

Technical Efficiency and Agricultural Biodiversity: Identifying the Role of Knowledge and Attitudes¹

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INTRODUCTION

Agricultural biodiversity is a sub-set of general biodiversity which is essential for global food production, livelihood, security, environmental protection and sustainable agricultural development (Food and Agriculture Organization-FAO, 2007). In addition to providing direct benefits to farmers, agricultural biodiversity improves ecological processes by regulating climate, maintaining soil quality, providing protection from erosion, storing nutrients and breaking down pollution (Di Falco and Chavas, 2009). Despite all these benefits previous experience has shown that agricultural biodiversity has been decreasing rapidly in the world. Low levels of knowledge and lack of integrated research on natural ecosystems and their innumerable components may exaggerate the process, especially in developing countries.

The study attempted to identify the role of farmers' knowledge as well as attitudes on agricultural biodiversity on determining farm level technical efficiency in diverse farming systems in Sri Lanka. It analysed how farmers' knowledge and attitudes affect the farm level technical efficiencies. Randomized Control Method (RCM) is

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employed to collect field data and Stochastic Production Function Approach (SFA) was used to analyse the data. In RCM firstly, 21 villages from the Ampara District were selected purposively. Then the villagers were divided into three groups (one control group and two treatment groups) randomly. Accordingly, randomisation to select households into different groups (two treatments and the control) was done at the village level and 'village' is the unit of randomisation in this study. Then a number of 20 farmers were selected from each village randomly (using the farmers' list). The survey involved several steps. First, households for the survey from the district were selected. Second, base line survey was carried out covering all three groups. The main purpose of this survey is to understand their knowledge and attitudes on agricultural biodiversity and test whether there is any significant spillover effect among the respondents. This survey includes a set of simple questions related to agricultural biodiversity and environment concerns. Third, one treatment group was educated using a formal educational program on agricultural biodiversity designed for this study while other treatment group was provided information in order to improve their environmental concerns. the control group is not provided any information. Final survey covers all groups in the district. The questionnaire used for this study was developed using the results from six focus groups' discussions and a pre-test.

The education program included two steps. Firstly, we met respondents of two treated groups and explained the importance of agricultural biodiversity or environmental protection individually. Secondly, we provided leaflets (but not to keep with them; they could read it in front of us or we could read it for them) showing the importance of maintaining diverse farming system 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.

REVIEW OF LITERATURE

There have been many studies on technical efficiency in agriculture (Vangelis et al. 2001; Gunaratne and Thiruchelvam, 2002; Binam et al., 2004; Amos et al. 2004; Idiong, 2007; Hadgu et al. 2009). In general the review of these studies suggests that the best option to assist developing countries to raise productivity is increasing efficiency. Moreover, some of these studies support that agricultural biodiversity plays a major role on technical efficiency in small farms. However, to the best of my knowledge, none of those studies attempted to identify the role of farmers' knowledge and attitudes of agricultural biodiversity and its impacts on farm level technical efficiency. This study is attempting to fill this void in the literature.

METHODOLOGY

The empirical model of estimating technical efficiency in this study is based on the stochastic production function proposed by Battese and Coelli (1995). Accordingly, the first stage equation of the stochastic frontier model can be defined by:

$$\ln Y_i = \beta_0 + \sum_{i=1}^4 \beta_i \ln X_i + V_i - U_i \dots \dots \dots (1)$$

Where, 'ln' represents the natural logarithm. The subscript i , indicates the i^{th} farmer in the sample ($i = 1, 2, \dots, n$).

$\ln Y_i$ represents the natural logarithm of the value of farm output

$\ln X_1$ represents the natural logarithm of the total area of land (in acres) under cultivation

$\ln X_2$ represents the natural logarithm of labour in man dates

$\ln X_3$ represents the natural logarithm of capital expenditure

$\ln X_4$ represents the natural logarithm of other cost: raw materials

β_j 's are unknown parameters to be estimated

V_i 's are assumed to be independent and identically distributed normal random errors having zero mean and unknown variance; σ_v^2 ; U_i 's are non-negative random variables, called technical inefficiency effects. The second stage equation that shows the technical inefficiency can be written as follows:

$$U_i = \alpha_0 + \alpha_1 Z_{1i} + \alpha_2 Z_{2i} + \alpha_3 Z_{3i} + \alpha_4 Z_{4i} + \alpha_5 Z_{5i} + \alpha_6 Z_{6i} + \alpha_7 Z_{7i} + \alpha_8 Z_{8i} + \alpha_9 Z_{9i} + \alpha_{10} Z_{10i} + g_i \dots \dots \dots (2)$$

Z_{1i} is the age of the responded in years (AGE)

Z_{2i} is the formal education of the responded in years (EDU)

Z_{3i} is the household size (HS)

Z_{4i} is farming experience in years (FE)

Z_{5i} is full time farmer or Not: Dummy variables if Yes 1, else 0.

Z_{6i} is the land ownership (LO); Dummy variable if owned 1, otherwise 0

Z_{7i} is credit access : Dummy variables if Yes 1, otherwise 2.

Z_{8i} is member of a farm organization: Dummy variables if Yes 1, otherwise 2.

Z_{9i} is agricultural extension services contacts (AEC): Dummy variables if Yes 1, else 0.

Z_{10i} is crops diversity (number of varieties)

Given functional and distributional assumptions, maximum-likelihood estimates (MLE) for all parameters of the stochastic frontier production and inefficiency model were simultaneously estimated using the program, FRONTIER 4.1.

RESULTS AND DISCUSSION

First, the descriptive statistics of the respondents of three groups are compared. The mean value of age 38, 40 and 37 of the two treatment groups and control group respectively. The average number of persons in the household was 5, 4 and 5 while average education levels are 10, 9 and 9 respectively. The comparison of descriptive statistics clearly indicates that there is no significant difference between different groups.

First, we estimated the production functions for three groups separately. Results are reported in Table 1. The production function estimates of all three groups indicate the relative importance of factor inputs in agricultural production. The coefficients of all factors have the expected signs and were highly significance. The values of γ are 0.71, 0.67 and 0.63 respectively. They are statistically significant at one per cent level which implies that more than half of the residual variation is due to the inefficiency effect.

Table 1: Maximum-Likelihood Estimates for Parameters of the Production Function

Variables	Education (biodiversity)	Education (Environment)	Control group
Constant	1.221(0.028)**	2.024(0.012)**	1.974(0.019)**
Land	0.397(0.012)**	0.218(0.033)**	0.112(0.069)***
Labour	0.212(0.032)**	0.254(0.056)***	0.012(0.072)***
Capital	0.136(0.021)**	0.067(0.030)***	0.004(0.071)
Raw Material	0.062(0.013)**	0.125(0.006)*	0.004(0.001)*
Variance Ratio	0.713(0.001)*	0.675 (0.003)*	0.622 (0.002)*

Log Likelihood function	-466.083	-426.010	-356.231
Number of observation	140	140	140

Note:

- i. *P values are shown in brackets.*
- ii. **denotes significant at 1% level while ** and *** indicates significant variables at 5% and 10% level respectively.*

Table 2: Maximum-Likelihood Estimates for Parameters of the Inefficiency Model

Variable	Education (biodiversity) Coefficient	Education (Environment) Coefficient	Control group Coefficient
Constant	0.546(0.002)*	0.787(0.000)*	0.285(0.023)**
Age	0.026(0.000)*	0.031(0.001)*	0.117(0.000)*
Education	-0.013 (0.024)**	-0.061 (0.036)**	-0.033 (0.024)**
HH size	-0.032 (0.057)***	-0.053 (0.004)*	-0.051 (0.006)*
Experience	0.012(0.000)*	0.079(0.044)**	0.018(0.056)***
Full time farmer	-0.046(0.000)*	-0.048(0.000)*	-0.026(0.042)**
Land ownership	-0.054(0.000)*	-0.056(0.000)*	-0.042(0.058)**
Credit	-0.055 (0.008)***	-0.053 (0.065)**	-0.085 (0.080)***
Member of FO	-0.093(0.000)*	-0.064(0.000)*	-0.043(0.004)*

Extension	-0.025 (0.087)***	-0.034 (0.012)**	-0.044 (0.003)*
Crops diversity	-0.056(0.000)*	-0.044(0.003)*	-0.027(0.009)*

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

As the second step of the analysis, inefficiency models were run to identify the determinants of inefficiency of production among farmers in three groups. The sign of the variables in the inefficiency models is very important in explaining the observed level of TE of the farmers. A negative sign would imply that the variable had the effect of reducing technical inefficiency, while a positive coefficient would indicate increasing inefficiency. The results are presented in Table 2 and indicate that all included variables had the expected sign. Interestingly, diversity variable is highly significant in all models and has taken negative signs, implying that it helps to reduce the farm level technical inefficiency in study the area.

As the final step of the analysis, we examine the distribution of technical efficiency of farmers. The result is reported in Table 3. Results clearly show that two treated groups are performing better than control group.

Table 3: Frequency and Percentage Distribution of the Technical Efficiencies

Efficiency-range	Education (biodiversity)		Education (Environment)		Control group	
	Number of farms	%	Number of farms	%	Number of farms	%
0.00 - 0.40	0.00 - 0.40	1	0.71	0	0.00	8
0.41 - 0.45	0.41 - 0.45	3	2.14	2	1.43	26
0.46 - 0.50	0.46 - 0.50	6	4.29	7	5.00	27
0.51 - 0.55	0.51 - 0.55	10	7.14	12	8.57	16

Agriculture Efficiency

0.56 - 0.60	0.56 - 0.60	8	5.71	14	10.00	13
0.61 - 0.65	0.61 - 0.65	15	10.71	13	9.29	15
0.66 - 0.70	0.66 - 0.70	13	9.29	15	10.71	12
0.71 - 0.75	0.71 - 0.75	24	17.14	22	15.71	8
0.76 - 0.80	0.76 - 0.80	22	15.71	18	12.86	10
0.81 - 0.85	0.81 - 0.85	18	12.86	16	11.43	3
0.86 - 0.90	0.86 - 0.90	15	10.71	17	12.14	2
0.91-1.00	0.91-1.00	5	3.57	4	2.86	0

Note: Number of farms used for this analysis are 140 in each group.

CONCLUSIONS, IMPLICATIONS AND SIGNIFICANCE

This research is one of the first attempts to use the SPF approach to investigate the technical efficiencies for a RCM sample in Sri Lanka. The overall findings of this research help implement policies to reduce technical inefficiency in agriculture in the country. It also helps increase awareness and generates support for investment in increasing technical efficiency in the agricultural sector. The results show the potential of encouraging the methods of increasing more efficient farms in the country. Econometric analysis of survey data provides the information of current technical efficiency levels as well as the factor which determines the technical efficiency in these farms. These determinant factors, in turn, can be used to make policies in order to reduce technical inefficiencies in agriculture in the country.

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