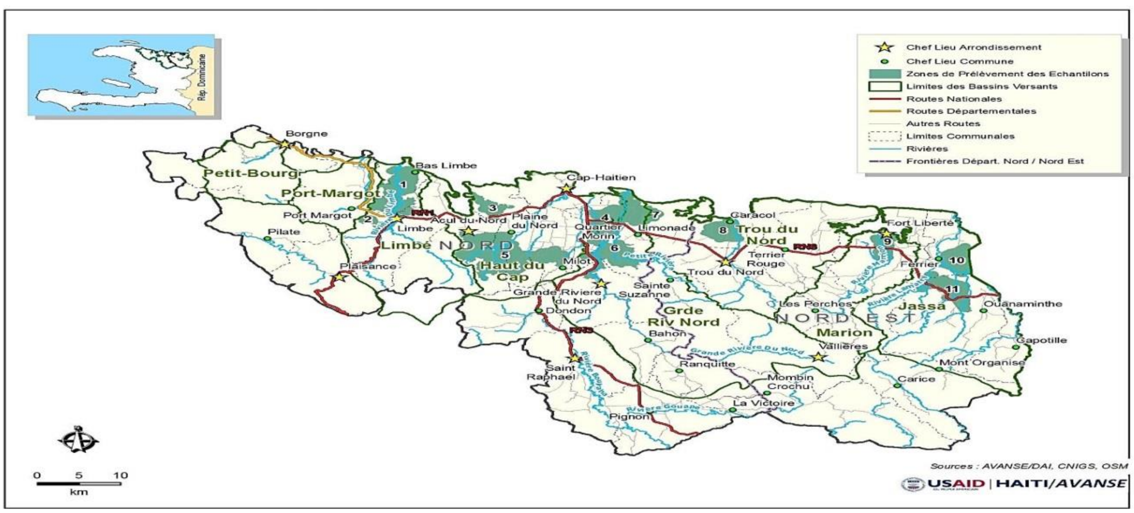

Figure 3.2. Study area

3.3.2. Empirical modeling

In this study we are interested to find out how psychological factors and socio-economics factors affect farmers' decision to pay for soil testing services in Haiti. Such objective could be modeled using the hybrid discrete choice model. This model was proposed by Ben-Akiva and Walker (2002) as an integration of latent variable into choice model as shown in figure 3.3. HCMs incorporate a latent variable model into a discrete choice model in order to improve the explanatory power of the choice model by considering the effects of decision makers' latent attitudes (Kim et al., 2014). In figure 3.3 the ellipses represent unobservable variables, while the rectangles represent observable variables. Given that the latent variables cannot be directly observed, attitudinal indicators were used instead. The latent variable model permits identifying latent constructs as a function of the indicators, and capture the causal relationships between exogenous explanatory variables and the latent variables (Kim et al., 2014).

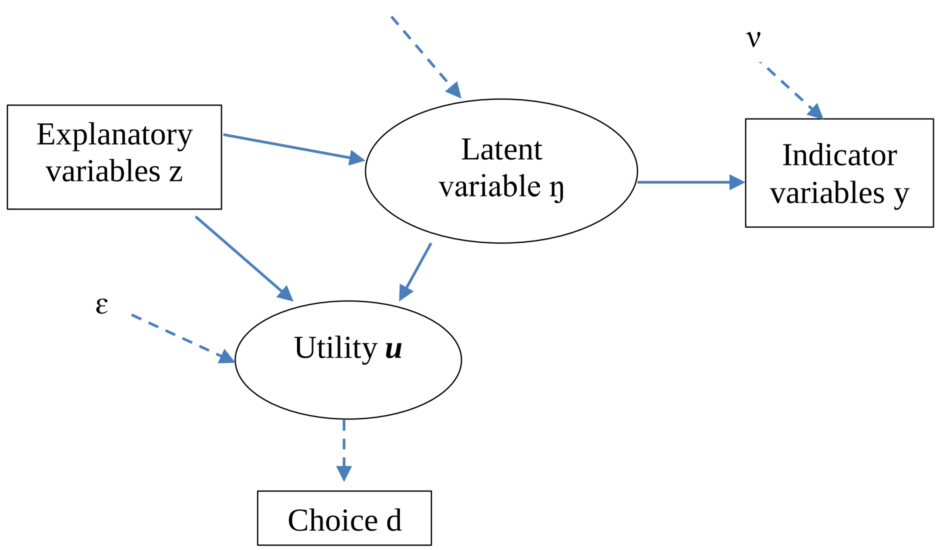

Figure 3.3. Hybrid Discrete Choice Model

We then modeled farmers' knowledge of soil testing using structural equation models (SEMs), particularly Multiple-indicator causes (MIMIC) models. The MIMIC model comprises of two components, a measurement model and a structural model (Skrondal and Rabe-Hesketh, 2005). The structural equations were linear and the measurement equations were ordered probit (Greene & Hensher 2010). The MIMIC model is an ideal model to use when multiple dependent variables need to be associated with a single variable. SEM allows for a multivariate modeling of key consumers' behaviors which cannot be measured directly, like attitudes, social pressure and lifestyles (Lobb et al., 2007). The measurement model relates observed responses on soil testing benefits and fertilizer items to latent variables. Here the statements about soil testing benefits include the following items: Soil tests help the producer to apply the right amount of fertilizer that will generate profit, A soil test provides information on the needs of the soil for fertilizer. Statements related to fertilizers items: insufficient fertilization reduces plant growth, excess use of fertilizer lead to money loss, insufficient fertilization reduces crop yields and too much fertilizer pollute the environment. Five-point Likert scales--- strongly disagree weights as 1, disagree as 2, not sure as 3, agree as 4, and strongly agree as 5--- were used to evaluate the degree of agreement on each statement (table 3.2). The structural model specifies relations between the latent variable and the covariates by using regression analysis. Figure 2 present the structure of our hybrid models. In the hybrid model the explanatory variables affect the response to different items via the latent variable (Skrondal and Rabe-Hesketh, 2005). The generated latent variables from the measurement model are incorporated in the choice model as shown in figure 3.4. For the choice we use logit model which predict the probability of paying for the soil testing.

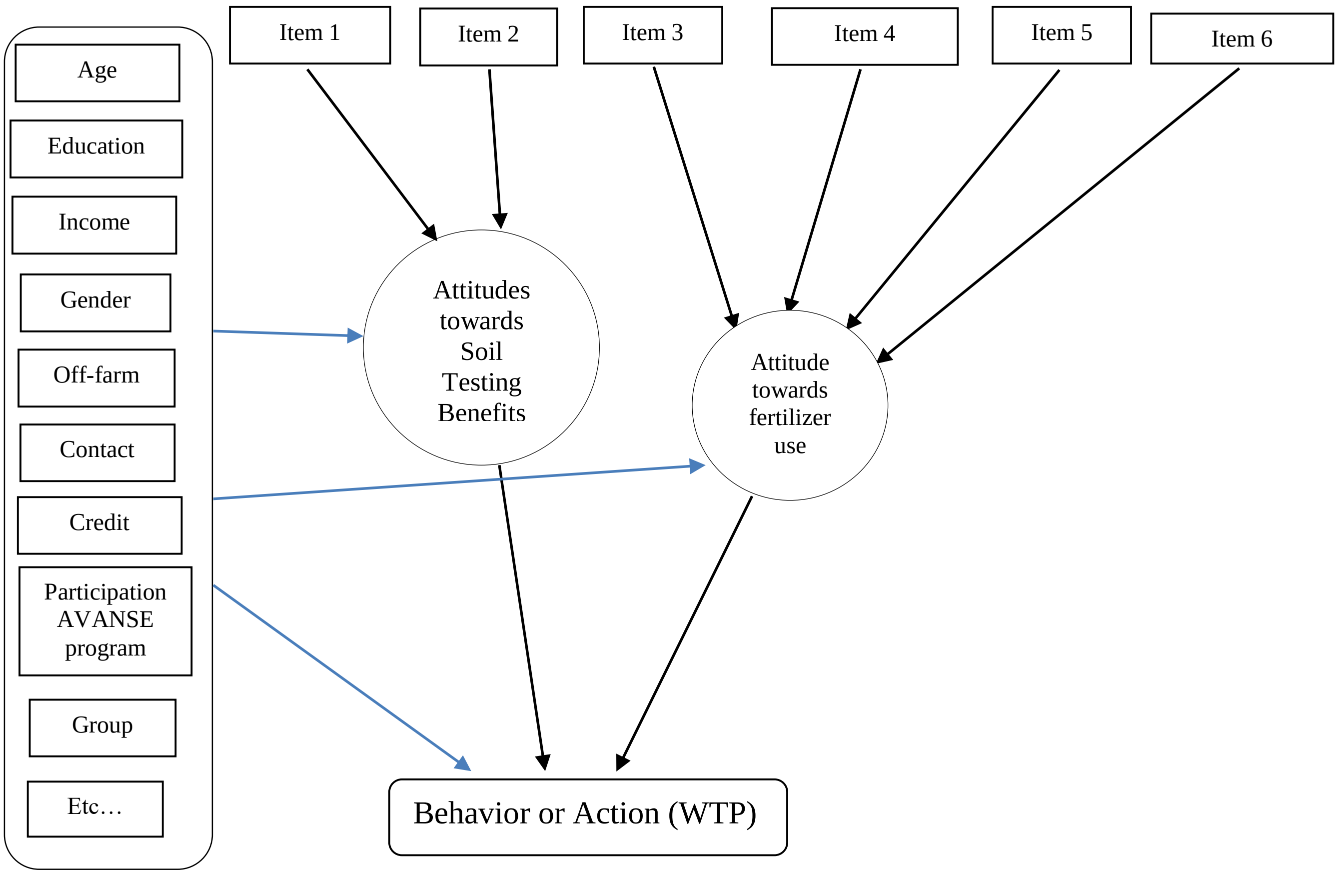

Figure 3.4. Path Diagram of Hybrid choice model

Table 3.2. Likert scale table on Benefits of soil testing services

Items	Likert Scale
1. Soil tests help the producer to apply the right amount of fertilizer that will give profits.	1 – 5
2. A soil test provides information on the needs of the soil for fertilizer	1– 5
3. Too much fertilizer pollutes the environment	1 – 5
4. Using too much fertilizer means wasting money	1 – 5
5. Insufficient fertilizer reduces crop yields	1 – 5
6. Insufficient fertilizers reduce plant growth	1 – 5

Note: Scores 1, 2, 3, 4, and 5 mean strongly disagree, disagree, do not know, agree and strongly agree respectively.

3.3.2.1. Structural model

Let's denote i the individual farmer who was surveyed and stated his/her opinion on the different items in table 3.2 the structural model can be written as follow:

η_i^*=$\gamma' X_i + \varepsilon_i$ [5]

Where η_i^* is a latent –unobserved –variable representing attitude towards soil testing benefits and fertilizer use, X_i is the set of independent variables representing socio-economic factors, γ' is a regression parameter matrix that describe the relation between latent variables and explanatory variables and ε_i is the error which is assumed to be a multivariate normal distribution with mean 0. In our study the latent variables which represent farmers' knowledge on soil testing benefits and fertilizer are regressed on explanatory variables such as age, gender, income, educational level, and contact with extension services using equation [5].

3.3.2.2. Measurement model

The measurement model we fit can be written as follows:

$y_i = \delta\eta_i^* + \mu_i$ [6]

y_i is a vector of several indicators variables, δ is the factor loading parameter and μ_i is the measurement error which is assumed to be a multivariate normal distribution with mean 0 and variance equal to 1.

By substituting Equation [5] into [6], this gives the following reduced form equation:

$y_i = \Gamma X_i + \zeta_i$ [7]

Where $\Gamma = \delta\gamma'$ and $\zeta_i = \delta\varepsilon_i + \mu_i$. ζ_i a linear transformation of the white noise error terms ε_i and μ_i resulting from the structural equation and measurement models. The MIMIC model — equation [7] ---, is the reduced form of equation [5] and [6]. At least two observable indicators and at least one exogenous variable are needed to ensure that the MIMIC is identified, provided that one of the factor loadings of the indicators is set equal to one to form the scale of the latent variable. The MIMIC model is estimated using the maximum likelihood method. Once the MIMIC model is estimated, the two latent variables were constructed for each individual, and then included in the discrete choice model.

Drawing from the above models the choice model of WTP is:

$WTP_i = aZ_i + c_j\eta_i^* + \vartheta_i$ [8]

Where WTP_i farmers' willingness to pay for soil testing taking value 1 if farmer is willing to pay and 0 if not. η_i^* is the latent variable, Z_i is the set of exogenous variables and ϑ_i is the error term.

3.4. Results and discussions

3.4.1. Farmers' socio-economic and demographic characteristics

The table 3.3 show farmers' socio-economics and demographics characteristics. The sample is composed 82% of male and 18% of female. Farmers in the sample are on average 47 years old and have 6 years of schooling. They spent on average 6 years in school. About 76% of the farmers own their land and 37% use fertilizer on their crops. With 14 years of experience in farming, farmers in Northern Haiti have on average 1ha of land to cultivate their crops.

Table 3.3. Farmers' access to agricultural resources

Qualitative Variable	Frequency	Percentage
Income	-	--
Less than 2000 HTG	60	13.27
2001 - 4000 HTG	80	17.70
4001- 6000 HTG	93	20.58
More than 6000 HTG	219	48.45
Fertilizer use	166	36.73
Land ownership	343	75.88
Gender	-	-
Male	370	81.86
Female	82	18.14
Access to credit	81	17.92
Participation in AVANSE soil testing	41	9.07
program Group membership	255	56.42
Slope	32	7.08
Contact with institution/extension	272	60.18
Market access	216	47.79
Quantitative Variables	**Mean**	**Standard deviation**
Farm size	1.03	1.20
Age	47.14	13.49
Experience in agriculture	14.64	12.15
Household size	6.15	2.43

Source: Survey, Auburn University, 2016

3.4.2. Perception and knowledge of soil testing benefits

Farmers' knowledge and perceptions on soil testing benefits in the Northern region was established through creating scenarios and testing for their level of agreement. With the first scenario (Table 3.4), farmers were asked whether they agreed that *soil testing generates information on fertilizer requirements*. Many (49%) of the farmers disagreed with that statement, 32% strongly disagreed, 13% don't know or are unsure, 5% agreed, and 1% strongly agreed. On the statements that *insufficient fertilizer reduces plant growth*, 31% strongly agreed with the statement, 50% agreed, 10% don't know or were unsure, 7% disagreed, and only 2% strongly disagreed with the statement (Table 3.4).

The perception that *insufficient fertilizer reduces crop yields* was found to be true with as many farmers (50%) agreed to the statement while only 2% strongly disagreed. Farmers' views on the statement that *using too much fertilizer means wasting money* were also sought. On this statement 37% strongly disagreed, 41% of farmers disagreed with the statement, 2% strongly agreed, 5% agreed, and 15% don't know or were unsure.

On agreement with the statement that *soil testing helps farmers to apply the right amount of fertilizer* that will generate profits, 30% strongly disagreed with the statement and 2% agreed very strongly. When asked whether *too much fertilizer pollutes the environment*, 26% strongly agreed with the statement. In general, these results demonstrate that farmers have little knowledge of soil testing benefits.

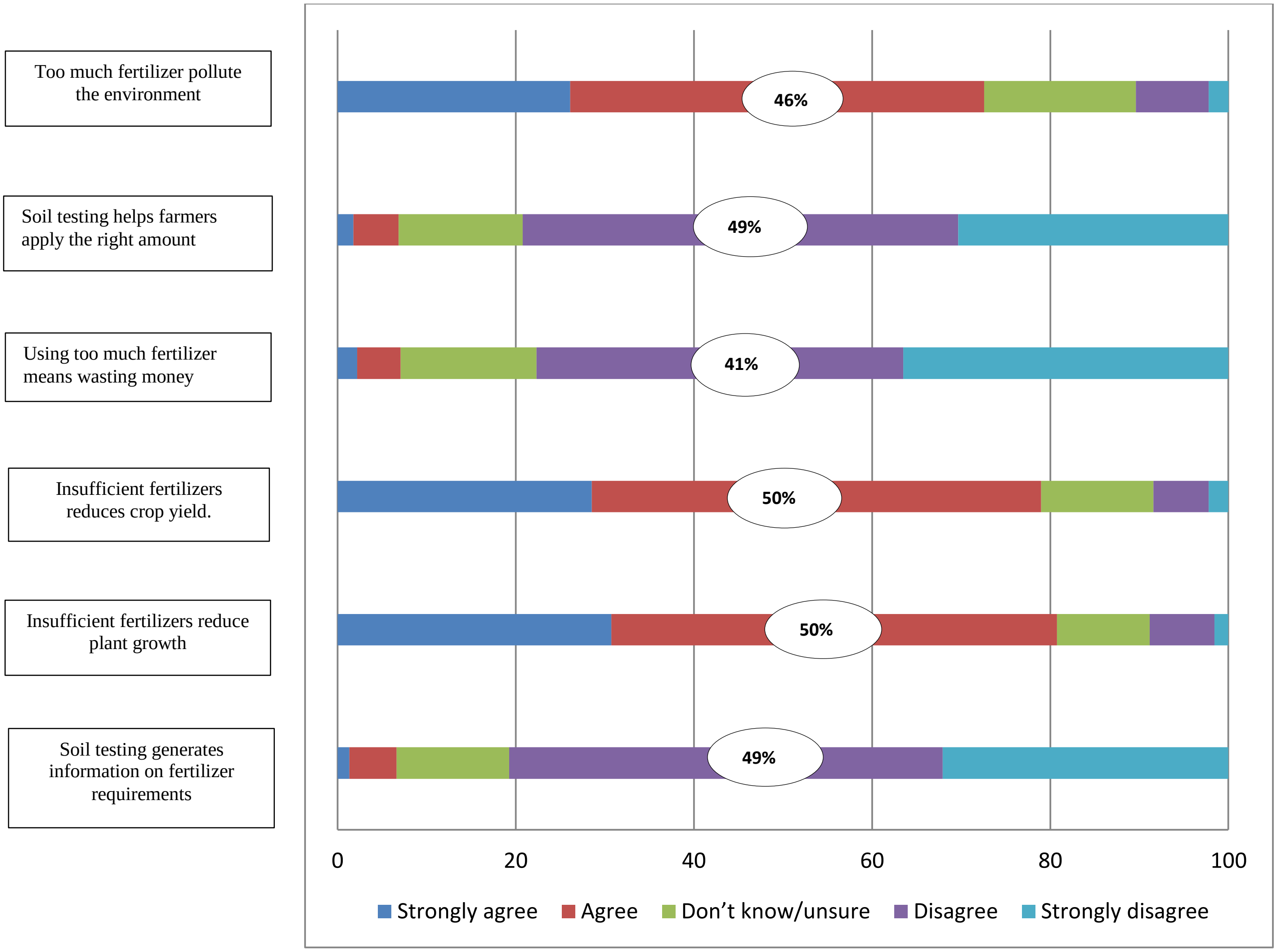

Figure 3.5. Responses to survey items, North Haiti farm survey 2016

Table 3.4. Level of agreement with statements about perceived soil testing benefits, Northern Haiti farm survey 2016

Response	Soil testing benefits					
	Soil testing generates information on fertilizer requirements	Insufficient fertilizer reduces plant growth	Insufficient fertilizer reduces crop yields	Using too much fertilizer means wasting money	Soil testing helps farmers apply the right amount	Too much fertilizer pollutes the environment
	percent					
Strongly agree	1	31	29	2	2	26
Agree	5	50	50	5	5	46
Don't know	13	10	13	15	14	17
Disagree	49	7	6	41	49	8
Strongly disagree	32	2	2	37	30	2
(Number)	(452)	(452)	(452)	(452)	(452)	(452)

3.4.3. Factors affecting perception and knowledge of soil testing benefits and fertilizers use.

Table 3.5 present the results of the two MIMIC models --- Knowledge on soil testing benefits and fertilizers use ---. The estimated path coefficients are 1 and -0.745 for item 1 and 2 respectively. These results suggest that farmers have negative attitude/knowledge towards soil testing benefits. This result is consistent with what we expected. Soil testing in Northern Haiti is quite new and farmers have little or no knowledge on the benefits of soil testing.

The estimated path coefficients are 1, -0.848, 0.683, and 0.715 for item 3, 4, 5 and 6 respectively. These coefficients are significant at 1% level. All these four items except item 4 show a positive attitude/knowledge of fertilizers. This results showed that farmers are pretty well informed and know about fertilizers. However, they are not well enough informed to know that they can apply too much. In addition, fertilizers availability is a problem in Haiti. The fertilizer market is not fully developed. Haitian farmers face high prices, limited availability and accessibility and potentially poor quality products. This prevents them from using fertilizers on their crops.

Looking at the structural model, knowledge on soil testing benefits is significantly affected by educational level, gender, types of crops (Banana, Banana and rice and rice growers), fertilizer use, experience in agriculture, participation in soil testing program, participation in AVANSE/USAID program.

Farmers who go to school have positive knowledge/attitude towards soil testing benefits. This result could be explained by the fact that going to school provides farmers the ability and intellectual capacity to understand the benefits of soil testing even though they are not well exposed to soil testing activities. Male farmers are more knowledgeable of soil testing services benefits than female farmers. The reason for that might be the fact that agriculture in Haiti is dominated by men. They may have accumulated knowledge and information that helps them to understand soil testing benefits. Rice growers have also positive and significant attitude/ knowledge of soil testing services. In Haiti, it is common to fertilize rice fields and since soil testing provide information on nutrients requirement rice growers might developed a positive attitude towards soil testing. However, farmers who grow banana or banana and rice combined behave negatively towards soil testing knowledge. Banana is among the crops that are less fertilized, this might justify these results. Participation in soil testing program by AVANSE/USAID helps farmers to develop a positive attitude towards soil testing benefits. Indeed, the USAID project collected 400 soil samples from participating farmers. Even though there has not been a formal training on soil testing benefits, the collection of soil samples might generate a favourable attitude about soil testing. This could explain the results obtained. Similarly, farmers who participate in the AVANSE/USAID also develop good knowledge of soil testing.

Rice and banana growers, those who already use fertilizer and participants in the soil testing program have greater knowledge about fertilizer than cacao growers. Rice farmers show positive attitude because they are used to fertilizer. However, banana and rice farmers on the contrary have a negative attitude towards fertilizers knowledge. As it was the case for soil testing, farmers participating in AVANSE/USAID project and their soil testing program have more information on fertilizers use. AVANSE has developed a voucher program that provides participating farmers fertilizers at subsidized price.

Table 3.5. Results of MIMIC models

	Soil testing benefits			*Fertilizers knowledge*		
Variables	*Coefficients*	*Standard Errors*	*P>z*	*Coefficients*	*Standards Errors*	*P>z*
Factor loadings						
λ_1[item 1]	1			-	-	-
λ_2[item 2]	-0.745	0.239	0.002***	-	-	-
λ_3[item 3]				1	-	-
λ_4[item 4]				-0.848	0.129	0.000***
λ_5[item 5]				0.683	0.102	0.000***
λ_6[item 6]				0.715	0.092	0.000***
Structural model						
Age	0.006	0.008	0.421	0.009	0.007	0.214
Educational level	0.514	0.254	0.043**	0.334	0.222	0.132
Credit	0.311	0.248	0.211	-0.145	0.231	0.529
Gender	0.436	0.234	0.063*	-0.309	0.214	0.149
Household size	0.019	0.036	0.590	0.016	0.034	0.638
Group membership	0.065	0.178	0.715	0.247	0.169	0.146
Contact	-0.237	0.192	0.217	-0.084	0.180	0.642
Crops grown	-	-	-	-	-	-
Banana	-2.227	0.660	0.001***	1.138	0.351	0.001***
Cocoa	-0.517	0.686	0.452	0.347	0.461	0.451
Cocoa and Banana	-0.701	0.620	0.258	0.260	0.349	0.457
Rice	1.184	0.403	0.003***	0.736	0.343	0.032**
Banana and rice	-2.164	0.7921	0.006***	-1.731	0.704	0.014**
Income	-	-	-			
2001-4000HTG	0.112	0.308	0.715	0.179	0.294	0.542
4001-6000HTG	0.033	0.300	0.911	0.052	0.291	0.856
More than 6000HTG	0.005	0.267	0.984	0.153	0.257	0.550
Fertilizer use	1.418	0.692	0.041***	0.019	0.010	0.056*
Experience	0.015	0.008	0.064*	0.011	0.007	0.144
Farm size	0.047	0.075	0.526	0.033	0.071	0.638
Participation in AVANSE soil testing program	0.775	0.354	0.029**	0.629	0.312	0.044**
Participation in AVANSE	0.541	0.229	0.018**	0.666	0.212	0.002***
Log pseud o-likelihood	-2820.13					
Number of observations	452					

*, **, *** significant at 10% ($p < 0.10$), 5% ($p < 0.05$), and 1% ($p < 0.01$), respectively

3.4.4. Factors affecting WTP for soil testing services.

Farmers’ WTP for soil testing services is affected by group membership, type of crops grown, whether farmer’ land is on the slope, his farm size and whether he participates in the USAID project.

Cocoa farmers are less likely to pay for the soil testing services. Traditionally farmers use less chemical fertilizers for both crops. About 4% of cocoa farmers in our dataset use chemical fertilizers. Farmers who belong to a group are less likely to pay for soil testing. The farm size positively affects the decision to pay for soil testing services. Farmer who has a large farm size looks for innovation that helps to increase agricultural yields which is the case for soil testing services, hence their positive attitude towards the decision to pay for soil testing services.

The attitude on soil testing benefits is positive but non-significant. This suggest that farmers with positive attitude are more likely to pay for soil testing services. Similarly, farmers who show positive attitude towards fertilizer use are more likely to pay for the services.

Table 3.6. Estimation of WTP model

Variables	*Coefficients*	*Standard Errors*	*P>z*
Age	-0.007	0.018	0.704
Educational level	-0.364	0.692	0.599
Credit	0.140	0.641	0.827
Gender	0.398	0.528	0.451
Household size	0.090	0.092	0.330
Group	-0.761	0.468	0.104*
Contact	0.341	0.451	0.449
Crops grown			
Cocoa	-0.044	1.544	0.030**
Rice	1.456	1.008	0.075*
Banana	-0.896	1.116	0.422
Banana and rice	-0.061	1.198	0.959
Per capita income	-	-	-
2001-4000HTG	0.033	0.719	0.963
4001-6000HTG	0.708	0.790	0.370
More than 6000HTG	0.182	0.645	0.778
Slope	-1.285	0.725	0.076*
Experience	-0.008	0.019	0.683
Farm size	0.605	0.296	0.041**
Participation in AVANSE soil testing program	0.645	0.267	0.073*
Participation in AVANSE	0.624	1.099	0.570
Knowledge on soil testing	0.112	0.269	0.677
Knowledge on fertilizer use	0.387	0.249	0.121
Constant	3.876	1.715	0.024
Number of observations	452	Prob >chi2	0.000

*, **, *** significant at 10% (p < 0.10), 5% (p < 0.05), and 1% (p < 0.01), respectively

3.4. Conclusions

The goal of this study is to find out whether psychological factors such as attitude towards soil testing benefits and fertilizers knowledge affect farmers' willingness to pay for soil testing services. The results suggest that various factors guide farmers' attitudes and knowledge of soil testing benefits and fertilizers' knowledge. These factors include: educational level, gender, Rice growers, Slope on the land, experience in agriculture, participation in soil testing program, participation in AVANSE/USAID program. The attitudinal factors are not significant but appear to be positive and have positive impact on soil testing payment.

The results from this study show that farmers need more information on soil testing benefits. This will strengthen their knowledge on the subject matter and improve their desire to pay for the services. Particular attention needs to be made farmers who have an interest to use fertilizers or are used to it. The results suggest that psychological factors worth be included in the choice model in order to improve the model. The TPB finds strong application in this study and bring evidence on how decision making process could be improved through the incorporation of latent variables.

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Appendix 1: Detailed cost and revenue of Rock walls and Rampaye

Table 1: Analysis of Returns to Soil Conservation Using Ramp Pay on Hillside Farms in Maissade, Haiti, for a 50-Year Time Horizon (gourdes per hectare unless otherwise noted)

Indicators	0	1	2	3	4	5	6	7	8	9	10	20	30	40	50
Without conservation															
Yield (kilograms per hectare)															
Corn	1180	1110	1041	971	902	832	762	693	623	553	484	260	0	0	0
Sorghum	1510	1421	1332	1243	1154	1065	975	886	797	708	619	333	0	0	0
Revenues	2566	2415	2264	2112	1961	1809	1658	1506	1355	1204	1052	565	0	0	0
Crop production costs	847	828	808	787	765	742	718	692	665	636	605	477	0	0	0
Returns	1719	1587	1456	1325	1196	1067	940	814	690	567	447	88	0	0	0
Present value returns	1719	1323	1011	767	577	429	315	227	160	110	72	2	0	0	0
With conservation															
Yield (kilograms per hectare)															
Corn	1350	1358	1366	1374	1382	1390	1398	1406	1414	1422	1431	1431	1431	1374	1293
Sorghum	1812	1823	1834	1845	1855	1866	1877	1888	1899	1910	1921	1921	1921	1845	1736
Revenues	3007	3025	3043	3061	3079	3097	3115	3133	3151	3169	3187	3187	3187	3062	2881
Crop production costs	886	888	890	893	895	897	900	902	904	906	909	909	909	893	869
Conservation costs	55	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Returns	2066	2087	2103	2119	2134	2150	2166	2182	2197	2213	2229	2229	2229	2119	1962
Present value returns	2066	1739	1460	1226	1029	864	725	609	511	429	360	58	9	1	0
Returns to conservation															
Net Benefits	347	500	647	793	938	1083	1226	1367	1507	1646	1782	2141	2229	2119	1962
Present value net Benefits	347	417	449	459	453	435	410	382	351	319	288	56	9	1	0
Cumulative present value net benefits	347	763	1213	1672	2124	2559	2970	3351	3702	4021	4309	5617	5858	5896	5902
Net present value at 50 years	5902														

Source: Adapted from Lutz et al., (1994)

Table 2: Analysis of Returns to Soil Conservation Using Rock Walls on Hillside Farms in Maissade, Haiti, for a 50-Year Time Horizon (gourdes per hectare unless otherwise noted)

Indicators	0	1	2	3	4	5	6	7	8	9	10	20	30	40	50
Without conservation															
Yield (kilograms per hectare)															
Corn	1180	1110	1041	971	902	832	762	693	623	553	484	260	0	0	0
Sorghum	1510	1421	1332	1243	1154	1065	975	886	797	708	619	333	0	0	0
Revenues	2566	2415	2264	2112	1961	1809	1658	1506	1355	1204	1052	565	0	0	0
Crop production costs	847	828	808	787	765	742	718	692	665	636	605	477	0	0	0
Returns	1719	1587	1456	1325	1196	1067	940	814	690	567	447	88	0	0	0
Present value returns	1719	1323	1011	767	577	429	315	227	160	110	72	2	0	0	0
With conservation															
Yield (kilograms per hectare)															
Corn	1305	1313	1320	1328	1336	1344	1352	1359	1367	1375	1383	1383	1383	1328	1247
Sorghum	1752	1762	1773	1783	1794	1804	1815	1825	1836	1846	1857	1857	1857	1782	1675
Revenues	2907	2924	2941	2959	2976	2994	3011	3029	3046	3064	3081	3081	3081	2958	2779
Crop production costs	886	888	890	893	895	897	900	902	904	906	909	909	909	893	869
Conservation costs	470	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Returns	1550	1969	1984	1999	2014	2029	2044	2059	2075	2090	2105	2105	2105	1998	1843
Present value returns	1550	1640	1378	1157	971	815	685	575	482	405	340	55	9	1	0
Returns to conservation															
Net Benefits	-169	381	528	673	818	962	1104	1245	1385	1522	1658	2017	2105	1998	1843
Present value net Benefits	-169	318	367	390	394	386	370	347	322	295	268	53	9	1	0
Cumulative present value net benefits	-169	149	516	906	1300	1687	2056	2404	2726	3021	3288	4513	4740	4776	4782
Net present value at 50 years	4782														

Source: Adapted from Lutz et al., (1994)

Appendix 2: Survey questionnaire

USAID, AVANSE, UNIVERSITE ROI CHRISTOPHE AND AUBURN UNIVERSITY

North Haiti Producers Willingness to Pay for Soil Testing Services and improved seeds

SURVEY OBJECTIVES:

I. Measure producer awareness of benefits of soil testing and improved seeds
II. Determine willingness to pay for soil testing, for seed acquisition (plantain and banana plant, rice seed, cocoa plants) and pesticide treatment services.
III. Evaluate producer concerns about crop nutrient management benefits

I. LOCATION

1. ID No. ____________________
2. Date ______________________________________
3. Interviewer name: ______________________________________
4. Region (**DEPART**) ____
5. Commune (**COMM**)____
6. Village / neighborhood (**VILG)**____

II. LAND LOCATION

7. What is the main type of soil on your farm? Is it sand, clay, or what? **(LAND)**

[1.] SANDY ;
[2.] CLAY
[3.] SAND AND CLAY
[4.] OTHER (TO SPECIFY)____

8. Describe the land where you produce each of the following crops. Are the soils good, fair or poor? (circle the answer)

	POOR	FAIR	GOOD
a. Rice **(RSTAS)**	1	2	3

b.	Plantain / Banana **(BSTAS)**	1	2	3
c.	Cocoa **(BSTAS)**	1	2	3

9. Do you apply chemical fertilizer to any of your crops? Which ones?

		NO	YES	TYPE	RATE kg/ha
a.	Cocoa **(CFERT)**	0	1		
b.	Plantain / Banana **(BFERT)**	0	1		
c.	Rice **(RFERT)**	0	1		

10. Do you use organic manure on any of your crops?

		NO	YES➔
a.	Rice **(ROM)**	1	2
b.	Plantain / Banana **(BOM)**	1	2
c.	Cocoa**(CCOM)**	1	2

Please indicate whether you agree, disagree, or are undecided about each of the following statements about soil testing.

11. Have you ever had your soil tested before? (**STINF0**)

[1] YES
[2] NO
[3] DON'T'KNOW

12. A soil test provides information on the needs of the soil for fertilizer. **(STINF1)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

13 Insufficient fertilizers reduce plant growth. **(STINF2)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

14 Insufficient fertilizers reduces crop yield. **(STINF3)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

15. Using too much fertilizer means wasting money. **(STINF4)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

16 Soil tests help the producer to apply the right amount of fertilizer that will give profits. **(STINF5)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

17. Too much fertilizer pollute the environment **(STINF6)**

[1] AGREE
[2] UNDECIDED
[3] DISAGREE

Soil testing gives information on fertilizer needs of plants. Little or no fertilizer reduces plant growth and crop yields remain low. On the other hand, too much fertilizer results in waste of money as the excess fertilizer is leached downstream. Soil analysis helps the farmer to apply the right quantity of fertilizer on his crops that will maximize crop yields.

18. How much are you willing to pay? (**WTPS1**)_________________[1500grdes , 1000 grdes[

19. Would you be willing to pay 1000 Gourdes for a soil test? **(WTPS2)**

[1.] NO➔ SKIP TO Q20
[2.] YES

20. Would you be willing to pay 700 Gourdes for a soil test? **(WTPS3)**

[1.] NO➔ SKIP TO Q21
[2.] YES

21. Would you be willing to pay 400 Gourdes for a soil test? **(WTPS4)**

[1.] NO➔ SKIP TO Q22
[2.] YES

22. Would you be willing to pay 100 Gourdes for a soil test? **(WTPS5)**

[1.] NO
[2.] YES

23. If you are not willing to pay. Explain why? (**STB1**)__________________________

24. Have you ever paid for a soil test? **(STB2)**

[1]NO
[2] YES ➔IF YES; How much? **(STB3)**____________

25. Who do you think should pay for the soil test? **(PST)**

[1.] FARMER

[2.] GOVERNMENT
[3.] NGO
[4.] SOMEONE ELSE (WHO?)________________________________

Please indicate whether you agree, disagree, or are undecided about each of the following statements about the use of pesticides.

26. Pesticide reduces crop losses from pests. **(PESTINF1)**
[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

27. The application of the appropriate pesticide increases yields. **(PESTINF2)**
[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

28. The application of the appropriate pesticide increases profits. **(PESTINF3)**
[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

29. The improper application of pesticide can be harmful to the farmer. **(PESTINF4)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

30. Pesticide can be safely applied by the farmer. **(PESTINF5)**
[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

Pesticide application on your crops reduces pest infestation, crop damage and improves yields. The application of pesticides increases cost but also generate an increase in revenue. The pesticides can be applied to the crop by the farmer himself or he could pay a company or someone to apply the pesticide at an agreed cost.

31. How much are you willing to pay? (**WTPEST1**)________________ [1500gourdes , 1000 gourdes]

32. Would you be willing to pay 1000 Gourdes per hectare for a pesticide application? **(WTPEST2)**
[1.] NO➔ SKIP TO Q34
[2.] YES

33. Would you be willing to pay 500 Gourdes per hectare for a pesticide application? **(WTPEST3)**

[1.] NO➔ SKIP TO Q35
[2.] YES

34. Would you be willing to pay 100 Gourdes per hectare for a pesticide application? **(WTPEST4)**

[1.] NO
[2.] YES

35. If you are not willing to pay. Explain why? **(WTPEST5)--**

36. Have you applied pesticide before? **(PESTB1)**

[1.] NO
[2.] YES➔

37. IF YES, Did you pay someone to apply pesticide? How much? **(PESTB1)**

[1.] NO, never used
[2.] YES ➔ __________Gourdes for ______________ Hectares **(PESTB2)**

Please indicate whether you agree, disagree, or are undecided about each of the following statements.

38. A hybrid banana could increase production on my farm. **(HB1)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

39. A hybrid banana could be sigatoka resistant for a while my farm. **(HB2)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

40. Hybrid banana plant is more expensive. **(HB3)**

[1.] AGREE
[2.] UNDECIDED
[3.] DISAGREE

41. I do not have a source of hybrid banana plants. **(HB4)**

[1]AGREE
[2]UNDECIDED
[3]DISAGREE

42. A. hybrid banana is more drought resistant **(HB5)**

[1]AGREE
[2]UNDECIDED
[3]DISAGREE

Hybrid banana plants gives higher yields and are pest resistant. The hybrid banana plants are resistant to sigatoka diseases. Sigatoka diseases kill banana plants and result in lower yields.

43. How much are you willing to pay? (**WTPHB0**)__________________[25 gourdes, 20 gourdres]

44. Would you be willing to pay 20 Gourdes for a hybrid banana plant? **(WTPPHB1)**

[1.] NO➔ SKIP TO Q45
[2.] YES

45. Would you be willing to pay 15Gourdes for a hybrid banana plant? **(WTPHB3)**

[1.] NO➔SKIP TO Q47
[2.] YES

46. Would you be willing to pay 10 Gourdes for hybrid banana plant? **(WTPHB4)**

[1.] NO➔SKIP TO Q48
[2.] YES

47. Would you be willing to pay 5 Gourdes for a hybrid banana plant? **(WTPHB5)**

[1.] NO
[2.] YES

48. If you are not willing to pay. Explain why? **(WTPHB6)**---

49. Have you ever planted a hybrid banana plant on your field before? **(HBP1)**

[1.] NO
[2.] YES

50. IF YES, Did you rent the land how much? **(HBP2)**

[1.] NO, OWN OR USE WITHOUT PAYMENT
[2.] YES ➔___________Gourdes for _______________ Hectares **(HBP3)**

Please indicate whether you agree, disagree, or are undecided about each of the following statements about hybrid rice seedlings.

51. Hybrid rice increases production on your farm. **(HBR1)**

[1] AGREE
[2] UNDECIDED
[3] DISAGREE

52. Hybrid rice requires more inputs. **(HBR2)**

[1] AGREE
[2] UNDECIDED
[3] DISAGREE

53. Hybrid rice requires more water. **(HBR3)**

[1] AGREE

[2] UNDECIDED
[3] DISAGREE

54. Hybrid rice is more disease resistant. **(HBR4)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

55. Hybrid rice requires less pesticide. **(HBR5)**
[1] AGREE
[2]UNDECIDED
[3] DISAGREE

56. Hybrid rice requires more labor **(HBR6)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

57. How much are you willing to pay for a kg of hybrid rice?(**WTPHBR0**)**_____**[75 gourdes, 50 gourdes]

58. Would you be willing to pay 50 Gourdes per kg of hybrid seeds? **(WTPHBR1)**
[1] NO➔ SKIP TO Q59
[2] YES

59. Would you be willing to pay 40 Gourdes per kg of hybrid seeds? **(WTPHBR2)**
[1] NO➔ SKIP TO Q61
[2] YES

60. Would you be willing to pay 30 Gourdes per kg of rice? **(WTPHBR3)**
[1] NO➔ SKIP TO Q62
[2] YES

61. Would you be willing to pay 20 Gourdes per kg of hybrid rice? (**WTPHBR4)**
[1] NO
[2] YES

62. If you are not willing to pay. Explain why? **(WTPHBR6)**--

63. Have you ever planted hybrid rice on your farm before? **(WAHBR1)**
[1] NO
[2] YES ➔IF YES,

64. Have you ever paid for a soil test for the soil test? How much? **(WHBR2)**
[1]NO
[2] YES ➔IF YES; How much? **____________ (WAHBR3)**

65. Who do you think should pay for the hybrid seeds? **(WAHBR)**

[1] FARMER
[2] GOVERNMENT
[3] NGO
[4] Other__________________

Please indicate whether you agree, disagree, or are undecided about each of the following statements about hybrid cocoa seedlings.

66. Hybrid cocoa increases production on your farm. **(HBC1)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

67. Hybrid cocoa requires more inputs. **(HBC2)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

68. Hybrid cocoa requires more water. **(HBC3)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

69. Hybrid cocoa is more disease resistant. **(HBC4)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

70. Hybrid cocoa requires less pesticides. **(HBC5)**
[1] AGREE
[2]UNDECIDED
[3] DISAGREE

71. Hybrid cocoa requires more labor **(HBC6)**
[1] AGREE
[2] UNDECIDED
[3] DISAGREE

72. No: How much are you willing to pay for hybrid a cocoa seedling? (**WTPHBC0**)__________[
60 gourdes, 40 gourdes]

73. Would you be willing to pay 40 Gourdes for a cocoa seedling? **(WTPHBC1)**
[1] NO➔ SKIP TO Q66
[2] YES

74. Would you be willing to pay 30 Gourdes for a cocoa hybrid seedling? **(WTPHBC3)**

[1] NO➔ SKIP TO Q67
[2] YES

75. Would you be willing to pay 20 Gourdes for hybrid cocoa seedling? **(WTPHBC4)**
[1] NO➔ SKIP TO Q68
[2] YES

76. Would you be willing to pay 10 Gourdes for a hybrid cocoa seedling? (**WTPHBC5)**
[1] NO
[2] YES

77. If you are not willing to pay. Explain why? **(WTPHBC6)**--

78. Have you ever planted hybrid cocoa seedling on your farm before? **(WAHBC1)**
[1] NO
[2] YES ➔IF YES,

79. Have you ever paid for a soil test for the soil test? How much? **(WHBC2)**
[1]NO
[2] YES ➔IF YES; How much? **____________ (WAHBR3)**

80. Who do you think should pay for the hybrid seeds? **(WAHBR**1 FARMER
[2]GOVERNMENT
[3] NGO
[4] Other**_________________**

III. CREDIT INFORMATION

81. Have you ever received credit before? **(CREDBF)**
[1.] NO
[2.] YES

82. If NO do you know where to receive credit? **(WCRED)**
[1.] NO
[2.] YES

83. Have you participated in the voucher program managed by AVANSE? **(VPROG)**
[1] NO
[2] YES

84. Are you ready to receive a credit? **(RCREDI)**
[1.] NO

[2.] YES
[3.] NOT SURE

IV. DEMOGRAPHIC AND ECONOMIC INFORMATION

85. Gender (GEND)

[1.] [MALE
[2.] [FEMALE

86. Age in years (AGE) (number) ______________________

Who was president of Haiti when you were born___________________________?

87. Matrimonial position (MSTATU)

[1.] MARRIED ;
[2.] SINGLE ;
[3.] WIDOWER ;
[4.] DIVORCEE
[5.] Living together
[6.] Other explain_______________________________________

88. Household size (number of persons) _____________________

89. How many children have you? (NCHILD) (Number of persons)

____

90. Number of children 9 years and under in household (CHILD9) (number of persons)

____

91. Number of children attending primary school (CHILSCHP) (number of persons)

____

92. Number of children attending secondary school (CHILSCHS) (number of persons)

____

93. Schooling of respondents: (INSTRU) Have you received a formal education?

[1.] NO ;
[2.] YES

94. IF YES, What level?

[1.] NIVEAU PRIMARY LEVEL ; Number of years_________
[2.] SECONDARY LEVEL ; Number of years _________
[3.] SUPERIOR LEVEL; Number of years _________

95. Have you received an education in Creole?

[1.] NO
[2.] YES

96. IF YES, what can you do?

[1.] TO READ ;
[2.] TO WRITE ;
[3.] TO READ AND TO WRITE

97. 108. Quelle est votre principale activité? **(PRINACT)**

[1]=Agriculture; [2]= Animal breeding; [3]= Commerce; [4]= Artisan [5]=Employee; [6]= Fishing ; [7]= Public sector job; [8]= Private business, not farming; [9]= Other (specify)__________________

98. How many persons contribute to your household's income (number) _______________?

99. About what is your monthly income received from all sources? (Gourdes/month) **(INCOM)**

[1] LESS THAN 2000 GOURDES

[2] 2001 TO 4000 GOURDES

[3] 4001 TO 6000 GOURDES

[4] MORE THAN 6000 GOURDES

V. Do you have cash income from peanuts? ***Ask each crop.***

	Do you have income from peanuts?	**Do you sell it by the kilo or what?**	**About how many units did you sell last year**	**What was the main price you received?**	***TO BE CALCULATED***
Product	**Quantity Produced (Kg)**	**Unit**	**Quantity Sold (Kg)**	**Main Price Received (Gourdes)**	***Total Sales In Gourdes***
a. Peanut					
b. Cocoa					
c. Maize					
d. Bananas					
e. Rice					

f. Beans					
g. Other					

100– State the main constraints encountered in your activities?

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101 – What are the solutions you propose to remedy to these constraints?

Appendix 3: NGO's Willingness to support soil testing activities

IRATAM (Institut de Recherchche et d'Appui Technique en Amenagement du Milieu)

Following the survey activities, we visited the IRATAM ONG located in Cap Haitian. The NGOs is directed by Mr. Emile Eyma and work with farmers in the North-East, Trou du Nord, and Saint Suzanne. They provide support and extension services to 5,000 farmers focusing on coffee, legumes, agroforestry, and urban agriculture. The NGO tested the soil in Quebec, Canada on several occasions with the assistance of University of Quebec.

Given the distance and the difficulties encountered before testing farmers' soil, the director thought it was an excellent idea to put in place a soil testing laboratory in the North. It will surely benefit farmers and avoid all the difficulties the NGOs face to get the soil tested. He said he is willing to include a training module in his extension program to inform farmers of the need to test their soils. He thinks other NGOs should also train farmers on the same topics. This will raise awareness on the necessity to have the soil tested.

Village Planete- Cap Haitian

The NGO, Village Planete, works with about 200 farmers. Farmers get assistance for the restoration of mangroves, the production of legumes and other crops. The director of the NGOs, Mr Guy Mathieu, an agricultural engineer also found the idea of soil laboratory very interesting and suggested the establishment of a mechanism to raise farmers' awareness given that farmers are not used this new input. "*It is a new experience for farmers and we need to help them to understand the need to test their soils,*" said Mr Guy Mathieu.

NGO Lakay

We met Mr Doddy Pierre, who is in charge of the NGOs at Ouanaminthe. The NGO provides technical assistance to 10,000 farmers. Pest control and fertilizer supply are the main activities of the NGO. Mr Doddy recognized that most of the farmers do not have knowledge about their soils. So there is a need to introduce a soil testing module in their training. The laboratory would provide a great opportunity for farmers and avoid the travel to the South to test their soil.

Solidarite Frontalieres

This NGO, located at Ouanaminthe, provides technical assistance to farmers in all the main crops. They provide seeds, compost, and insecticides to farmers. They had done some soil testing before in Dominican Republic. The agronomist in charge of the agricultural sector has welcomed the establishment of the soil laboratory and suggests that other NGOs emphasize the importance of farmers' training in soil testing as an input that will increase profits. "*Soil testing can help farmers to choose which crops to grow,*" said Mr Alcime Michel Edouard. However, he raised some concerns about the price to charge for soil testing.

He suggested two prices: one for the farmer and one for institutions working or supporting farmers. He also suggested providing subsidies to support soil testing for farmers. In order to popularize the soil testing services, he suggested doing some radio spots on the activities. It will also help to reach a large number of farmers.

"Soil sampling is a significant issue," he said, "as farmers are not trained to do it." As a solution he advised that an agronomist be trained in soil sampling. Students on Limonade campus might also be involved in soil sampling whenever farmers make request for soil testing.

Appendix 4: INFORMED CONSENT LETTER

INFORMED CONSENT LETTER for a Research Study "Willingness to Pay for Soil Test"

You are invited to participate in a research study to assess farmers' willingness to pay for soil test to increasing yield in five key farm enterprises. The study is being conducted by Professors Joseph Molnar, Curtis Jolly, Dennis Shannon and Gobena Huluka in the Auburn University College of Agriculture in collaboration with AVANSE technical experts with Development Alternatives Inc.

You were selected as a possible respondent because you are a farmer participating in AVANSE project and are age 19 or older. If you decide to participate in this research study, you will be asked to discuss your farming experiences, and soil testing services. We ask you to participate in an interview.

Your participation will be either in the form of conversation discussing your crop and soil testing issues. Your total time commitment will be approximately one hour or less. The risks or discomforts associated with participating in this study are minimal.

If you participate in this study, you can expect to receive a summary of the results and a copy of the full report if you so request.

To thank you for your time you will be offered the opportunity to receive additional technical information about new possibilities and approaches rendered from this research as they develop. There are no costs for participation.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable.

Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University or the College of Agriculture and AVANSE.

Any data obtained in connection with this study will remain confidential. We will protect your privacy and the data you provide by not associating your name or specific location with any quotations, comments, or assertions. For interviews where others may be present, we ask that each individual keep their identities as well as the discussion confidential.

Information collected through your participation may be published in a professional journal, and/or presented at producer and professional meetings.

If you have questions about this study, please ask them now or contact Joseph J. Molnar at 334.844.5518, 5615, or 334.663.2375 (cell).

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

Thank you. Joseph J. Molnar, Professor ___________________________________

I agree to participate in this research

Printed Name Signature Date