

Technical efficiency in the spice based agroforestry sector in Matale, Sri Lanka

By

Lindara M.J.K. Lindara, Fred H. Johnsen
and Herath M. Gunatilake

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Noragric
Agricultural University of Norway
P.O. Box 5003
N-1432 Ås
Norway
Tel.: +47 64 94 99 50
Fax: +47 64 94 07 60
Internet: <http://www.nlh.no/noragric>

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CONTENTS

<i>Abstract</i>	1
1. INTRODUCTION	1
2. MATERIALS AND METHODS	4
2.1. Site Selection and Sampling Procedure	4
2.2. Data Collection	4
2.3. Data Analysis	6
2.4. Results and Discussion	8
2.4.1. <i>Technical efficiency of the spice based agroforestry</i>	8
2.4.2. <i>Factors causing technical inefficiency of spice based agroforestry</i>	10
2.4.3. <i>Causes of unsustainability of the spice based agroforestry system</i>	12
3. CONCLUSIONS	16
4. REFERENCES	17

Technical efficiency in the spice based agroforestry sector in Matale district, Sri Lanka.

By Lindara M.J.K. Lindara¹, Fred H. Johnsen² and Herath M. Gunatilake³

Abstract

Spices constitute an important sub-sector of the economy of Sri Lanka. Most perennial spices are cultivated in agroforestry types of farming systems. The technical efficiency of spice based agroforestry systems was estimated in order to identify the potential increase in production without incurring additional costs for farm inputs. The factors affecting technical efficiency and constraints and potential of the agroforestry system were also investigated. A field survey was conducted covering 120 agroforestry farmers in six divisional secretariats in Matale district during the period of October to December 2002. According to a stochastic frontier production function using a Cobb-Douglas model, hired labour, organic fertilizer, inorganic fertilizer, land size, and soil fertility maintenance cost showed significant positive effects on the agroforestry production. The mean technical efficiency of the spice based agroforestry systems was 84.32 percent. According to the inefficiency model the efficiency increased significantly as a result of farm visits by extension officers, participation in farmer training, less sloping lands, more experience, and higher diversity of the agroforestry system. Technical efficiency decreased, however, with higher education level of the farmer and with higher off-farm income. Farm income from the spice based agroforestry system is low due to low productivity, market constraints, lack of technology, and institutionally related constraints. Environmental conditions in Sri Lanka are such that a vast number of high value export crops can be grown in the agroforestry system. There is a good possibility for stepping up production of these crops in marginal lands through appropriate crop diversification.

Key words: Cobb-Douglas model, Export crops, Farm income, Farm inputs, Farming systems, Stochastic frontier production function.

1. INTRODUCTION

Traditional agroforestry systems are widespread in Sri Lanka. Shifting cultivation involves clearing of forest land by slashing and burning followed by cultivation of annual crops for about three years before shifting to another forest patch (Ranasinghe and Newman 1993), and is not considered a sustainable form of cultivation. Kandyan forest gardens are traditional systems of mixed perennial cropping combining agriculture, forestry and livestock in small homestead holdings (Jacob and Alles 1987). Intercropping of coconut utilises two windows for intercropping food crops, spices, condiments and pasture during the lifecycle of the coconut plantation, when the palms are aged 0 to 5 years and 25 to 30 years (Lyanage et al.

¹ Department of Export Agriculture, 1095, Peradeniya, Sri Lanka.

² Noragric, Agricultural University of Norway, Box 5003, N-1432 Ås, Norway.

³ Dept. of Agricultural Economics, Faculty of Agriculture, University of Peradeniya, Sri Lanka

1984). Beverage crops under shade trees include tea, coffee and cacao cultivated under a large number of leguminous and other shade trees (Ranasinghe and Newman 1993). Spice crops under shade trees is an agroforestry system that includes three sub-systems; these are pepper under shade trees, mixed spice and beverage crops under shade trees, and cardamom grown beneath the forest cover. All perennial spices, except cinnamon, are cultivated in agroforestry types of farming systems.

Spices historically and currently constitute an important sub-sector of the economy of Sri Lanka. Spices are important commodities both in domestic and overseas markets. Spices contribute about 0.6% to the total Gross Domestic Product and 1.2% to the total foreign exchange earnings by generating LKR 9,707 million in 2002 (USD 1 = LKR 95). Its share in the total agricultural foreign exchange earnings is 9%. In comparison, the beverage crops coffee and cocoa generate only about LKR 86 million of foreign exchange (Central Bank of Sri Lanka 2001).

In addition, spices are important in the economy of Sri Lanka due to following reasons (Herath 2002):

- Sri Lanka exports spices to about 70 countries in total and about 20 of them are major importers thereby providing a very stable market.
- Over 50,000 ha of wet zone land are under spices, accounting for about 6% of the land under all perennials crops.
- There are more than 200,000 small-scale growers involved in cultivating spices and thus the sector has a small farm orientation.
- Further, there are about 10,000 people involved in various activities connected with the process from cultivating to shipping of spices and thus benefiting from employment.

Matale is the leading district in spice cultivation in Sri Lanka. The population of the district is about 442,000 of whom 91.8% live in the rural areas and are mainly occupied by farming (Department of Census and Statistics in Sri Lanka 2002). The local spice based agroforestry sector is crucial to the local economy, but it has faced severe problems during the last decades. Some of these problems are prolonged fall in the production and productivity of spice based agroforestry systems, increasing cost of production, fall in export prices and

reduced share of the world market. The Department of Export Agriculture in Sri Lanka with the mandate of perennial spices launched several programmes to develop this sector, including subsidy schemes for new planting, replanting and infilling, fertilizer subsidy schemes and extension services. Despite such efforts, the performances of spice based agroforestry systems are not satisfactory. The average yield of pepper is 350-500 kg per hectare, but target yield is 1000 kg per hectare (Department of Export Agriculture in Sri Lanka 2002). Even when farmers use same amount of farm inputs their outputs differ widely.

In view of the growing competition in the world spice market and high production costs, production efficiency will become an important determinant of the future of Sri Lanka's spice industry. Developing and adopting new production technologies could improve productive efficiency. In addition the spice based agroforestry systems could maintain their economic viability by improving the efficiency of existing operations with given technology. In other words, the industry's total output can be increased without increasing the total cost by making better use of available inputs and technology.

The role that agriculture should play in economic development has been recognized for years. The adoption of new technologies designed to enhance farm output and income has received particular attention as means to economic development. Output growth is however not only determined by technological innovations but also by the efficiency with which available technologies are used. The potential importance of efficiency as means of fostering production has yielded a substantial number of studies focusing on agriculture (Bravo-Ureta and Pinheiro, 1993, Kalirajan, 1984, Rawlins, 1985).

The importance of productivity and efficiency is likely to increase in the future. Since in this study farm level data is used rather than aggregate data, it provides important insights into the micro nature of the production, which could not be captured by aggregate data that largely ignores the behaviour of individual farmers.

Following the above discussion, this study examines the efficiency of spice based agroforestry systems. The general objective of the study is to examine technical efficiency for spice based agroforestry systems in Matale district in Sri Lanka. The specific objectives of the study are:

- To estimate technical efficiency of the spice based agroforestry

- To identify the factors causing technical inefficiency of spice based agroforestry
- To identify the causes of unsustainability of the spice based agroforestry system

2. MATERIALS AND METHODS

2.1. SITE SELECTION AND SAMPLING PROCEDURE

The research was carried out in Matale district where spice garden agroforestry systems are frequently found and more than 30,000 people are involved in spice and beverage crops cultivation covering approximately 10,000 ha. A stratified random sample was constructed by dividing the district into the following levels of sub-units:

- (1) Electorates,
- (2) Divisional secretariats,
- (3) Agrarian service centre ranges,
- (4) Villages.

Matale district consists of four electorates: Matale, Rathtota, Laggala and Dambulla. While there is no spice garden agroforestry in Dambulla electorate due to dry climate, the other three electorates were found suitable for the study. Within each of these three electorates, two divisional secretariats were selected randomly, and within each divisional secretariat two agrarian service centres were selected randomly. Within each agrarian service centre, two villages were selected randomly based on a list of villages in each agrarian service centre. Within each village five households were randomly selected from a list provided by the respective village *Goviniyamaka* (village agriculture head) office. This procedure gave the following total sample size: 3 electorates * 2 divisional secretariats per electorate * 2 agrarian service centres per divisional secretariat * 2 villages per agrarian service centre * 5 households per village = 120 households.

2.2. DATA COLLECTION

Secondary information on the study area was obtained from extension officers in the study area, research officers in Department of Export Agriculture in Sri Lanka, Agrarian Service Centres, Central Bank and Department of Census and Statistics in Sri Lanka. Such

information was in the form of publications and unpublished reports and files as well as personal communication with key staff.

A structured questionnaire was formulated for primary data collection. The questionnaire comprised of seven main sections:

- 1 General household information like household size, age and education level.
- 2 Farming activities, experience with spice cultivation, extent of cultivation of various crops and reasons for crop selection.
- 3 Use of inputs including land (also covering land tenure and land management), labour (both family and hired labour), seeds and other planting materials, credit and subsidies, fertilisers and pesticides.
- 4 Yields and prices of all relevant crops, marketing channels and marketing problems.
- 5 Extension services in terms of number of visits as well as the quality of advice given.
- 6 Open ended questions regarding the farmer's perceptions on the profitability and the future of spice cultivation.
- 7 Farmer's perceptions on constraints to increased spice garden productivity.

The questionnaire was pre-tested on ten non-sample households. After the pre-test, the questionnaire was modified. The final questionnaire was used to interview all 120 sample households in face-to-face interviews conducted from October to December 2002.

Diversity of spice gardens is one of the independent variables in the inefficiency model. While all other independent variables could be estimated from questionnaire data, diversity required a survey in the farmers' fields. Representative plots were selected, following the requirements suggested by Muller-Dombois and Ellenberg (1974):

- The plot should be large enough to contain the most important species that belong to the spice gardens.
- The plant cover should be as homogenous as possible.

The diversity of spice gardens was investigated with the Counter-Plot analysis (Muller-Dombois and Ellenberg 1974). Plot sizes varied between 100m² and 400m².

2.3. DATA ANALYSIS

Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) independently proposed a stochastic frontier production function model with the following structure:

$$\ln Y = f(X_i; \beta) + \varepsilon_i$$

$$\varepsilon_i = v_i - u_i, \quad i = 1, \dots, N$$

where Y denotes production level, X_i is input level and β is a vector of unknown parameters to be estimated. ε_i is the composed error term and f is Cobb- Douglas function form. v_i is independently and identically distributed random errors, having $N(0, \sigma^2)$ distribution while u_i is non-negative random variables, called technical inefficiency effect, associated with the technical inefficiency of production of farmers involved.

According to Battese and Coelli (1995), technical inefficiency effects are defined by:

$$u_i = z_i \delta + w_i$$

$$i = 1, \dots, N$$

where z_i is a vector of explanatory variables associated with technical inefficiency effects, δ is a vector of unknown parameters to be estimated, w_i is unobservable random variables, which are assumed to be identically distributed, obtained by truncation of the normal distribution with mean zero and unknown variance σ^2 , such that u_i is non-negative.

Stochastic frontier production functions can be estimated using either the maximum likelihood method or using a variant of the COLS (Corrected Ordinary Least Squares) method suggested by Richmond (1974). The maximum likelihood method was applied, using the FRONTIER computer programme developed by Coelli (1994).

The following model specifications were used in the analysis:

$$\ln Y_i = \beta + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + v_i - u_i$$

where ln denotes logarithms to base e

Y_i = quantity of spice garden products produced by the i- th farmer

X_1 = cost of hired labour in Rs

X_2 = cost of organic fertilizer in Rs

X_3 = cost of inorganic fertilizer in Rs

X_4 = total land area in hectare

X_5 = soil fertility maintenance cost in Rs

X_6 = value of the subsidy in Rs

Spice production has different outputs. The stochastic frontier technique can be used only for a single output. Therefore, the different outputs were aggregated to a single output index using the formula

$$Y_j = \frac{\sum_{r=1}^s p_{rj} q_{rj}}{\sum_{j=1}^n p/N}$$

where Y_j is the normalized output for the j 'th firm, s denotes the number of differentiated products, p_{rj} denotes the price of the r 'th product for the j 'th firm, and q_{rj} denotes the amount of r 'th product for the j 'th firm. The average price in the denominator is defined as:

$$\bar{p}_j = \frac{\sum_{r=1}^s p_{rj} q_{rj} / q_r}{\sum_{r=1}^s q_{rj}}, \quad q_j = \sum_{r=1}^s q_{rj}$$

The inefficiency model based on Battese and Coelli (1995) specification was

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + W_i$$

where

Z_1 = Number of farm visits by extension officer per year

Z_2 = Number of farmer training classes attended by farmer

Z_3 = Other income sources of farmers

Z_4 = Slope of the land

Z_5 = Experience of the farmer

Z_6 = Age of the farmer

Z_7 = Diversity of spice gardens

Z_8 = Educational level of farmer

2.4. RESULTS AND DISCUSSION

2.4.1. Technical efficiency of the spice based agroforestry

The estimated coefficient for six inputs: labour, organic fertilizer, inorganic fertilizer, land, soil fertility maintenance cost and subsidy are shown in table 1. Labour, organic fertilizer, inorganic fertilizer, land and soil fertility maintenance cost are significant at $p=0.05$ level, while subsidy did not give a significant figure. The estimated Maximum Likelihood (ML) coefficient of land showed positive value of 0.452, and was significant. Therefore increments of land area by one percent will increase output by 0.452 percent. Similarly, the estimated ML coefficient for soil fertility maintenance cost showed positive and significant value. Therefore increment of soil fertility expenditure by one percent will increase the output by 0.651 percent. The estimated coefficients for hired labour, inorganic fertilizer, and organic fertilizer showed positive values of 0.204, 0.024, and 0.287 respectively.

The estimated mean technical efficiency for the spice based agroforestry production is 84.32 percent, which indicates that output could be increased substantially if all farmers achieved highest possible technical efficiency. Technical efficiency level ranged from 30.53 to 97.35 percent, indicating a vast difference between technical efficiency levels of farmers even if they used same level of inputs. Figure 1 shows distribution of technical efficiencies. Technical efficiencies of farmers in Matale district are expected to be high because Department of Export Agriculture has launched several programmes such as fertilizer subsidy and extension programme to promote spice based agroforestry in this area. Also, several organizations have supported spice-based systems in Matale area. A research station of export agriculture crops, an in-service training station of Department of Export Agriculture and the district office of export agriculture are situated in Matale area, therefore farmers can easily benefit from these organizations.

Table 1 OLS estimates and Maximum Likelihood Estimates for parameters of the stochastic frontier for farmers involved in spice based agroforestry in Matale district.

Variable	Parameter	Coefficient		Standard error		T ratio	
		OLS	MLE	OLS	MLE	OLS	MLE
Constant	β_0	2.326	1.582	0.648	0.568	3.49*	2.78*
Hired labour	β_1	0.155	0.204	0.062	0.058	2.35*	3.47*
Organic fertilizer	β_2	0.263	0.287	0.065	0.059	4.03*	4.85*
Inorganic fertilizer	β_3	0.046	0.024	0.008	0.007	5.41*	3.27*
Land	β_4	0.399	0.452	0.073	0.064	5.44*	6.97*
Soil fertility maintenance cost	β_5	0.440	0.651	0.132	0.133	3.33*	4.86*
Subsidy	β_6	0.0023	0.007	0.008	0.009	0.28	0.82
δ^2			0.127				
γ			0.53				
Log likelihood		-37.48	-18.36				
LR test			38.22				

* Significant at 5 percent probability level

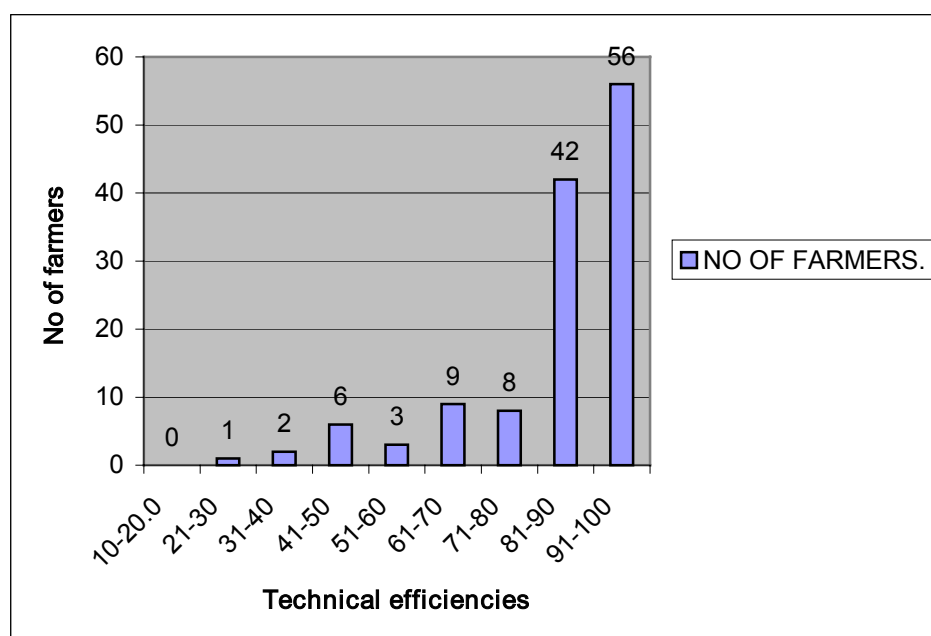


Figure 1 Distribution of technical efficiency level for farmers involved in spice based agroforestry in Matale district.

Small-scale farmers (those who have below 1 ha agroforestry farms) were found more efficient than large farmers (those who have above 1 ha agroforestry farms). Mean technical efficiency of small farms was 89.93 percent and it ranged from 65.75 to 96.89 percent. However, mean technical efficiency of large farms was 79.43 percent and it ranged from 30.53 percent to 97.35 percent. Because most small-scale farmers are involved full time in farming, they try to harder get maximum output from their land.

2.4.2. Factors causing technical inefficiency of spice based agroforestry

The estimated coefficients in the inefficiency model are of particular interest to this study. The estimated efficiency scores were used to find the factors affecting the efficiency. The factors considered in estimation of technical efficiency of farmers and their estimated coefficients are shown in Table 2.

While the estimates for all other factors in Table 2 were based on questionnaire data, diversity in terms of number of species was based on inventories in farmers' fields. The inventories showed that the species number per spice based agroforestry garden ranged from 31 to 62 with mean of 42. The highest canopy layer (>15m) was dominated by jak (*Artocarpus integrifolia*) and coconut (*Cocos nucifera*), while durian (*Durio zibethinus*) and mango (*mangifera indica*) were also commonly found. The next layer (9-15 m) was dominated by areca nut (*Areca catechu*), nutmeg (*Myristica fragrans*) and clove (*Eugenia caryophyllata*), while kithul palm (*Caryota urens*) was also common. Pepper (*Pipper nigrum*), gliricidia (*Gliricidia sepium*) and avocado (*Persea gratissima*) were the most dominant species in the lower middle layer (5-8 m). In the lower layer (1-4 m) coffee (*Coffea arabica*) and vanilla (*Vanilla fragrans*) were the most dominant species. The ground level (< 1 m) did not have distinctly dominant species, but the most commonly found species was ginger (*Zingiber officinale*). There was no relationship between the farm size and crop diversity.

From the eight coefficients estimated in Table 2, only age is not significantly related to efficiency at 5% confidence level. All the other factors affect technical efficiency level of farmers in the study area.

Table 2 Determinants of inefficiency in a Cobb-Douglas model for farmers involved in spice based agroforestry in Matale district.

Variable	Parameters	Coefficient	Standard error	t-ratio
Farm visit	δ_1	-0.087	0.029	-2.911*
Farmer training	δ_2	-0.106	0.0238	-4.446*
Other income source	δ_3	0.000005	0.000002	2.488*
Slope of the land	δ_4	-0.563	0.180	-3.123*
Experience	δ_5	-0.033	0.013	-2.467*
Age	δ_6	-0.001	0.004	-0.271
Diversity	δ_7	-0.012	0.008	-1.45*
Education	δ_8	0.174	0.028	6.17*

* Significant at 5 percent probability level.

Number of farm visits by extension officers coefficient was negative and significant, which indicates that increase of the farm visits of extension officers, decreases the inefficiency level of farmers in the study area. So it is clear that with the increase in farm visits their efficiency also increases. Participation of farmers for farmer training class coefficient was also negative and significant. That means with increase of participation for farmer training class their efficiency level also increases. Because of training class their skills increase as well as their adoption of new technology for cultivation. These results indicate that government can effectively support farmers by allocating funds to human resource development.

The experience coefficient was also negative and significant, indicating that more experienced farmers tend to be more efficient. This may be due to good managerial skills, which they have learnt over time. Extension service should be aware of the experienced farmers as a resource with potential to train the less experienced ones.

Coefficient of slope of the land also gives significant results with efficiency. Negative coefficient for slope of the land indicates that farmers who have flat land are more efficient than farmers who have sloping land. The reason is probably that if they have sloping land they will need to allocate more money for improving soil conservation of land, and cost of

production will be high. Moreover because of soil erosion in the sloping land overall productivity of the agroforestry system is reduced. Soil conservation programmes seems therefore to be an appropriate measure to improve efficiency of farmers who cultivate steep land.

The coefficient of species diversity is significant and negative. That means increase of the species diversity of the agroforestry system increases the efficiency level. Some farmers grow 3-4 cash crops in the same system (e.g. pepper, clove, nutmeg, coffee, areca nut etc). But some of them cultivate one or two cash crops in the system. Species diversity is important in terms of positive effect on soil condition and erosion control. The relatively low amount of soil loss of spice based agroforestry systems can be attributed to high species diversity. Diversity of trees, shrubs, and climbers of the agroforestry system depends partly on farmers' preferences and partly on the geographic location. It would apparently be beneficial for the farmers if crop diversification programmes were implemented in the area. For this purpose, different institutions such as Tea Research Institute, Coconut Cultivation Board, Rubber Research Institute and Department of Export Agriculture should work collaboratively.

Coefficients of education and other income sources showed positive and significant relationship with inefficiency, which indicates that with increased education and off-farm income, their efficiency level decreases. A plausible explanation is that more educated farmers are involved in part time farming. Because of education they have permanent jobs and other income sources. This result suggests that those farmers who are involved in only spice cultivation as full time farmers are more efficient than others, because they devote more time to spice cultivation.

2.4.3. Causes of unsustainability of the spice based agroforestry system

The majority of farms in the study area are small-scale home gardens below 1 ha. According to Department of Export Agriculture in Sri Lanka (2002) 70% of pepper cultivations belong to smallholder category. Majority of owners are subsistence level farmers who are not willing to invest in productivity improvement programmes unless there is a state support. Many others are part time farmers with other sources of income and not very much interested in spice cultivation. Only a small group of farmers have commercial orientation and are willing to improve productivity. However, because of increasing population pressure farmers don't have more land even though they want to expand the system. On the other hand the younger

generation are not willing to work as farmers. They are migrating to urban areas to seek employment. Among the sample farmers, only 1.5% were below 30 years.

Input use in many spice based agroforestry systems is minimal. Only 44% of the farmers in the study use inorganic fertilizer for cultivation, but even they do not use sufficient amounts. Those who use organic fertilizer also apply inadequate amounts for cultivation. Reason for not using inorganic fertilizer is high cost.

All the farmers in the study area reported that if the government would provide fertilizer at a subsidized price for farmers, they would use it. Lack of constant replacement of soil nutrients through manuring and leaching due to heavy rains are among the factors contributing to low fertility. Moreover, in the majority of cultivations plant density is below the recommended level and gap filling has not been done properly, so the per hectare yield is low.

A considerable number of cocoa and coffee crops are old/senile plantations in which productive lifespan is already over. But farmers are not interested in replanting or rehabilitation due to unattractive prices of coffee and cocoa. Compared to pepper, farm gate prices of coffee and cocoa are very low.

Scarcity of labour and high labour costs are major reasons for limited attention to productivity improvement programmes. Therefore the farmers are reluctant to adopt productivity improvement practices such as land and soil conservation practices, shade management and agronomic practices. Some farmers respond to high labour cost by selling the standing crop to the traders during harvesting time. The agricultural sector in Sri Lanka in general faces a scarcity of labour, which results in increased labour costs.

All the farmers in the study area reported that they are getting low prices for their production. The major crop in the spice based agroforestry system in the study area is pepper. During the period of data collection pepper price reduced from about LKR 280 to LKR 130 (US\$ 1 = 95 LKR). Price instability also causes lack of farmers' interests for productivity improvements. According to the farmers in the study area clove prices remained very low for the last five or six years and suddenly increased to record levels. But farmers had already abandoned their cultivations. Productivity increases of such cultivations need another 3-4 years. On the other

hand, continuing low price levels for coffee and cocoa, for nearly 10 years, have prevented investment in these crops.

Another important constraint is the poor market link between farmers and exporters. Middlemen (mobile traders) take advantage from this situation. They buy farmers' products at a low price and sell it to exporters at high price. Farmers don't have proper facilities to store the product when the market price goes down. Even though the Department of Export Agriculture promotes the spice based agroforestry system, it has no responsibility for marketing the products.

Spice based agroforestry is clearly different from the commercial plantation sector such as tea, rubber, coconut etc, which is in continuing need of new technology. Spice cultivation sector research is largely supply driven. Thus, research outcomes on productivity improvement are according to interests of researchers and highly suitable for commercial plantations (fertilizer recommendation, weeding, soil conservation, etc.). But interest of small-scale farmers for such new technology is not encouraging.

A related important issue with production is the quality. A large proportion of spices leave the farm gate with quality that is far below the expected level. Many producers don't have proper processing facilities and are also not aware of the quality parameters. Small-scale producers sell small quantities of spices to finance daily domestic requirements. It is not economically viable to process these small quantities to expected qualities. Even if farmers produce a better quality product, there are no attractive and differentiated farm gate prices for a better quality product. Processing technology appropriate for small scale producers are lacking. Only 13 farmers in the sample (11%) had post harvest equipment for processing.

As shown in Figure 2 various constraints are responsible for low income of spice-based agroforestry. Farmers responded to these constraints in a variety of ways, the main ones being out migration of youth in farm families, the farmers work as wage labourers, neglect of spice gardens, and dependency on annual cash crops such as tobacco. All these factors will lead to unsustainability of spice based agroforestry systems.

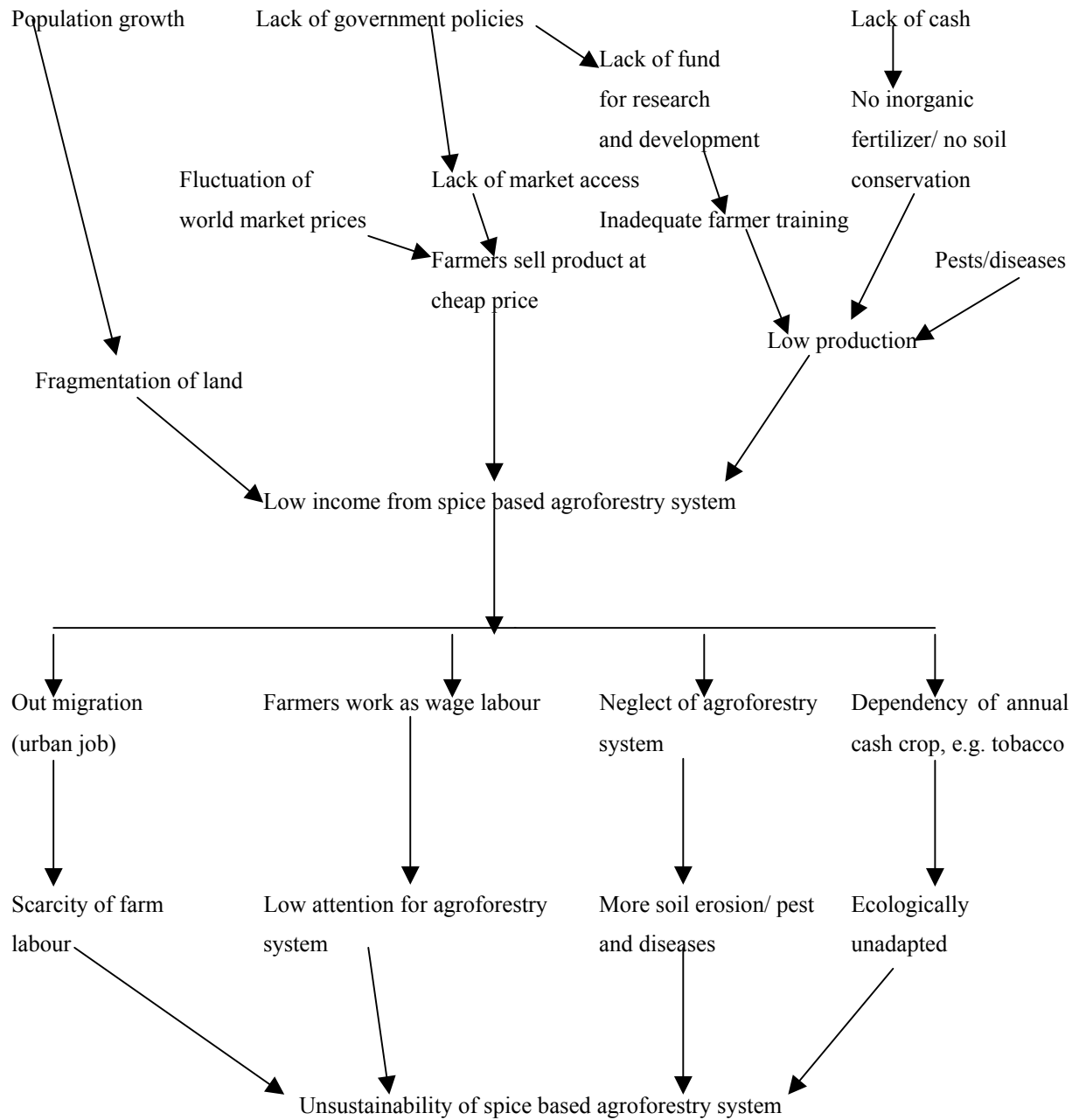


Figure 2. The cause and effect model for unsustainability of the spice based agroforestry system in Matale, Sri Lanka

3. CONCLUSIONS

The objectives of this study are to find the technical efficiency of spice-based agroforestry holdings in Matale district, identify the factors causing inefficiency, and causes of unsustainability of the system.

According to the result obtained from Stochastic Frontier estimation, the average technical efficiency of the spice based agroforestry sector given by the Cobb-Douglas model is 84.32 percent. Technical efficiency level of farmers ranged from 30.53 to 97.35 percent. Thus it is clear that there is a vast difference between technical efficiency levels of farmers even if they used the same level of inputs.

From the factors that were assumed to affect technical efficiency, higher number of farm visits of extension officer, more farmer training, less sloping land, more experience, and higher species diversity of agroforestry system increased the efficiency level of farmers in the study area. Higher education level and more off-farm income sources decreased the efficiency level. All these observations were significant at 5% confidence level.

Over the years the spice based agroforestry farming has succumbed to a variety of constraints such as productivity, market, technology, and institution related constraints. These constraints have led to the decline of farmers' income from spice-based agroforestry. All these factors lead to unsustainability of the spice based agroforestry system. The potential for expanded agroforestry is however high if government and other related institutions pay more attention to this sector.

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