# The Sustainable Choice: How Gendered Difference in the Importance of Ecological Benefits Affect Production Decisions of Smallholder Cacao Producing Households in Ecuador

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**Abstract**

Our research examines how the changing cultural norms and legal status in Ecuador have impacted women's empowerment in the agricultural sector and in rural communities. Cacao provides a particularly relevant case because of its economic and ecological importance to Ecuador and the region. The traditional cacao agroforests also provide many ecological services such as habitat for many endangered plants and animals. However, they are not as profitability as the monoculture systems. Because of these economic and ecological concerns, promotion of cacao agroforests has been the focus of development efforts by the Ecuadorian government, nongovernmental organizations, and international donor agencies, many of whom also have goals of empowering Ecuadorian women (Suarez 2013). Thus, women's involvement in cacao production would be an important indicator of women's status in rural Ecuador.

To determine the value that men on women place on these nonmarket benefits and ability of women to influence household production decisions, we conducted 350 household interviews throughout coastal Ecuador from February through July, 2013. We implemented a choice experiment separately with the principle male and female member of the household. The choice experiment consisted of the household member choosing between pictures of two parcels to determine how much more profit the participant would need to receive in order to prefer the monoculture system over the agroforestry system. By employing a Random Effects Logit regression, we were able calculate men and women's average willingness to pay for the attributes of the cacao agroforests (Birol et al. 2006). We found that both genders place a higher value on the agroforests than monoculture corps; however, women place a higher value on these benefits than men do.

## Introduction

Establishing mechanisms to correct for the suboptimal provision of environmental services (ES) is a particular challenge that policy makers face nowadays. Conservation and development entities have touted the creation of markets for these goods as a solution for their provision (Pattanayak et al. 2010). The so called Payments for Environmental Service Schemes seek to stimulate and facilitate the transfer of money from individuals (or governments) who value the use or existence of these services to individuals producing them, as a way to ameliorate the type of market failure that undermines their supply (Pagolia et al. 2005).

Studies that have examined this provision problem and the payment for environmental services schemes have almost exclusively examined external positive effects, while ignoring the personal nonmarket benefits (and costs) that the individual agent and her household receives from undertaking a sustainable productive activity (Engel et. al 2008). Consideration of these internal nonmarket values is necessary to fully understand what influences an economic agent's decision to undertake sustainable productive activities. These nonmarket benefits (costs) could induce individuals to produce more (less) of a good than would be suggested from the cash income they receive in the market (Useche and Blare 2013). This chapter utilizes the case of the environmental and subsistence benefits obtained by Ecuadoran farmers from their cacao agroforests to develop a framework to estimate the value of these personal benefits.

Contingent valuation methods (CVMs) must be used to determine the monetary value of these benefits, as they are not traded in markets and often embody other types of values (e.g. non-use, cultural) that cannot be inferred from observation of market

transactions. Environmental economics studies using CVMs have estimated the value of external positive externalities such as carbon sequestration, the presence of endangered species and the benefits of biodiversity in a variety of native ecosystems, including rain forests, grasslands, and marshes (Farber et al. 2002; Togridou et al. 2006; Campbell 2007; Nijkamp et al. 2008; Kotchen and Reiling 2000, Bandara and Tisdell, 2003; Cardoso de Mendonca et al. 2003; Baral et al. 2007; Turpie 2003). However, research has generally overlooked the environmental services provided by managed landscapes, such as cacao agroforests.

Common CVMs utilized in environmental economics studies include the travel cost method, willingness to pay (WTP) studies, hedonic pricing, averting behavior models and the estimation of biodiversity production functions (Nunes and van den Bergh 2001; Baral et al. 2008). The WTP studies are part of a large class of stated and revealed preference methods, including choice experiments (CEs), which have been tested during last twenty years (Schläpfer 2008). A CE is stated preference method where the respondent chooses her preferred option between at least two alternatives with each preference with the experiment being repeated with new options. This method is advantageous to other CVMs because it allows for the researcher to determine the value of each nonmarket benefit bundled in the larger good.

In this study of the nonmarket benefits of Ecuadorian cacao agroforests, we propose the use of a choice experiment (CE) framework to elicit the value of non-market benefits and costs associated with productive activities. In forestry research, CEs have been utilized to determine the value Australians and Fins place on their tropical forests and boreal forests (Rolfe et al. 2000; Lehtonen et al. 2003), the value Finnish and

British forest users place on recreational uses and biodiversity in forest preserves (Horne et al. 2005; Christie et al. 2007), and how much Finnish land owners would need to be paid to undertake forest conservation efforts (Horne 2006). CEs have yet to be applied to understand land uses and preferences for forest conservation in developing countries.

The results from this study help to better understand the land use preferences for smallholder households in the Ecuadorean region. This CE reveals that the respondents on average were willing to earn less on cacao agroforests, relative to monoculture systems, if the agroforest included subsistence crops. However, they had a modest aversion to agroforest parcels with high levels of "biodiversity". We also demonstrate that men and women have different preferences for sustainable production methods. On average, women value cacao agroforests significantly more than men do. Women would be willing to earn less on the cacao agroforest and still prefer this production method to the monoculture system.

This paper is divided into six sections. The first provides an overview of the nonmarket benefits present in cacao agroforests. The second section explains how the experiment was conducted. The third section establishes the conceptual framework using random utility theory to explain respondent's utility maximizing decisions. The fourth describes the empirical model, a random effects logit (RELM), utilized to estimate the probability of the respondent choosing the agroforest given the nonmarket benefits and the gender of the individual. The next section provides an overview of the calculations of the WTP estimates and the results of these estimations. The final section concludes.

## Nonmarket Benefits from Agroforestry Cacao Production

When compared to monoculture cacao production systems, traditional agroforestry systems provide ecological services to households that produce the crop as well as to greater society. Agroforestry cacao systems contain a diversity of native plants and animals (Reitsma, Parrish, and McLarney 2001). Both the above ground and below ground biological diversity of cacao agroforests have been found to be greater than that of commercial cropping systems and similar to that of long term fallowed fields. However, they are less diversified than native forests (Duguma 2001). Thus, agroforestry cacao production provides a second best solution where forest conservation is impractical due to the need of smallholder households to dedicate a portion of their land to food cultivation.

These agroforesty systems control pollution, enhance soil quality, and sequester carbon. The use of cacao agroforestry systems can ameliorate soil erosion which is critical in the sustainability of crop production (Beer et al. 1998). The dense planting of trees and plants in cacao agroforestry systems provide a large level of litter and organic matter to be recycled back into the soil to maintain its fertility and long term sustainability. These agroforestry systems also proved to have larger amounts of organic matter and higher levels of calcium and magnesium in the soil than secondary forests (Duguma 2001). Furthermore, soil decomposition rates and the abundance of soil arthropods were found to be greater in shaded cacao agroforestry systems as compared to systems that provide less shade (Steffan-Dewenter et al. 2007). Cacao agroforestry systems can be a useful tool in the sequestration carbon. These agroforestry systems are able to store carbon at a similar rate to that of native forests (Gama-Rodrigues 2009).

Agroforest production can provide a type of satisfaction that is not captured by standard market prices. Useche and Blare (2013) found that shadow wages, which includes the value of the additional crops planted in the cacao agroforestry system, is higher for agroforestry produced cacao than it is for cacao produced in monoculture systems. Steffen-Dewenter et al. (2007) also found that Indonesian cacao farmers would be willing to accept a price lower than full compensation for growing cacao in a traditional agroforestry system instead of the modern more productive system.

These diverse cropping systems do have economic advantages in providing additional sources of income and controlling market risks. Cameroon farmers were found to be able to supplement their income from the non-timber forest products in cacao agroforests (Sonwa et. al 2007). Furthermore, cacao agroforests in Costa Rica were shown to have less risky economically than monoculture cacao and plantain plantations (Ramirez et. al 2001). Diversified cropping systems act as a type of insurance against price drops as a farmer can sell another crop from the agroforest (Beer et al. 1998). As the expected profits from cacao increase, the individual would likely become more risk averse so that they would prefer this attribute (Binswanger 1981).

**Farmers' Perceptions of Relative Benefits (costs)to Agroforestry**

Farmers' perceptions of the nonmarket benefits of these farming systems seem to validate research results on the ecological and social benefits provided by cacao agroforests. From 2009 household interviews and 2012 focus groups I conducted with smallholder households near Santo Domingo de los Colorados, we found that farmers demonstrated that the salient non market benefits that influenced their adoption of

agroforesty production or monoculture production are the abundance of native plants and animals, soil quality, and inclusion of additional food crops. They are concerned about preserving habitat for native plant and animal species so that future generations would be able to enjoy the beauty of these species. They stated they would be willing to earn less to ensure their children and grandchildren would be able to see these plants and animals that they claim were becoming scarcer. In addition, they stated that the soil in the cacao agroforests was of much better quality than the one in their other parcels of land that were not planted with cacao agroforests. The farmers described how leaf litter had enriched the soil so that the land in the agroforests was more productive.

In this study the farmers stated --and research has shown-- that access to plants in the cacao agroforest for subsistence, medicinal, and spiritual uses may actually be more important to these smallholder households than the cash they can earn from cacao production. The farmers also described how the crops and trees in the agroforests provided their families with an additional food and income source. They see these additional crops as a diversification method if the price or the yield of one crop declines they can depend on another crop or sell a tree for timber. This planned diversity of crops and tree species would have the positive externality of providing habitat for other plant and animal species with symbiotic relationships with these species.

## Design of the Choice Experiment

In total 350 farmers participated in the choice experiment in the four study areas of Taura, Naranjal, Vinces, Buena Fe and Quininde, 96 (27%) were men and 254 (73%)

were women.[1] Individual members of the smallholder farming households were surveyed in the CE to demonstrate each person's valuation of nonmarket characteristics from production systems (subsistence crops, biodiversity, and organic matter). Both male and female household members when possible were interviewed.

To conduct the choice experiment, the respondents were shown six series of choices where they chose between two different pictures of one hectare cacao parcels. One of the parcels had characteristics similar to that of a cacao agroforest and the other had characteristics similar to that of a cacao monoculture production system (Figure 1). The picture representing the cacao monoculture hectare was the same for each choice scenario (Figure 2). The attributes included in the agroforestry parcel are the ones found to be significant by focus groups meetings, organic material, subsistence crops, and biodiversity (Table 1).[2] The annual profit estimates were also estimated from the focus group interviews in Santo Domingo based on production costs and from market prices for cacao. The profit levels for the agroforests were presented as either 500 USD, 750 USD, or 1250 USD while the monoculture parcel had a profit 1500 USD. Thus, depending on the parcels presented to the farmer, the amount of profit loss the

[1] The unequal participation of men and women in the experiment is factor of the fact that when the enumerators visited farm households women were more likely to be present than men. Similarly, women more fully participated in farmers' association meetings.

[2] The profiles included at least one and up to all three of the characteristics. For the organic material benefit, a picture was shown of leaf litter stating that the agroforest provided double the amount of organic material. The associated crops benefit showed a picture of a plantain tree, an orange tree, and an *Inga sp.* tree, which is referred to as guaba in Ecuador. The plots with this attribute were presented as containing 200 plantain trees, 50 orange trees, and 25 *Inga sp.* trees. The biodiversity characteristic included ten *Guaiacum sp.* trees, known locally as guayacan, and the quantity and diversity of animals similar to that found in the forest including pacas, agoutis, parrots, hummingbirds and butterflies.

respondent would be willing to incur and still prefer the agroforestry system ranged from 250 USD to 1000 USD.

With a total of four attributes included in the experiment, three having only two levels and the fourth four levels, a total of twenty profiles were available to include in the experiment.[3] After conducting pretesting for the CE, ten agroforestry profiles were chosen to be randomly rotated in the sequence. The ten profiles were chosen because several of the profiles provided too little or too great of a profit difference given the nonmarket benefits present that all the participants made the same selection. Since the number of choice sets and the rounds should be limited in order to retain the concentration and interest of the respond (Swait and Adamowicz 1997), only six rounds of the experiment were conducted with each participant. With additional rounds, the farmers became tired of the experiment and did not careful consider the choice.

A major concern with using CVMs is that they rely upon hypothetical propositions so that preferences are not tied to actions. Thus, respondents may provide biased answers (Diamond and Hausman 1994). The primary sources of bias relevant to this CE include: strategic bias, hiding true preferences to sway the results to the respondent's benefit (Throsby 1986); starting point bias, whereby the first value present influences the respondent's conceptualization of the valuation of the good (Boyle et al. 1985; Herriges and Shogren 1996); hypothetical bias, overstating WTP or based on the fact that expectations of having to submit an actual payment may not be present (Murphy et al. 2005); and sample selection basis, where the sample does not represent

[3] The order that attribute is listed on the profile would not influence the decision. So, only twenty profiles possible.

the population (Heckman 1979; Greene 1981). While bias cannot be entirely eliminated, each can be controlled to a certain degree through careful study design (Venkatachalam 2004).

By randomizing the profiles that were shown to each respondent, I was able to control for starting point basis, as the profit difference for the first choice sequence between the monoculture and agroforest options changed from one respondent to the next. In addition, the choice experiment was conducted after the household and production interview was concluded where I ask the participants about the market prices and input costs. Thus, the farmers would have conceptualized the profits from their parcels in order to make a realistic selection given their reality and preferences (Landenburg and Olsen 2008). By this type of research design, I was also able to diminish the likelihood of hypothetical and strategic bias as the values and benefits were placed in a real world context.

## Random Utility Theory

The CE relies on random utility theory, developed by Thurston (1927), to explain how a respondent makes her or his choice to maximize her or his utility (Caussade et al. 2005; Liu and Wirtz 2009). When someone is faced with a choice between two alternatives *j* and *k*, she or he will choose the alternative that provides her or him with the highest expected utility given her or his budget constraint, personal attributes, and the characteristics of each option. The utility of this person *i* given alternative *h*, cacao agroforest *j* or cacao monoculture *k*, can be represented as including a deterministic variable $V_{ih}$ and a random component $\varepsilon_{ih}$.

$$U_{ih} = V_{ih} + \varepsilon_{ih} \quad h = j \ or \ k \tag{1}$$

However, only observe characteristics $V_{ih}$ can captured which can be represented as

$$V_{ih} = \beta X_{ih} \tag{2}$$

Where $X_{ih}$ is a matrix of vectors of the known attributes of alternative *h,* the nonmarket benefits, and the personal attributes of individual *i*, including gender. *β* is a matrix of the coefficients of each attribute's marginal impacts on deterministic variable.

Where there are just alternatives, individual *i* will choose alternative *j* when the indirect utility of *j* is greater than the utility from *k*

$$U_{ij} > U_{ik} \Rightarrow V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik} \tag{3}$$

Since alternative *j* has the highest utility then $y_i = j$, where $y_i$ is the choice for person *i*, the probability of choosing *j* is given by

$$\Pr(y_i = j) = \Pr\left(U_{ij} > U_{ik}\right) = Pr\,(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \tag{4}$$

**Random effects logistics model estimation**

The estimation of this selection of alternative *j*, cacao agroforests, can be estimated through a logistic model estimation several models have been used in valuing environmental services including a logistic regression, a mutlinomial logistic model, conditional logistic model, mixed logistic model, and panel data logistic models (Baral et al. 2008; Karousakis and Birol 2008; Liu et al. 2009; Campbell 2007). For many Ecuadorian farmers, cacao is the main cash crop. Once a farmer choses to grow cacao the choice facing them is essentially a dichotomous choice between agroforestry *j* and monoculture production *k*. Because of the reality facing Ecuadorian households, the CE can be treated as having a panel data structure, where each individual faces multiple

dichotomous choice situations. Each situation can be considered an observation for individual *i* at time *t*. Each respondent, thus, has six observations at time $t_1$ through time $t_6$.[4]

Given the two profiles presented to the respondent, the model can be developed as the respondent accepting or rejecting the agroforestry parcel *j*. As the monoculture profile has none of the nonmarket benefits, each of these binary variables is represented as a zero. On the other hand, the agroforestry profiles contains one or all of these benefits and, thus, are represented by combination of zeroes and ones. Because of this structure, the monoculture profile can be subtracted from each of the agroforestry profiles creating negative profit values for the difference of the two profiles from -1000 USD to -250 USD, which become -1 to -0.25 in the estimation as the profit values were divided by 1000 to make the comparisons more straightforward between each of the coefficients.

A panel data structure can be analyzed using a random-effects logistic model (RELM) or fixed effects panel logistic model (FELM) (Campbell 2007; Baral et. al 2008). When the RELM provides unbiased estimates, it is preferred to the FELM because the RELM is a more efficient and consistent estimator. As shown in the coefficient estimates in Table 3-2, the difference between the coefficients in the RELM and the

[4] Panel data models has an advantage over other models of cross sectional data in that they control for unobserved heterogeneity and omitted variable bias. They control for unobserved heterogeneity by their assumptions on the individual specific estimators being either fixed or random effects. Panel data models allow a respondent's WTP for one attribute to be correlated with her or his WTP for another attribute, which is a logical assumption. These models also control for some types of omitted and unobserved variables. These omitted variables are assumed to be the individual attributes but to be constant across the profiles, as attributes stay the same for the profiles across participants (Campbell 2007).

FELM are minimal.[5] Since the FELM provides unbiased results, the RELM would as well. So, the RELM is the best unbiased estimators to calculate the WTP for these nonmarket benefits in cacao agroforests (Cameron and Trivedi 2010).

Furthermore, the RELM is preferred for this study because it can provide an estimate for the variable estimating the direct effects of gender. The FELM allows for the individual-specific effects $\alpha_i$, the intercept term, to be correlated dependent variables $X_{it}$ while the RELM assumes that the individual-specific effects is random and uncorrelated with the regressors (2010).[6] As gender is included as a dependent variable in the module, the coefficient is perfectly corrected with the individual-specific effects. The gender variable is dropped in the FELM but can it be estimated in the RELM due to the different assumptions in the models.

The coefficients for the RELM are estimated using the maximum log-likelihood procedure that follows from the economic model for a CE suggested by Hanemann (1984). The regression estimates the probability of the WTP and includes the following explanatory variables for the attributes of each profile at each choice at time $t_n$: organic material, subsistence crops, biodiversity, and profit regressors. In addition, the gender variable for individual *i* has two different impacts on the equation. First, it enters directly, indicating if one gender has stronger preference for the agroforestry parcel.

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[5] A Hausman test cannot be conducted on the two models, since a variable is dropped in the FELM the two models are not comparable. However, a Hausman test conducted on the RELM and FELM when the gender covariate was not included concluded that no significant difference exists between the two models.

[6] In the RELM, $\alpha_i$are independent random variables for each individual *i* with the same mean ($\alpha$) and variance ($\sigma_v^2$). Thus, the RELM has two error terms. The first, $v_i$, captures a respondent's effect on WTP, and $\varepsilon_i$ is the idiosyncratic error from the differences across the profile attributes and levels. Given this randomness, $v_i$ is specific to each individual and is constant across all the participant's choices. The random error, $\varepsilon n$, is specific to a particular observation (Campbell 2007).

Gender also enters in as an interaction term with each of the profile attributes to determine if women and men place a different value on each of these nonmarket benefits.

$$prob(WTP) = \alpha_i + \beta_1 profit + \beta_2 organic\ mat. + \beta_3 sub.crops + \beta_4 biodiversity + \beta_5 gender_i + \beta_6 gender_i * profit + \beta_7 gender_i * organic\ mat. + \beta_8 gender_i * sub.crops + \beta_9 gender_i * biodiveristy \quad (5)$$

The estimated coefficients are shown in Table 3-2. Both the estimates for the FELM and the RELM are presented in order to demonstrate that the coefficients are of nearly the same magnitude and have the same sign, which suggests that the RELM provides consistent estimates of the coefficients. The coefficients for two of the nonmarket benefits are statistically significant, biodiversity and subsistence crops. In addition, two of the gender variables are statistically significant, one for women's overall preference for agroforests and another for the interacted gender, organic materials variable.

The subsistence crops variable has the expected positive sign, so these crops provide a benefit to the farmers. However, the biodiversity coefficient has an unexpected negative sign, indicating the respondents would prefer not to have a cacao parcel with a high level of biodiversity, the same amount of native plants and animals as would be present in the forest. This biodiversity aversion is understandable considering the livelihood of these households. This coefficient captures competing preferences that respondents obtain from this attribute. Many smallholder households value biodiversity because of the additional benefits that the wildlife provide from hunting, timber, medicinal plants, and other non-timber forest products provides the household. However, many participants also associate this attribute with undesirable side effects.

In particular, they do not want animals on their parcel that may be dangerous to their health such as venous snakes and/or wasps and/or animals that eat their cacao, particularly squirrels.[7] Thus, for many respondents the disadvantages for biodiversity were greater than the benefits.

For the gender coefficients, two of them are also statistically significant. The coefficient for women's preference for the agroforestry system as a whole has the expected positive sign. This coefficient indicates that women place a greater value on the agroforestry parcel than men do. However, the interaction term of gender and organic material has an unexpected negative sign. This sign indicates that women do not place as much value on the organic material attribute as men do. Since this attribute is not significant for men, women actually have a marginal aversion to organic material. Like biodiversity, this coefficient is capturing not only a benefit for the household in enhanced soil quality but also an aversion in creating habitat for snakes. Women were specifically concerned about this negative externality, not only for their safety but also that of their young children or grandchildren, who help in the fields.

## Willingness to Pay Estimation of Nonmarket Benefits

### Module of the willingness to pay estimation

If the profits from both cacao production methods were the same, economic rationality assumptions would mean that farmers who prefer cacao agroforests do so because of the nonmarket benefits they receive from the agroforests. Following this

[7] Farmers in Vinces were particularly concerned about squirrels. Many farmers claimed they did not have any snakes in their forests, as they had killed them all. Buena Fe farmers claimed they did not have face much loss of cacao from squirrel damage. They also shared that there were many snakes in their fields, which control the squirrels.

assumption, the value of these nonmarket benefits is located where the farmer would have to earn high enough profits in her or his monoculture parcel to be indifferent between the two production methods. This equilibrium point is given by

$$V\left(X_j, E_j = 0, Z_i\right) = V(X_k, E_k^*, Z_i) \tag{6}$$

where $E_k^*$ represents the amount of profits that individual *i* would be willing to give up in order to be indifferent between the two production methods (Hanemann 1991; Liu and Wirtz 2009).

Following the calculations for WTP developed by Hanemann (1984), the probability that a respondent would be willing to pay a given amount for a certain good, including the nonmarket benefits in the cacao agroforest, is assumed to be a standard logistic variate. Thus, the probability estimation becomes

$$Prob\ (j) = \left(1 + e^{-(\alpha_i + \beta_1 profit + \beta_2 m_2 + \cdots + \beta_9 m_9)}\right)^{-1} \tag{7}$$

The value of each nonmarket benefit for women and men can be determined by estimating the marginal WTP for men ($mWTP_{m,n}$), which is the marginal rate of substitution between a change in profit and the nonmarket benefit, organic material, subsistence crops, or biodiversity (Bennett and Blamey 2001). These estimations are presented in Table 3-3.[8] For men, these marginal values are the ratio of the coefficient

[8] The delta method was selected to estimate the 95% confidence intervals. This method has not been proven to be significantly different than the Fieller, Krinsky Robb or the bootstrap methods especially when the regression is unbiased as can be assumed for this model since the coefficients are similar to those in the FELM (Hole 2007).

of the non-market attributes, $\beta_2$, $\beta_3$, and $\beta_4$, over the coefficient for profit $\beta_1$ from the RELM model.[9] Then, $mWTP_m$ for biodiversity in the cacao agroforest becomes

$$mWTP_{m,biodiversity} = \frac{\beta_4}{\beta_1} \tag{8}$$

To calculate women's marginal WTP ($mWTP_{w,n}$) for each of the nonmarket benefits, the coefficient for the gender interaction variable for each of the attributes is added to men's value of this attribute in the numerator of Equation 3-8.[10] The interaction term demonstrates how gender affects the marginal change. Since the gender is a binary variable with a women taking the value of one, the women's mWTP for biodiversity is estimated by

$$mWTP_{f,biodiversity} = \frac{\beta_4 + \beta_9}{\beta_1 + \beta_6} \tag{9}$$

This framework can be extended to estimate the value that each gender places on the choice for the cacao agroforest in addition to marginal value for the nonmarket attributes estimated in Equations 8 and 9. The estimates of the WTP for these estimates of are displayed in Table 4. The ratio of the individual specific-effects coefficient $\alpha_i$ and the profit coefficient, $\beta_1$, capture the additional factors influencing men's valuation of the agroforest ($WTP_m$).[11]

[9] Since only the coefficients for biodiversity and subsistence crops are the only statistically significant the coefficient $\beta_2$ is dropped from the final estimation of the mWTP.

[10] Only the interaction term for organic material is statistically significant. Thus, only coefficient $\beta_7$ takes a value in the estimation.

[11] The individual specific-effects coefficient estimates the effect of the average individual's characteristics not estimated in the regression on the probability of choosing the cacao agroforest parcel. Since a

$$WTP_m = \frac{\alpha_i}{\beta_1} \tag{10}$$

As the gender coefficient, $\beta_5$, enters the regression directly, the summation of $\alpha_i$ and $\beta_7$ over $\beta_1$and $\beta_6$ estimate women's valuation of these additional factors ($WTP_f$).

$$WTP_f = \frac{\alpha_i + \beta_5}{\beta_1 + \beta_6} \tag{11}$$

The estimates of the marginal impacts of each nonmarket value and gender in Equations 3-8 through 3-11 can be utilized to determine women's and men's valuation of cacao agroforests. Specific valuations of the different combinations of nonmarket benefits present in the agroforests are estimated in Table 5.

**Willingness to pay estimation results**

The WTP estimates in Table 3 and Table 4 place a monetary value on the RELM coefficients in Table 2. The marginal value of subsistence crops has a positive value for both the average man and woman while biodiversity has a negative marginal impact for both genders and the marginal value of organic material is negative for the average woman. Table 4 reveals that an average female respondent would be estimated to perceive a 694.50 USD more in benefits than the average male respondent from the agroforest in additional to the estimated attributes, which is 61% more than what the average man's valuation of these estimates.[12] The WTP estimates in Table 5

gender variable is include in the regression with women taking the value of one, $\alpha_i$ represents the average man's preferences.

[12] Even though the estimation of the men's estimation is within the 90% confidence interval for women. The women's WTP is outside that the 90% confidence interval of the estimation of men's WTP. The large difference in WTP and strong statistical significance of the gender coefficient in the RELM indicates that women value the cacao agroforest more than men do.

allow for an easy comparison between the values women and men place on monoculture cacao parcel's and cacao agroforests. These values demonstrate the value of all the nonmarket benefits of cacao agroforests to both female and male respondents. Women clearly have higher values for these benefits.

Since the monoculture profile presented to the respondents was shown as providing 1500 USD in profits, this value can used as a reference point to determine how much cash income the respondent would need to earn on the cacao agroforest to be indifferent between the two options. Table 6 provides the break even prices between the cacao agorofrest and monoculture parcel. Positive values indicate how much profit the respondent would need to obtain for the hectare of agroforest in order to be indifferent between the two options. A negative value demonstrates that the respondent would not have to receive any cash income from the parcel and still prefer the agroforesty option. In fact, the respondent would be willing to lose that much money to be indifferent between the two cropping methods.

The WTP estimates demonstrates that on average women would actually be willing to earn no profit from the cacao agroforest in nearly all circumstances and still prefer it to the monoculture parcel. The only option where the average woman would have to earn an income to be indifferent between the two farming systems is when the agroforest contains organic material and biodiversity. She would only need to receive a profit of 130.70 USD on the agroforest to be indifferent between the two options. Men on average not need to earn any income on and still prefer the agroforst parcel to the monoculture one if the agroforest contained only subsistence crops or subsistence crops and organic material. Men on average prefer a limited agroforest that includes

other crops that provide the household with additional incomes and consumption sources. None the less, the size of profits that average man would have to receive on a hectare of cacao agroforest to be indifferent between the two parcels is small compared to the potential profits he could earn on the hectare. The size of profits he would need to be indifferent between the two farming methods ranges from 108.50 USD to 548.11 USD per hectare.

Cacao agroforests in Ecuador produce half as much as the monoculture production systems (Blare and Useche 2013). So, by the values establish in this CE, a household would be expected to earn at least 750 USD. Even most of the lower bound estimations for cacao agroforests are smaller than the 750 USD, which indicates that the respondent would prefer the cacao agroforests under the market conditions in the summer of 2013. Considering this expected profit, only on average would men prefer the monoculture parcel at the lower bound estimate when its only attributes is organic material or biodiversity or both of these attributes together. The subsistence crops attribute is clearly important to

## Discussion/Conclusion

Cacao agroforests provide many additional environmental and social goods, whose value is not captured in the market. These additional benefits provide both a positive externality captured by those outside the farm as well as nonmarket benefits occurred internally in the farm. These internal benefits enhance smallholder farmers' utility shifting out the supply curve, inducing her or him to produce more even than would be indicated by the market price alone. In the case of cacao agroforestry production, these nonmarket benefits encourage smallholder households to adopt this agroforests method even when monoculture cacao parcels are more profitable. The

case of Ecuadorian cacao production demonstrates that nonmarket ecological and subsistence benefits influence their production decisions, and the value they place on these benefits differs by a gender.

The results of a CE conducted with a smallholder cacao producers in Ecuador reveals that the inclusion of subsistence crops in an agroforest encourages individuals to prefer agroforests. The value of the benefits from subsistence crops is greater than the profit difference between agroforestry and monoculture production systems. However, smallholder producers did not view biodiviersity as a benefit but as a disincentive for their choice to adopt a cacao agroforest. They are likely concerned about undesired animals such as squirrels and snakes that are included in a highly species diverse system. The small disadvantages biodiversity may be considered a cost they are willing to incur in order to have access to the subsistence crops as this planned diversity of crop, timber, and medicinal plant species creates natural biodiversity (Vandermeer and Perfecto 1995).[13] The biodiversity cost is high enough to discourage the adoption of cacao agroforests, as the agroforest parcels are still preferred to the monoculture parcels that include both native plant and animal species and subsistence crops. Even though farmers are not be compensated for the positive externalities they produce from their farmers. The nonmarket benefits that they obtain from these agroforestry systems would encourage them to produce closer to the socially optimal amount than would be indicated if they profit maximization where their only objective.

[13] Native animals in particular are drawn to the variety of plants that provide habitat and foodstuff.

The results of the CE also reveals that men and women place different values on these nonmarket benefits. On average, female participants value cacao agroforests much more than men do. Thus, the land use choices undertaken by female or male farmer would be expected to be different with women more likely to favor cacao agroforests to monoculture production methods. Providing women a voice in the production decision may lead to different outcomes than if men dominated the decision. Thus, institutions that are involved in establishing policy and developing programs to promote sustainable production practices should develop strategies to guarantee women's participation not only for social justice but also to ensure outcomes that are the most beneficial to smallholder households and society.

Table 1. Attributes and levels present in the various profiles in the choice experiment.

| Attribute | Level |
|---|---|
| Profit | 500 USD<br>750 USD<br>1000 USD<br>1250 USD<br>1500 USD (Only level of this attribute for the monoculture profile) |
| Organic Material | Same amount of organic material as in a cacao monoculture plot<br>Double the quantity of organic material as in a monoculture plot |
| Subsistence Crops | No Additional subsistence crops included in the parcel<br>Includes 200 plantains, 50 citrus trees, and 25 *Inga sp.* trees |
| Biodiversity | No native trees and no mammal presence and half the birds species found in a forest<br>10 *Guaiacum sp.* and the quantity and diversity of animals similar to that found in the forest including pacas, agoutis, parrots, hummingbirds and butterflies. |

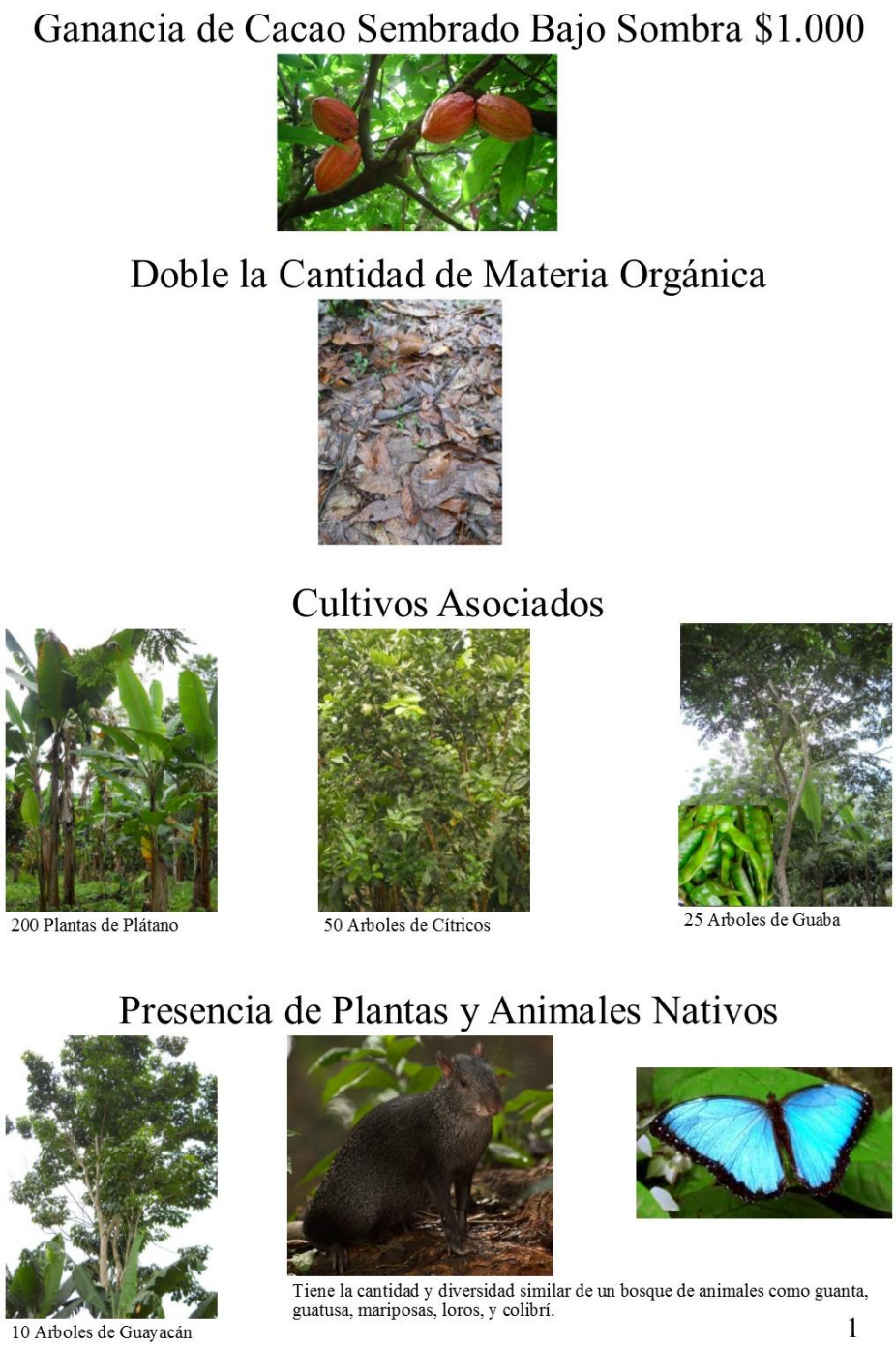


Figure 1. An example one of the agroforestry profiles presented to the respondent which contains shad grown cacao with a 1000 USD profit, twice the quantity of organic material as the monoculture profile, 200 plantain trees, 50 citrus trees, 25 *Inga sp.* trees, 10 *Tabebuia palustris*, and the quantity and diversity of animals in the forest such as agouti (*Dasyprocta punctate*), pacas (*Agouti paca)*, butterflies, parrots, and hummingbirds.


Figure 2. Monoculture profile shown to the respondents that presents a hectare of land planted with only cacao with an annual profit of 1500 USD

Table 2. Estimation of the panel data logistic models

| Variable | RELM | FELM |
|---|---|---|
| Organic Material | 0.462<br>(0.314) | 0.503<br>(0.314) |
| Biodiversity | -0.860***<br>(0.329) | -0.700**<br>(0.330) |
| Subsistence Crops | 2.104***<br>(0.564) | 2.202***<br>(0.546) |
| Profit | 4.785***<br>(0.001) | 5.053***<br>(1.069) |
| Gender | 3.323***<br>(1.072) | omitted |
| Gender*Organ. Mat. | -1.326*<br>(0.757) | -1.152<br>(0.744) |
| Gender* Biodiversity | -1.208<br>(0.819) | -1.002<br>(0.806) |
| Gender*Sub. Crops | -1.010<br>(1.318) | -0.931<br>(1.310) |
| Gender*Profit | -3.585<br>(2.532) | -3.361<br>(2.523) |
| Constant | 5.415***<br>(0.709) | --------- |
| $X^2$ | 99.73<br>(significant at 0.000) | 101.72<br>(significant at 0.000) |
| Log likelihood | -655.04 | -176.686 |
| Number of Observations | 2099 | 2099 |
| Number of Groups | 351 | 351 |

***Significance at the 1% level
**Significance at the 5% level
*Significance at the 10% level

Table 3. Marginal effects of each attribute on WTP in USD

| Attribute | WTP | 90% Confidence Interval | |
|---|---|---|---|
| Organic Material | | | |
| Men | 0 | --------- | --------- |
| Women | -277.16 | -532.06 | -22.26 |
| | | | |
| Biodiversity | | | |
| Men | -179.17 | -340.08 | -19.35 |
| Women | -179.17 | -340.08 | -19.35 |
| | | | |
| Subsistence Crops | | | |
| Men | 439.61 | 356.22 | 523.00 |
| Women | 439.61 | 356.22 | 523.00 |

Table 4. Gender effects of on WTP for cacao agroforests in USD

| Gender | WTP | 90% Confidence Interval | |
|---|---|---|---|
| Women | 1826.17 | 1086.77 | 2565.57 |
| Men | 1131.61 | 732.60 | 1530.61 |

Table 5. Valuation of cacao agroforest with the following attributes

| Profile | WTP | 90% Confidence Interval | |
|---|---|---|---|
| Organic Material | | | |
| Women | 1549.01 | 825.56 | 2272.47 |
| Men | 1131.61 | 732.60 | 1530.61 |
| Biodiversity | | | |
| Women | 1646.45 | 1017.05 | 2275.86 |
| Men | 951.89 | 679.48 | 1224.30 |
| Subsistence Crops | | | |
| Women | 2265.79 | 1528.93 | 3002.64 |
| Men | 1571.22 | 1180.80 | 1961.64 |
| Organic Mat& Biodiversity | | | |
| Women | 1369.30 | 755.89 | 1982.71 |
| Men | 951.89 | 679.48 | 1224.30 |
| Organic Mat.& Sub. Crops | | | |
| Women | 1988.63 | 1265.43 | 2711.82 |
| Men | 1517.37 | 1180.80 | 1961.64 |
| Biodiversity & Sub. Crops | | | |
| Women | 2086.07 | 1458.53 | 2713.60 |
| Men | 1391.50 | 1129.12 | 1643.89 |
| Biodiversity, Sub. Crops, & Organic Mat | | | |
| Women | 1808.91 | 1164.66 | 2423.16 |
| Men | 1391.50 | 1129.12 | 1643.89 |

Table 6. Profits for Agroforest to be Indifferent with Monoculture Production in USD

| Profile | WTP Estimate | Lower Bound of 90% Confidence Interval |
|---|---|---|
| Organic Material | | |
| Women | -49.01 | 674.44 |
| Men | 368.39 | 767.40 |
| Biodiversity | | |
| Women | -146.45 | 482.95 |
| Men | 548.11 | 820.52 |
| Subsistence Crops | | |
| Women | -765.79 | -28.93 |
| Men | -71.22 | 319.17 |
| Organic Mat. & Biodiversity | | |
| Women | 130.70 | 744.11 |
| Men | 548.71 | 820.52 |
| Organic Mat. & Sub. Crops | | |
| Women | -488.69 | 234.57 |
| Men | -17.37 | 319.20 |
| Biodiversity & Sub. Crops | | |
| Women | -586.07 | 41.47 |
| Men | 108.50 | 370.88 |
| Biodiversity, Sub. Crops, & Organic Mat. | | |
| Women | -308.91 | 335.34 |
| Men | 108.50 | 370.88 |

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