EDUCATION, ATTITUDES AND AGRICULTURAL BIODIVERSITY: AN APPLICATION OF RANDOMISED CONTROL METHOD

RESEARCH PAPAERS

Sri Lanka Journal of

Economic Research

Volume 3 (1)

June 2015: 29-64

Sri Lanka Forum of

University Economists

SLJER

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Abstract

The study¹ attempts to investigate the role of education and environmental concerns in conserving 'agricultural biodiversity' of diverse farming systems in Sri Lanka. It analyses how farmers' valuation of agricultural biodiversity alters with education on agricultural biodiversity and environmental concerns. The Choice Experiment (CE) Method, combined with Randomized Control Method (RCM) was used to collect data, while models such as Conditional Logit (CL) and Random Parameter (RP) Logit were used to analyse the collected data. The results clearly illustrate that farmers' education level, as well as environmental concerns play a major role in the conservation of agricultural biodiversity. The overall findings of this study will help the policy makers to implement relevant policies in reducing degradation of agricultural biodiversity, which is increasingly posing a major impediment to agricultural growth, to the environmental protection and sustainable development.

Keywords: *Agricultural Biodiversity, Education, Valuation*

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¹ Financial assistance received from the Peradeniya University Research Grant (RG/AF 2013/61/A) for this project is greatly appreciated

INTRODUCTION

‘Agricultural biodiversity’ is a sub-set of general biodiversity, which is essential for the global food production, livelihood security, environmental protection and sustainable agricultural development (FAO, 2007). The direct and indirect benefits of conserving farm level biodiversity can be explained on the basis of the Total Economic Value (TEV) framework. TEV consists of both ‘use’ and ‘non-use’ values. The benefits obtained by individuals using agricultural biodiversity are defined as ‘use values.’ ‘Use values’ include, direct, indirect, portfolio values and option values² (Primack, 1993; Swanson, 1996; Evenson et al. 1998). On the other hand, bequest values, altruistic values, existence values and cultural values of agricultural biodiversity are considered under ‘non-use values’ (Brown, 1990; Primack, 1993; Evenson et al. 1998).

Some direct benefits that farmers can gain from maintaining a ‘diverse farming system’ can be smmerised as follows. Firstly, a diverse farming system minimizes the external risk that farmers often faced. For example, if a farmer has both crops and livestock, this will minimize the risk of loss from drought or water shortage. That is, though crop harvests may be devastated by harsh climatic conditions, the farmers still can derive an income from livestock. Second, high levels of agricultural biodiversity provide fresh nutritional foods for

² Option values can be placed under both use and non-use values. It includes future direct and indirect use values.

the members of their families. Third, a diverse farming system can help farm families to utilise family labour optimally (Brookfield et al. 2002). For example, crop diversity demands labour in different time periods and family labour can easily be distributed among different crops and/or livestock in order to obtain maximum benefits. Fourth, agricultural biodiversity is found to have positive impacts on the overall productivity and quality of soil (Karunaratna, 2013). In addition to providing direct benefits to farmers, agricultural biodiversity improves ecological processes through regulating climate, maintaining soil quality, providing protection from erosion, storing nutrients and breaking down pollution (Di Falco and Chavas, 2009). Despite all these benefits, the previous experience has shown that population growth, inequity, inadequate economic policies and institutional systems have mainly contributed towards the increasing loss of agricultural biodiversity in the world. Low levels of education and lack of integrated research on natural ecosystems and their innumerable components may exaggerate the process, especially in developing countries.

The overall aim of this study is to evaluate the farmers' preference of agricultural biodiversity in diverse agricultural systems in Sri Lanka. Accordingly, the study attempts to investigate the fact that how farmers' valuation of agricultural biodiversity would change along with changes happened in relation to the discrepancies of their education and environmental concerns. The Choice Experiment (CE) method (combined with Randomized Control Method) is used to

estimate farmers' preferences for agricultural biodiversity. Models such as Conditional Logit (CL) and Random Parameter (RP) Logit are used to analyse the data. The results are then used to estimate the likely welfare gains under different groups of farmers. The overall findings of this research will help for implementation of policies to reduce degradation of agricultural biodiversity in developing countries.

LITERATURE REVIEW

A number of studies have already been undertaken to investigate the various aspects of agricultural biodiversity (Kontoleon, 2003; Lusk et al. 2003; Birol, 2006; Ouma et al. 2007; Ruto et al. 2008; Roessler et al. 2008; Zander and Drucker, 2008; Kassie et al. 2009; Asrat et al. 2009). Brock and Xepapadeas (2003) developed a conceptual framework for valuing biodiversity from an economic perspective. This study illustrated that a more diverse system could attain a higher value, even though the genetic distance of the species in the more diverse system could be almost zero. Kontoleon (2003) investigated consumers' perceptions of 'Genetically Modified' (GM) food and found that consumers across the European Union (EU) were willing to pay more to obtain information on the GM content in their food supplies.

Di Falco and Perrings (2003) investigated the impact of providing financial assistance to farmers in maintaining crop biodiversity in an uncertain setting. The findings reveal that risk aversion is an important

driving force for crop biodiversity conservation. This is because, risk averse farmers can hedge against uncertainty they face, by allocating land to different crop species. Van Dusen et al. (2005) carried out an empirical case study about farmer management of rice genetic resources in two communities of Nepal. In this study, the decision-making process of farm households is modelled and estimated in order to provide information for the design of community-based conservation programmes. The CE method was used to investigate farmers' valuation of agricultural biodiversity of maize varieties, using 414 farm households from three States of Mexico by Birol et al. (2006). The results revealed that there was a considerable heterogeneity among the farmers' preferences for *Milpa* diversity and GM maize across within the three States.

Poudel and Johnsen (2009) sought to advance the application of Contingent Valuation (CV) method to document the economic value of crop genetic resources, based on farmers' willingness to pay for conservation. According to them, landholding size, household size, education level, socio-economic status, gender of the respondents, number of crop landraces grown, and the knowledge of biodiversity influence the willingness to pay for in situ conservation; whereas only landholding size and household size influence the willingness to pay for ex-situ conservation. The CE approach was employed to investigate Ethiopian farmers' crop variety preferences and to estimate the mean willingness to pay for each crop variety attributes by Asrat et al. (2009). They also identified household-specific and institutional factors that

governed the preferences. Recently, a Choice Experiment method was used by Kikulwe et al. (2011) to estimate farmers' valuation of agricultural biodiversity in the *milpa* system, and examined their interest in cultivating Genetically Modified (GM) maize.

Meanwhile, several studies have used econometric models to identify the determinants of diversity in livestock and crops in developing or transitional economies. Some studies, conducted in Peru (potato), Turkey (wheat), and Mexico (maize), have sought to identify some of the important factors that positively and negatively affected the conservation of agricultural biodiversity (Brush et al. 1992; Meng, 1997; Van Dusen, 2000; Smale et al. 2002). However, most of these studies (Brush et al. 1992; Franks, 1999; Bellon, 2004; Benin et al. 2004) concentrate on diversity within a single crop or animal breed. When analysing the multiple benefits of the farms under semi-subsistent rural areas, concentration on variety diversity, mix farming systems and organic farming are more important than considering a single crop.

Although these studies identified the importance of conserving agricultural biodiversity, literature on economic valuation of diverse farms in semi-subsistence economies are very limited in developing countries. This is because, assigning monetary values to diverse farming systems are complicated in subsistence farming systems (Gauchan, 2004; Diwakar and Johnsen, 2009); therefore, a challenging area of study. As a result, these studies have only provided limited

information on the value of the different attributes of agricultural biological diversity. This study is expected to fill this void in the literature by applying CE method to analyse farmer's preference for different aspects of agricultural biodiversity in Sri Lanka.

CHOICE EXPERIMENT METHOD

CE approach has a theoretical grounding in Lancaster's Attribute Theory of Consumer Choice (Lancaster, 1966) and an econometric basis in models of random utility (McFadden, 1974). Lancaster proposed that consumers derive satisfaction not from goods themselves, but from the attributes they provide. To illustrate, the basic model behind Choice Experiments, it is assumed that farm families have a utility function of the form:

$$U_{ij} = U(X_{ij}, Z_i) \dots \dots \dots (1)$$

Where, for any farm family i , a given level of utility will be associated with any alternative farm j . Utility derived from any farm alternatives depend on the attributes of the farm X_{ij} and the social and economic characteristics of the farm family Z_i , since different families may receive different levels of utility from these attributes. According to the 'Random Utility Model', the utility of a choice comprises of a systematic (deterministic) component, T_{ij} and an error (random)

component e_{ij} , which is independent of the deterministic part and follows a predetermined distribution (Hanemann et al. 1991):

$$U_{ij} = T_{ij} + e_{ij} \dots \dots \dots (2)$$

The systematic component can be explained as a function of the characteristics of the farm and of the social and economic characteristics of the farm family. Accordingly, Equation 2 can be expressed as:

$$U_{ij} = T(X_{ij}, Z_i) + e_i$$

Given an error part in the utility function, choices made among alternative farms will be a function of the probability that the utility associated with a particular farm option (j) is higher than that for the other alternative farm. Hence, the probability that farm family i will choose farm j over all other options n is given by:

$$P_{ij} = \text{prob}\{T_{ij} + e_{ij} > T_{in} + e_{in}\} \text{ Where, } j \neq n.$$

It is assumed that the relationship between utility and attributes follow a linear path in the parameters and variables. We further assume that the error terms are identically and independently distributed with a Weibull distributio³ (Greene, 1997). These assumptions ensure that the probability of any particular alternative j being chosen can be

³Weibull distribution is a continuous probability distribution. For further details about the basic properties of this distribution (1997).

expressed in terms of logistic distribution. This specification is known as the ‘CL Model’ (McFadden, 1974; Greene, 1997; Maddala, 1999) which has the following general form:

$$P_{ij} = \frac{\exp(X'_{ij}\beta + Z'_i\alpha)}{\sum_{j=1}^J \exp(X'_{ij}\beta + Z'_i\alpha)} \dots\dots\dots(3)$$

The components of X_{ij} are typically called the attribute of the choices. However, Z_i contains characteristics of the individual and is, therefore, the same for all the choices. Equation 3 is the probabilistic response function and it shows that, given all other options, the probability of farmer i selecting the option j type farm. The CL model generates results for a conditional indirect utility function of the form:

$$T_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots\dots + \beta_m X_m + \alpha_1 Z_1 + \alpha_2 Z_2 + \dots\dots \alpha_k Z_k \dots\dots\dots(4)$$

Where, β is the alternative specific constant (ASC), that captures the effects in utility from any attributes, which are not included in choice specific attributes (Rolfe et al. 2000). The number of farm attributes considered is m and the number of social and economic characteristics of the farm family employed to explain the choice of the farm is k . The vectors of coefficients are attached to the vector of attributes (X) and to a vector of socio-economic factors (Z) that influence utility, respectively. The CE method is consistent with Utility Maximization and Demand Theory. When parameter estimates are obtained, welfare

measures can be estimated from the CL model using the following formula:

$$CS = \frac{\ln \sum_i \exp(T_{i1}) - \ln \sum_i \exp(T_{i0})}{\delta} \dots\dots\dots(5)$$

Where CS is the compensating surplus welfare measure, δ is the marginal utility of income (generally represented by the coefficient of the monetary attribute in the CE) and T_{i0} and T_{i1} represent indirect utility functions of alternative i (with subscript 0 indicating the base situation and 1 indicate the changed situation) before and after the change under consideration. For the linear utility index, the marginal value of change within a single attribute can be represented as a ratio of coefficients, reducing Equation 5 to 6:

$$W = - \left(\frac{\beta_{attribute}}{\beta_{monetary_variable}} \right) \dots\dots\dots(6)$$

In addition to this, the following Equation 7 can be used to estimate the consumer surplus in different areas.

$$CS = \frac{-1}{\beta_{cos ts}} [\Delta\beta_{crops} + \Delta\beta_{mix} + \Delta\beta_{organic} - ASC] \dots\dots\dots(7)$$

Using Equation 6, the implicit prices (W) for the various farm attributes can be calculated. These demonstrate the marginal rate of substitution between cost and the attribute in question. This is the same as the marginal welfare measure (WTP or WTA) for a change in any of the attributes. An alternative model specification to the CL model is random parameter logit (RPL) model which is increasingly becoming popular in CE studies. The advantage of RPL model is that it accounts for consumers' taste heterogeneities and also relaxes the Independence of Irrelevant Alternatives (IIA) assumption of the CL model. More importantly, preferences are in fact heterogeneous and accounting for this heterogeneity, enables estimation of unbiased estimates of individual preferences and enhances the accuracy and reliability of estimates of parameters of the model and total welfare (Greene, 1997).

DESIGNING CE STUDY

In this study the most important attributes of farms and their levels were identified through consultation with experts from the Department of Agriculture in Sri Lanka; drawing on the results of informal interviews and workshops with farmers in the study sites, focus group discussions and a thorough review of previous research in this area in the country. After identifying the attributes for the experiment, we assigned values or levels to each attribute. Selected attributes for this study, their definitions and the levels are given in Table 1.

Table 1: Identified Attributes of Agricultural Biodiversity in the Country

Attributes	Definition	Levels
Number of species	This is measured by the total number of crops and animal species that are cultivated in the farm, in a given season	1, 4, 7, 10
Mixed farming system	This attribute investigates whether a farmer prefers an integrated crop and livestock production system to a system that is specialised in crops or livestock.	Yes, No
Organic production	This attribute investigates whether a farmer prefers organic methods of production to a system using chemical fertiliser and pesticides	Yes, No
Estimated costs in terms of additional labour days	This is defined as a percentage of additional labour requirements under different policy options. This is the monetary attributes of the CE study.	5 %, 10% 15%

Note: i. Upper and lower bound of the crop species diversity and additional labour requirements are estimated using pilot survey information.

Table 1 shows the attributes that we used in the CE study. The first three attributes reflect the various attributes of a diverse farming system, found in the farms in Sri Lanka. The last factor is the monetary attribute in terms of additional labour costs⁴ that farmers have under different policy options. As compared to willingness to pay (WTP),

⁴This indirect measure is preferred over a direct monetary attribute due to three reasons. First, most of the outputs and functions of the farms that are considered in this study are not traded in the markets, but consumed by the farm families themselves. Therefore, they are not likely to be familiar with a direct monetary measure. Second, the proxy monetary attribute can easily be converted into actual monetary units by using secondary data on labour costs. Third, it is obvious that a diverse farming system requires more labour than a specialised farming system. Therefore, monetary attribute that measure the additional labour costs that farmers have to allocate for receiving the benefits of agricultural biodiversity may work as a good proxy for measuring welfare changes in the community in this study.

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willingness to accept is measured as a benefit rather than a cost (Freeman, 2003). In order to estimate this benefit, a monetary attribute in terms of additional labour costs that farmers are willing to offer is included. The size of the hypothetical farm is fixed at one acre in area in each case (this is the average farm size in study area). A large number of different types of farms (combinations of attributes) could be constructed from this number of attributes and levels. However, in this study we used 16 choice options and they were randomly blocked into 4 different versions (each has four options). Using the Dptimal procedure in Engine, an experimental design was undertaken to recover 16 pair wise comparisons of farm profiles. A sample choice set presented to respondents is given below.

Assuming that the following farms were the **ONLY** choices you have, which one would you prefer to cultivate?

Farm Characteristics	Farm (A)	Farm (B)	Neither farm (A) nor farm (B)
Number of species	1	10	
Mixed farming system	Yes	No	
Organic production	No	No	
Estimated costs in terms of additional labour days	5	10	

I prefer to cultivate

Farm (A)

Farm (B)

Neither Farm

(Please pick one option)

SURVEY METHOD, DATA CODING AND ESTIMATION PROCEDURE

This study employs Randomized Control Method (RCM) to collect the data. Firstly, 21 villages from Ampara district were selected purposively. Then, the villages were randomly divided into three groups: one control groups and two treatment groups. Accordingly, randomisation to select households into different groups (two treatment and the control) was done at the village level and ‘village’ is the unit of randomisation in this study. Then, using the farmers' list, 20 farmers were randomly selected from each village. The survey involved several steps. First, households for the survey from the district were selected. Second, based line survey was carried out covering all three groups. The main purpose of this survey is to understand their education and environmental attitudes on biodiversity and test whether there is any significant spill over effect among the respondents. This survey includes a set of simple questions related to agricultural biodiversity and environment concerns⁵. Third, one treatment group was educated using a formal educational programme (specially designed for this study) on agricultural biodiversity, while other treatment group was provided with information in order to improve their environmental concerns. Control group was not provided with

⁵ During the final survey, the same questions were asked. By comparing the information of those two surveys, spillover effects can be judged. For example, we can check whether there is a significant change of the knowledge on biodiversity/environmental concerns of the control group.

any information. Finally, CE survey⁶ covers all groups in the district. After one month of the formal educational programme, the final survey was conducted using structured questionnaire which was developed based on the results from six focus group discussions and a pre-test. A pre-test for 15 respondents was undertaken in February 2013. On the basis of the pre-test, only minor modifications to the questionnaire were required. In the questionnaire, respondents were said that the development of the Choice Experiment questionnaire was based on focus group studies. Six focus group discussions were conducted for both potential respondents (3) and for agricultural officers (3) to ensure that inputs for choice sets were correctly specified.

Education programme consisted with two steps. Firstly, we met the respondents of two control groups and explained the importance of agricultural biodiversity or environmental protection individually. Secondly, we provided leaflets (but not keep with them; they could read it in front of us or we can read it for them) showing the importance of maintaining diverse farming systems in their farms or the importance of protecting environment. Final survey was carried out by administering a questionnaire through a face-to-face interview with the Head or any other working member of the households. The final survey covered 420 households.

⁶ Before the interview it was confirmed whether the respondents were generally those responsible for farm production decision making.

Data coding is one of the important parts of the Choice Experiment Model. During this study, the data was coded according to the levels of the attributes. Attributes with 2 levels entered the utility function as binary variables that were effects coded (Louviere et al. 2000). Crops diversity variable is used as a continuous variable. Consequently, the crop species diversity attribute took levels 1, 4, 7 and 10. Estimated costs in terms of additional labour requirement were transformed into monetary values when estimating the models. The percentage values of additional labour requirements were given as 5, 10 and 15. On average, farm families need approximately 31 labour days per month for their one acre farm cultivation. Daily average wage rate per person was Rs.500⁷. Accordingly, value of the cost of accepting alternative farms can be expected as Rs. 2,500, Rs. 5,000 and Rs. 7,500 for the three levels respectively. In this way, the levels used for labour requirement variables were entered in a cardinal-linear form. The attributes for the 'neither farm' option were coded with zero values for all attributes. The alternative specific constants were equalled to 1, when either farm A or B was chosen and to 0 when the 'neither farm' alternative was chosen. Choice data were converted from wide to long format with a programme coded in LIMDEP 9.0 NLOGIT 4.0. This data conversion step was necessary in estimating models with multiple responses from each respondent; a format similar to panel data.

⁷ This varies between Rs. 600 and Rs. 400 depending on various factors (gender, period and area). For example, men wage rate is slightly higher than female. Wage rate in harvesting period is greater than other period.

First, we estimated the CLM. The IIA property of this model is tested using a procedure suggested by Hausman and McFadden (1984). This test involves constructing a likelihood ratio test around different versions of the model, where choice alternatives are excluded. If IIA holds, the model estimated on all choices (the full choice set) should be the same as that estimated for a sub-set of alternatives (Bateman et al. 2003). It is found that the IIA conditions have not violated any of the cases. We then included social and economic characteristics as interaction terms, and test whether there is an improvement of our result. It was found to not have any significant improvement in including any social-economic characteristics as the interaction term. As the next step of the analysis, Random Parameter Logit (RPL) model was used in order to take into account the preference heterogeneity. We estimated the basic RPL model, which includes only attributes as well as extended RPL model that includes some socio-economic variables. When comparing with RPL results with CL results, it was found that basic CL results were better in terms of overall fit of the model and number of significant variables. Therefore, the result of the basic CL model was used to simulate welfare change of the society, when changing different attributes and their level.

RESULTS AND DISCUSSION

The descriptive statistics of the samples show the similar characteristics of all three groups. The mean values of age were 38, 40 years for two treatment groups and 37 years for the control group. The

average number of persons in the household was 5, 4 and 5 while the average education levels were 10, 9 and 9, respectively. Although agriculture was the dominant source of household income, monthly income from non-farm activities was approximately estimated as Rs. 1,350, Rs. 1,300 and Rs. 1,425 per household; which accounted for almost 5 percent of the total household income. The mean labour usage per season was 74 man-days for three samples. This is expected, given the tedious labour intensity for all agricultural work in semi-subsistence economy. Rice was cultivated by almost all households followed by various types of vegetables and cash crops. The maximum number of crop varieties cultivated by any household was seven. More details of the descriptive are given in Table 2. The comparison of descriptive statistics clearly indicate that there is no significant difference among different groups.

Before estimating any model, we explored a variety of different specifications of the utility functions to identify the best specification of the data. These tests include both formal statistical tests and informal judgments about the signs, magnitudes, or relative magnitudes of parameters based on our knowledge about the underlying behavioural relationships that influence different choice of farms.

Table 2: Descriptive Statistics of the Variables Used in the Study

Variable	Average	Maximum	Minimum
Age	38.33	62.00	18.00
Household size	4.66	7.00	2.00
Education level	9.33	12.00	4.00
Farm income (Rs. per month)	26500.00	62450.00	6540.00
Off- farm income (Rs. per month)	1358.30	6500.00	0.00
Labour days (per month)	24.66	45.00	12.00

Note: As hypothetical scenarios are given in choice experiment, descriptive statistics of those variables are not recorded.

As a formal statistical process, different model specifications were compared according to higher log-likelihood value criterion in this study. Most appropriate specification was found to be the model with the linear version of the four attributes of the study. Accordingly, CL model is specified, so that the probability of selecting a particular alternative is a function of attributes of the alternatives and of the alternative specific constant. Indirect utility received by the farm attributes take the form:

$$T_{ij} = \beta_0 + \beta_1(X_{species}) + \beta_2(X_{mix}) + \beta_3(X_{organic}) + \beta_4(X_{cost}) \dots \dots \dots (8)$$

Where, β_0 refers to the alternative specific constant and β_{1-4} refers to the vector of coefficients associated with the vector of attributes describing farm characteristics. The results of the estimated basic CL model for the separate samples are presented in Table 3. All attributes

except the organic farms in the control group in the models were statistically significant at conventional levels, and their signs were as expected.

Table 3: Regression Results of the CL Model

Variables	Model 1	Model 2	Model 3
	Education (biodiversity)	Education (Environment)	Control group
ASC	2.32 (0.009)*	3.028 (0.005)*	2.984 (0.029)**
Crop diversity	0.081 (0.000)*	0.119 (0.002)*	0.011 (0.076)***
Mix system	0.229 (0.001)*	0.446 (0.001)*	0.022 (0.008)*
Organic farms	0.196 (0.041)**	0.477 (0.020)**	0.034 (0.341)
Costs	-3.1E-04 (0.000)*	-2.5E-04 (0.000)*	-2.1E-04 (0.000)*
LR chi2(5)	956.24	1425.14	971.44
Prob > chi²	0.000	0.000	0.000
Pseudo R²	0.228	0.321	0.120
N	1680	1680	1680

Note: i. P values are shown within parentheses
 ii. *denotes significant at 1% level while ** and *** indicates significant variables at 5% and 10% level respectively

All attributes in the first and second models were statistically significant at conventional levels (5 percent), and their signs were as expected. The overall fit of the model as measured by McFadden's R^2 was also good by conventional standards used to describe probabilistic discrete choice models (Ben-Akiva and Lerman, 1985). When analysing the results of these two models, it is clear that all of the farm attributes are statistically significant at 5 percent level, implying that

any single attribute increases the probability that a farm is selected; whereas different socio-economics variables and preferences remain equal. Since the underlying samples is statistically significant ($P < 0.05$), these parameters represent preference estimates of farm families for farms attributes among two treatment groups. Third model shows the situation of the control group. For this group, organic farm variable is not significant ($P > 0.01$) even under ten percent level while all other attributes were significant at five or ten percent level. Relatively, significance of the attributes of this model is less when compared to other two models. The results clearly show that the education has some impact on farmers' valuation of agricultural biodiversity in study area.

As the next step of the analysis, the IIA property of all models is tested using a procedure suggested by Hausman and McFadden (1984) and contained within NLOGIT 4.0. This test involves constructing a likelihood ratio test around different versions of the model where choice alternatives are excluded. If IIA holds, then the model estimated on all choices (the full choice set) should be the same as that estimated for a sub-set of alternatives (Bateman et al. 2003). It was found that the IIA property is not violated implying that the conditional logit estimates do not hold any bias that could have resulted from inclusion of the 'neither' option. However, CL model assumes homogeneous preferences across farm families in each district, though references across families are in fact heterogeneous. Accounting for this heterogeneity enables estimation of unbiased estimates of individual

preferences and enhances the accuracy and reliability of parameter estimates (Rolfe et al., 2000). Interaction of individual-specific social and economic characteristics with choice specific attributes or with ASC of the indirect utility function is a common solution to dealing with the heterogeneity. However, the main problem with this method is multi-collinearity, which occurs when too many interactions are included in the estimation. In this context, the model needs to be tested down, using the higher log-likelihood criteria (Bateman et al., 2003; Birol, 2004). Therefore, as the next step of the analysis, CL model is estimated using three socio-economic variables as interaction terms⁸. They are; age of the respondent (age), education level of the respondent (education) and household size (hhs). Accordingly, indirect utility received by the farm attributes and interaction with socio-economic characteristics can be re-specified as Equation 9:

$$\begin{aligned}
 T_{ij} = & \beta_0 + \beta_1(X_{species}) + \beta_2(X_{mix}) + \beta_3(X_{organic}) + \beta_4(X_{cost}) + \alpha_1(X_{species} \times Z_{age}) + \alpha_2(X_{species} \times Z_{edu}) \\
 & + \alpha_3(X_{species} \times Z_{hhs}) + \alpha_4(X_{mix} \times Z_{age}) + \alpha_5(X_{mix} \times Z_{edu}) + \alpha_6(X_{mix} \times Z_{hhs}) + \alpha_7(X_{organic} \times Z_{age}) \\
 & + \alpha_8(X_{organic} \times Z_{edu}) + \alpha_9(X_{organic} \times Z_{hhs}) + \alpha_{10}(X_{cost} \times Z_{age}) + \alpha_{11}(X_{cost} \times Z_{edu}) + \\
 & \alpha_{12}(X_{cost} \times Z_{hhs}) \dots \dots \dots (9)
 \end{aligned}$$

As it shown in equation 9, the total number of coefficients in the full model is 16. We tested various interactions of the four farm attributes with the household-level including other characteristics. An initial run

⁸ Different socio-economic variables were tried and finally those three were found to be more appropriate.

of the model with all interaction terms reveal that a large number of variables are insignificant for all three models. Then we estimated the correlation matrix and it was revealed that there was a higher level of correlation and multi-collinearity among these household-level variables. Estimation of variance inflation factor further provided the evidence about the higher correlation among household level variables. To address this limitation (except age, education and household size) all other independent variables were eliminated based on variance inflation factors, which were calculated by running ordinary least square regressions between each independent variable⁹. The estimated results of the final models are reported in Table 4.

This specification of the model was not significantly different from the previous specification. In particular, the model did not reveal a significant higher level of parametric fit, compared with the first model. Most of the interaction terms of all three models are not significant. Further, including the interaction terms has reduced the significance of some of the attributes of the models.

Therefore, it can be concluded that the improvement in model fit was not significant.

⁹ Those independent variables for which $VIF_j > 0.6$ indicate clear evidence that the estimation of the characteristic is being affected by multicollinearity (Maddala, 2000).

Table 4: CL Model Including Attributes and Socioeconomic Variables

Variables	Model 1	Model 2	Model 3
	Education (biodiversity)	Education (Environment)	Control group
ASC	1.42 (0.016)**	2.317 (0.004)*	2.984(0.019)**
Crop diversity	0.136 (0.002)*	0.362 (0.008)*	0.019 (0.169)
Mix system	0.124 (0.016)**	0.219 (0.021)**	0.063 (0.192)
Organic farms	0.116 (0.042)**	0.192 (0.000)*	0.044(0.041)**
Costs	-2.2E-4(0.000)*	-2.9E-05(0.000)*	-1.6E-04(0.000)*
Crops_age	0.026 (0.231)	0.051 (0.090)***	0.002 (0.201)
Crops_edu	0.002 (0.041)**	0.0160 (0.000)*	0.002 (0.131)
Crops_hhs	0.002 (0.620)	0.001(0.000)*	0.017 (0.870)
Mix_age	0.107 (0.821)	0.203 (0.141)	0.007 (0.121)
Mix_edu	0.001(0.060)***	1.425(0.059)***	0.074 (0.083)***
Mix_hhs	0.012(0.061)***	1.224 (0.587)	0.704(0.065)**
Organic_age	0.003 (0.506)	0.029 (0.601)	0.043 (0.801)
Organic_edu	0.043 (0.018)**	1.098 (0.017)*	0.247(0.060)***
Organic_hhs	0.01 (0.255)	0.051(0.401)	1.248 (0.294)
Costs_age	-0.073 (0.459)	-1.13 (0.410)	-0.233(0.094)***
Costs_edu	-0.305 (0.129)	0.451 (0.016)**	1.324 (0.183)
Costs_hhs	-0.031(0.149)	-0.130 (0.40)	-0.203(0.840)
LR chi2	1276.23	1825.88	1141.64
Prob > chi ²	0.000	0.000	0.000
Pseudo R ²	0.229	0.342	0.140
N	1680	1680	1680

Note: i. *denotes significant at 1% level while ** and *** indicates significant variables at 5% and 10 % level.
 ii. P values are given in parenthesis.

The Hausman-McFadden test also revealed that CL model without interactions is a better fit for the data, than the CL model with interaction. Among the significant interactions, households with a higher education level in all samples had a higher preference for organic and mix farming practices. The overall model is significant at the one percent level. Compared to basic CL model, the explanatory power of the model has not changed significantly.

An alternative method to account for preference heterogeneity is the use of RPL model¹⁰. We next estimate the results using RPL model to investigate the fact that whether there is an observable improvement of the results. Running the RPL model requires an assumption to be made about the distribution of preferences for each attribute. The main candidate distributions are normal and log normal. The former allows preferences to range between positive and negative for a given attribute, the latter restricts the range to being of one sign only. Further, treating preference parameters as random variables require estimation by simulated maximum likelihood. This means that the maximum likelihood algorithm searches for a solution by simulating m draws from distributions with given means and standard deviations. Probabilities can be calculated by integrating the joint simulated distribution. In this study the RPL model was estimated using NLOGIT

¹⁰ RPL model is one of the fully flexible versions of the discrete choice models because its unobserved utility is not limited to the normal distribution. It decomposes the random parts of utility into two parts. One has the independent, identical type 1 extreme value distribution, and the other representing individual tastes can be any distribution. It is also characterized by accommodating heterogeneity as a continuous function of the parameters.

4.0. All the parameters were specified to be independently normally distributed and distribution simulations were based on 500 draws. The results of the RPL estimations for the separate districts are reported in Table 5

Table 5: Regression Results of the RPL Model for Separate Districts and Pool Data

Variables	Model 1	Model 2	Model 3
	Education (biodiversity)	Education (Environment)	Control group
ASC	1.838 (0.042)**	1.343 (0.007)*	2.428 (0.013)**
Crop diversity	0.0640 (0.009)*	0.126(0.009)*	0.015 (0.032)**
Mix system	0.178 (0.040)**	0.157(0.001)*	0.135(0.081)***
Organic farms	0.147 (0.044)**	0.192(0.036)**	0.184 (0.145)
Costs	-2.0E-0.4(0.000)*	-2.3E-05(0.000)*	-1.4E-04(0.000)*
Log likelihood	-1722.65	-2943.43	-1647.32
Simulation	500	500	500
ρ^2	0.178	0.198	0.161
N	1680	1680	1680

Notes: i. P values are shown in brackets.

ii. *denotes significant at 1% level while ** and *** indicates significant variables at 5% and 10 % level respectively.

The results of the RPL model are quite similar in sign and magnitude to the CL model, where preferences are assumed to be homogenous. The crop diversity coefficient for the standard CL model is 0.081, whereas it is 0.064 for the RPL for Model 1. In this model coefficients of the mix farming systems are 0.229 and 0.178 for CL model and RPL model respectively. The CL model contains all positive and significant choice attributes, except organic farm in model three which is similar

to the RPL results. The major difference between the two models is that most coefficients of the CL models are highly significant, while RP models are relatively less significant. The Swait Louviere Log Likelihood ratio test results of the test cannot reject the null hypothesis that the RPL model and CL model estimates are equal. Hence no improvement in the model fit can be achieved with the use of a RPL model. Accordingly, it can be concluded that the CL model is sufficient for analysis of the data set presented in this study. Therefore, the results of the CL model reported in Table 2 can be used to calculate the value assigned by the farm families to farm attributes. Point estimates of the WTA, a change in one of the attributes in the choice sets can be found by estimating implicit prices. Implicit prices are the marginal rates of substitution between the attribute of interest and the monetary attribute. This is equal to the ratio of the coefficient of one of the non-monetary attributes and the monetary attributes. Equation 6 is used to estimate the implicit prices for each attribute. Estimates of implicit prices for each of the non-monetary attributes in the choice sets are reported in Table 6.

Table 6: Implicit Price Estimates for Attributes

Variables	Education (biodiversity) Rs.	Education (Environment) Rs.	Control group Rs.
Crop diversity	261	476	86
Mix system	739	1784	105
Organic farms	632	1908	162

Note: all implicit prices are estimated using the result of the basic CLM.

These estimates indicate that, for example, farmers' valuation of the additional benefits that farmers could obtain in increasing crop diversity by one per month is Rs. 86, 261 and 476 in control group, educated on biodiversity group and educated on environment group respectively. It is clear that farmers of 'educated on environment' group have placed relatively high values on all attributes. Interestingly, the highest valuation is given for organic farming when comparing with other attributes. This is expected as most farmers in these districts use their farm products for their own consumption.

These estimates of implicit prices are based on a *ceteris paribus* assumption, where we assume that all other parameters are held constant except the attribute for which the implicit price is being calculated. Implicit prices, however, do not provide estimates of compensating surplus. Estimating the overall WTA for a change from the current situation requires more substantial calculations. This is because, the attributes in the choice sets do not capture all of the

reasons why respondents might choose to increase agricultural biodiversity. To estimate overall WTA, it is necessary to include the alternative specific constant. As discussed earlier, the alternative specific constant captures systematic but unobserved information about why respondents chose a particular option (unrelated to the choice set attributes). Therefore, as the final step of the analysis, consumer surpluses for different samples are estimated using Equation 7. Then changes of the CS relative to the control group are estimated. These changes are given in Table 7.

Table 7: Changes of the CS under Each Scenario

	Crops diversi ty	Mix	Organic	Education (Biodiversity) ΔCS / Rs.	Education (Environment) ΔCS / Rs.
Status quo	1	0	0	-	-
Scenario 1	4	1	0	2,434	4,522
Scenario 2	7	1	1	3,127	4,786
Scenario 3	10	1	1	3,434	5,245

Note: After estimating the CS per farmer under each scenario, the deviation from the status quo were calculated. Then the changes of those two groups from the control group were estimated.

To illustrate this process, estimates are provided for three alternative scenarios. The status quo situation is identified as a farm with one crop variety and no mixed farming or organic farms. We changed these characteristics for the rest of the profile gradually and estimated change of the CS under each profile. Estimated change of CS in each sample is given in Table 7. The Δ CS values indicate that the value attached to deviation from control group to educated on biodiversity group were

Rs. 2,434, 3,127 and 3,434 respectively. Those values for educated on environment group were Rs. 4,522, 4,786 and 5,245 respectively. These are, the average benefits per household which can be obtained by increasing crop diversity, adopting mix farming practice and introducing organic farming practice in their farms. This shows that farmer welfare could be easily increased by shifting farming practice to more diverse systems in rural areas in Sri Lanka.

CONCLUSIONS AND POLICY IMPLICATIONS

This research is one of the first attempts to use choice modelling to investigate farmers' preference for different attributes of agricultural biodiversity that can be seen in diverse farms in Sri Lanka. The study applied the choice modelling approach with RCM to identify question that whether farmers preferences on different attributes of agricultural biodiversity are affected by different types of education or not? The result of this study shows that agriculture based families in the study area have strong preferences to increase agricultural biodiversity. It is clear that all diversity components are valued highly by all types of households in the study area.

In general, the findings of the Choice Experiment support the assumption that diverse farms and their multiple attributes contribute positively and significantly to the utility of farm families in Sri Lanka. Furthermore, their valuation is highly affected by their education on biodiversity and environmental attitudes. The present study illustrates

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the importance of education in determining farmers' valuation of agricultural biodiversity. Therefore, designing formal and informal education programmes will improve farmers' abilities to conserve agricultural biodiversity in the country. Moreover, a further initiative can be taken to strengthen the capacity of farmers through farmer-centred training workshops geared towards conserving agricultural biodiversity. This could be done in a collaborative manner involving the government, district assemblies and NGOs. The government also needs to intensify its agricultural extension service programmes by training and deploying qualified extension officers. The officers, in turn, should intensify farmer education on agricultural biodiversity.

The overall findings of this research will help to implement policies to reduce degradation of agricultural biodiversity that is increasingly posing a major impediment to agricultural growth, environmental protection and sustainable development. Further, the research findings will contribute to the sustainable use of agricultural biodiversity to improve farmers' well-being and achieve an environmentally friendly farming system. It also helps to increase awareness and generates support for investment in conservation and development of agricultural biodiversity. Moreover, it will provide an opportunity to make necessary policies that provide incentives to protect biodiversity at farm level that generate regional as well as global benefits in the future.

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