ASSESSMENT ECONOMIC EFFICIENCY AND DETERMINATION FACTORS AFFECTING ON AGROFORESTRY MODELS AT CAM MOUNTAIN, AN GIANG PROVINCE

Nguyen Chau Nien*, Duong Le Ngoc, Truong Minh Thuc, Pham Huu Nguyen, Vo Thai Dan
Nong Lam University – Ho Chi Minh City

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ABSTRACT

In recent years, the increasing demand for agricultural cultivation has put pressure on the preservation and development of forests in Cam Mountain. Various agroforestry cultivation models were applied by local households. However, the models, which must be established as an effective cultivation system, has not been fully evaluated. The study was carried out to evaluate economic efficiency and to determine correlation factors to economic efficiency and affecting factors to the technical efficiency to agroforestry farming models. The survey was conducted from April to October 2021 in Cam Mountain. The 88 agroforestry producers were selected for this study through random sampling. Data on the status of agroforestry production, total income, and natural conditions were collected and analyzed. The result indicated that five agroforestry models were found with four group of agricultural crops that were intercropped with forest trees. Agroforestry models accounted for 62.8% total annual income of households with profits ranging from 15.5 to 61.8 million VND/ha/year. The average technical efficiency of agroforestry models reached 77.98%. Main labor, cultivated area, and plant care labor were positively correlated to total income from agroforestry models. whereas slope of cultivated land and the number of times that householders participated in training were two factors affected on technique efficiency of the agroforestry models.

ĐÁNH GIÁ HIỆU QUẢ KINH TẾ VÀ XÁC ĐỊNH YẾU TỐ ẢNH HƯỞNG ĐẾN CÁC MÔ HÌNH NÔNG LÂM KẾT HỢP TẠI NÚI CẤM, TỈNH AN GIANG

Nguyễn Châu Niên*, Dương Lệ Ngọc, Trương Minh Thức, Phạm Hữu Nguyên, Võ Thái Dân
Trường Đại học Nông lâm, Thành phố Hồ Chí Minh

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TỪ KHÓA

Mô hình nông lâm kết hợp
Hiệu quả kinh tế
Hiệu quả kỹ thuật
Yếu tố tương quan
Yếu tố ảnh hưởng

TÓM TẮT

Những năm gần đây, canh tác nông nghiệp ngày càng cao tạo áp lực cho việc bảo tồn và phát triển rừng ở núi Cấm. Nhiều mô hình canh tác nông lâm kết hợp đã được áp dụng. Tuy nhiên, các mô hình hiện hữu chưa được đánh giá đầy đủ. Nghiên cứu được thực hiện nhằm đánh giá hiệu quả kinh tế, xác định yếu tố tương quan đến hiệu quả kinh tế và yếu tố ảnh hưởng đến hiệu quả kỹ thuật của các mô hình. Điều tra được thực hiện từ tháng 4 đến tháng 10 năm 2021. Có 88 hộ đã được chọn ngẫu nhiên để phỏng vấn. Các dữ liệu về hiện trạng sản xuất, tổng thu nhập và điều kiện tự nhiên đã được thu thập và phân tích. Kết quả cho thấy có 5 mô hình nông lâm kết hợp với 4 nhóm cây nông nghiệp được trồng xen cây rừng. Mô hình nông lâm kết hợp chiếm 62,8% tổng thu nhập hàng năm của nông hộ với lợi nhuận từ 15,5 - 61,8 triệu đồng/ha/năm. Hiệu quả kỹ thuật của các mô hình đạt 77,98%. Lao động chính, diện tích canh tác và công chăm sóc tương quan thuận với tổng thu nhập, trong khi độ dốc của đất trồng và số lần tham gia tập huấn của các nông hộ là hai yếu tố ảnh hưởng đến hiệu quả kỹ thuật của các mô hình nông lâm kết hợp.

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* Corresponding author. *Email: nien.nguyen@hcmuaf.edu.vn*

1. Introduction

The forest ecosystem in An Giang covers an area of 16,868 ha, accounting for 4.76% of the province's total natural land area (3,406 km2), of which, Tinh Bien District has 2.912 ha [1]. According to [2], Tinh Bien District is the largest mountain forest ecosystem of the Mekong Delta. Cam Mountain located in Tinh Bien District is known as a large and high diversity mountain area of An Giang Province. In Cam Mountain area, more than 256 thousand people depend on agroforestry production for their livelihood and the average poverty rate is 13.6%, higher than other districts [3].

Currently, the agricultural farming under the forest canopy is developing, especially in the area of Cam Mountain, Tinh Bien district that causes pressure for protetion of forest land. Facing that situation, it is necessary to have a production management method that can bring economic efficiency, be sustainable and protect the living environment in the ecosystem. According to [4], agroforestry models can be considered as the best solution to meet these requirements.

Study on the potential of fruit-tree-based agroforestry, Bellow and research group (2008) concluded that the fruit-based agroforestry model has potential for prosperous farmers or the farmers who have larger cultivation land [5]. Moreover, Do et.al. (2020) indicated that agroforestry model with fruit trees had provided more profitable than monocrop cultivation within a few years [6]. Zou and Sanford reported in 1990 that medicinal plants were planted with fir and empress tree forests in the south Hunan province [7]. Homestead agroforestry contributed to household income and saving through sales of vegetables, fruits, and other tree products, this production system contributes about 70% fruit, 40% vegetable, 70% timber, and 90% firewood and bamboo requirement of Bangladesh [8].

For many years, An Giang Department of Agriculture and Rural Development has encouraged farmers to cultivate different agroforestry models and the models of vegetables and fruit trees under the forest canopy are commonly applied. However, the economic efficiency of the models is low, then farmers tend to increase agricultural areas for increasing income from agricultural production, and that tend negatively affects forest resources [1]. Therefore, finding and applying appropriate agroforestry farming models, that are applicable to local farming conditions, are significance in recovering bare land, develop forests and reduce economic difficulties for farmers. In addition, it is necessary to identify factors that affect the agroforestry production models to improve technique and economic efficiency from agroforestry models in Cam Mountain.

2. Materials and Methods

2.1. Study site

The survey was conducted at Cam mountain in An Hao commune, Tinh Bien district, An Giang province (Figure 1) from April to October 2021. Cam mountain located in west – northwest of An Giang province with geographic coordinates from 10.52° to 10.46° north latitude, 104.96° to 105.02° east longitude [9]. The mountain is in the tropical monsoon climate with two distinct rainy and dry seasons. Average annual temperature is about 27.5^{o}C, average annual rainfall is about 1,478 mm and the average humidity is in range of 75 - 80%.

2.2. Estimate sample size and data analysis

The number of interviewers was established basing on finite population correction for proportions of [10]. Sample numbers were calculated relying on 95% confidence level and level of precision.

$$n = \frac{0{,}25\mathrm{N}Z^2}{e^2\mathrm{N} + 0{,}25Z^2 - e^2} \quad (1)$$

Where n is the sample size; N is the population; Z = 1,96 (95% confidence level); e = 0.1 (± 10% precision).

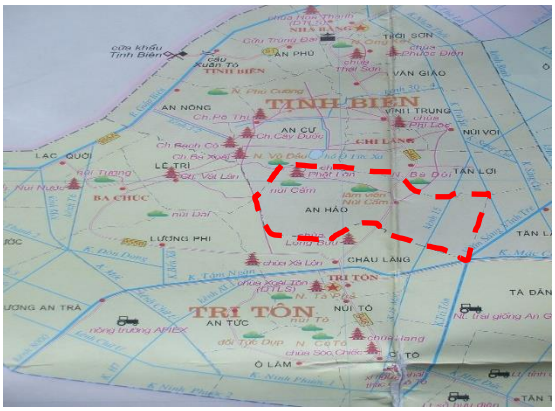

Figure 1. *Study site: dash red line indicated Cam Mountain area* [9]

Selected agroforestry producers were selected for this survey through random sampling with initial requirement of cultivation area larger than 1000 m^2 and according to [3], there are 841 farmers cultivating agroforestry model satisfy farm size. To ensure enough survey samples, it is necessary to add 5% of the samples (in case households do not cooperate or are busy). As a result, 88 households were interviewed in this study. The content of the survey is based on a prepared questionnaire with the following contents:

- General information about households
- Agroforestry cultivated model, cultivation area, types of crops in agroforestry, crop yield
- Cultivation techniques, production costs, labor
- Water sources for irrigation, slope of cultivated land, participate in training, loan (for production)

2.3. Data analysis

The stochastic production frontier approach was applied basing on [11] as follows:

$$lnY_i = ln\,[f(X_i)] - u_i + v_i \quad (2)$$

Where Y_i is the output (total income of household), X_i is the vector of physical inputs (as given in Table 3), v_i is assumed to be an independently and identically distributed $N(0,\sigma^2 v)$ two-sided random error, independent of the u_i, which is a non-negative random variable ($ui \geq 0$) that accounts for technical inefficiency in production and is assumed to be independently distributed as truncations at zero in the normal distribution with a mean $-Z_i$□, and variance $\sigma^2 u$ (|$N(-Z_i$□, $\sigma^2 u$|).

The technical efficiency (TE) of the stochastic frontier production function of the i^{th} farm is defined as follows [11]:

$$TE_i = \exp(-u_i) = \exp\,(-Z_i\text{□} - W_i) \quad (3)$$

Where W_i is truncation of the normal distribution with zero mean, Zi is technical inefficiency affecting factors, the factors were assumed to be related to knowledge and experience in agroforestry production of households and natural condition in study site (as given in Table 4).

Descriptive statistics were performed on the Microsoft Excel and Stochastic frontier analysis and inefficiency model were run on R version 4.1 using Benchmarking and AER packages.

3. Results and discussion

3.1. Status of Agroforestry Producers in Cam mountain, An Giang province

The study interviewed 91 farmers with the householders' gender rate was 28 females and 62 males. Table 1 shows that the age of householder who cultivated agroforestry model in Cam mountain has average age was 50.3 years old with range being 24 to 87. Average education of householders was after elementary school. Farming experience of the householders was 23.6 years, of which the lowest 1 year, and the highest was 60 years. The average number of members in household were 4, the highest was 10 people per household, the lowest was 1 person per household. Each household had average three main labors and two of them were agricultural labor. Households owned an average of 1.6 ha of agroforestry land.

Table 1. *Descriptive summary of agroforestry producers in Cam Mountain*

Household resource	Average	Min	Max	SD
Age of householder (year)	50.3	24	87	10.14
Education (level: 1=elementary, 2=secondary, 3=high; 4=graduate)	1.58	1	4	0.76
Experience (year)	23.6	1	60	12.37
Household member (person)	4	1	10	1.5
Main labor (person)	3	1	6	1.1
Agricultural labor (person)	2	1	5	0.7
Agroforestry land (ha)	1.6	0.1	10.0	1.8
Total income (million/year)	115.1	10.0	550.0	92.2
Income from agroforestry system (%)	62.8	10.0	100	28.9

Annual average income of each household was 115.1 million VND (equivalent to 38.4 million VND per labor) with a range of 10 to 550 million VND. According to [9], average income per labor was 40.7 million VND per year, thus income from labors in Cam mountain were lower than average income of general labors in province. Income from agroforestry model accounted for 62.8% of total income of labors in Cam mountain.

3.2. Agroforestry models in Cam mountain, An Giang province

Table 2 indicated that the most popular model in Cam mountain was the model of forest trees + fruit trees with total 63 households applied, and total area was 98.2 ha. Yearly revenue and profit were 74.3 million VND and 61.8 million VND. The second was forest trees + fruit trees + perennial spice crops model. This model was cultivated by 14 households with total 20.6 ha and the revenue and profit were 53.0 million VND and 42.0 million VND. The model forest trees + fruit trees + vegetables was cultivated by 5 households with total 5.4 ha. Total annual revenue and profit of this model were 70.0 million VND and 53.5 million VND. Forest trees + fruit tress + medicinal plants model was cultivated by 4 households with total 4.0 ha. Total annual revenue and profit of this model were 22.0 million VND and 15.5 million VND. The least common model was forest trees + vegetables, this model was cultivated by 2 households in 1.1 ha. Total annual revenue and profit were 70.7 million VND and 49.4 million VND.

Table 2. *Agroforestry models and its income in Cam mountain*

Agroforestry model	n	Total areas (ha)	Total revenue (million VND/household/year)	Profit (million VND/household/year)
Forest trees + fruit trees	63	98.2	74.3	61.8
Forest trees + fruit trees + perennial spice crops	14	20.6	53.0	42.0
Forest trees + fruit trees + vegetables	5	5.4	70.0	53.5
Forest trees + fruit tress + medicinal plants	4	4.0	22.0	15.5
Forest trees + vegetables	2	1.1	70.7	49.4

3.2. Correlation and affecting factors to agroforestry models in Cam mountain, An Giang province

3.2.1. Correlation between input factors and total income of agroforestry models

Estimated results basing on equation 2 showed that the initial factors including main labor, total cultivated area, and plant care labor were positively correlated with the economic efficiency of agroforestry models in Cam mountain (Table 3).

The analysis results show that the larger the area of agroforestry cultivation and the larger the number of employees, the higher the total income from the agroforestry models. The results prove that agroforestry farming models need a large farming area and require much labor. In addition, the analysis results also show that labor investment in crop care activities in agroforestry models made increasing income for households.

Table 3. *Correlation between input factors and total income of agroforestry models*

Variables	Parameters	Standard error	t-value	Pr(>|t|)
(Intercept)	3.22	1.73	1.863	0.07
Householder's age (year)	-0.47	0.34	-1.386	0.17
Main labor (person/household)	0.61	0.29	2.083	0.04
Agricultural labor (person/household)	0.09	0.36	0.249	0.80
Total cultivated area (ha)	0.59	0.15	4.030	0.00
Income from agroforestry model (%)	0.28	0.15	1.823	0.07
Model establishment (million VND/ha)	0.09	0.10	0.931	0.35
Planting labor (million VND/ha)	-0.10	0.08	-1.291	0.20
Fertilizer and agrochemical (million VND/ha)	0.06	0.10	0.571	0.57
Land preparation (million VND/ha)	0.13	0.19	0.698	0.49
Harvest labor (million VND/ha)	-0.17	0.10	-1.670	0.10
Plant care labor (million VND/ha)	0.19	0.09	2.224	0.03
Lambda	0.4897	2.5181	0.1945	0.846

3.2.2. Factors affecting the technical efficiency (TE) of agroforestry models

Stochastic frontier analysis resulted that technique efficiency (TE) from the agroforestry models in Cam Mountain reached 77.98% (with the range being 67.98 to 86.02). This result indicated that nearly 20% TE value reduced by some factors. In this study, the factors were determined by using equation 3 and the result was given in Table 4. The results showed that the factors affecting the technical efficiency include slope of cultivated land and number of training that householders were participant.

With respect to slope of cultivated land: agroforestry models with low slope (< 15^o) and medium slope (15^o - 25^o) was correlated to TE at 95% and 90% confidence levels, respectively. The results determine that to improve TE of agroforestry in Cam mountain, producers need to apply land prepare technique with the purpose of reducing slope level of agroforestry cultivation land or applying Sloping Agricultural Land Technology (SALT). According to [12], [13], SALT model has proven to be appropriate for high slope land and can conserve topsoil and generate steady income for producers.

Table 4. *Affecting factors on TE of agroforestry models*

	Estimate	Std. Error	z value	
(Intercept)	0.84382	0.060551	13.936	***
Gender (0: female; 1: male)	-0.02464	0.018002	-1.369	
Education level (level)	-0.0019	0.011755	-0.161	
Farming experience (year)	0.000661	0.000726	0.91	
Farming time (0: part time; 1 full time)	0.008332	0.015812	0.527	
Slope of cultivated land				
- High (>25^o)	-0.05931	0.042161	-1.407	
- Medium (15^o - 25^o)	-0.06706	0.039868	-1.682	.

- Low < 15º	-0.09153	0.045427	-2.015	*
Irrigation water (0: not enough; 1: enough)	0.014949	0.016639	0.898	
Loan (0: no; 1: yes)	-0.01822	0.018485	-0.985	
Participant in cultivation training (time)	-0.01339	0.006501	-2.06	*
Log(scale)	-3.35839	0.129099	-26.014	***

*Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1*

To concern on participant in training, result indicated that it had positive relationship between the number of times that householders participating in training and TE at 95% confidence level. In other words, the cultivation technique trainings would increase the technical efficiency of the agroforestry model. This result is consistent with the assessment of [14] when authors indicated that the participation of farmers in technical training programs has a positive relationship with technical efficiency in dragon fruit cultivation.

4. Conclusion

The results of the assessment of agroforestry models from 88 households in Cam mountain showed that the average number of members in household was 4 people per household with 3 main labors, two of them were agricultural workers. The average age of the householders was 50 years old, most of them was dropped at secondary school. Households had 24 years of farming experience in agroforestry cultivation with average area was 1.6 ha. Four groups of agricultural crops were intercropped with forest trees in agroforestry models: fruit trees, vegetables, perennial spice crops and medicinal plants. Agroforestry models accounted for 62.8% total yearly income of households with profits ranging from 15.5 to 61.8 million VND/ha/year in which, the model of forest trees + fruit trees + spice plants had the highest profit. The average technical efficiency (TE) of the Agroforestry models was 77.98%. The input factors including main labor, cultivated area, and plant care labor were positively correlated to total income from agroforestry models. There were two factors affecting the TE, including slope of cultivated land and the number of times householders participating in training.

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