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Economics of Production of Pulpwood Trees through Farmer-Industry Interface

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A B S T R A C T

The paper manufacturing units use pulpwood from tree like eucalyptus and casuarina. The cultivation of such trees is now being promoted by two leading paper industries in Tamil Nadu. This partnership (tie-up) is thus a new institutional innovation to bring synergy, mobilize resources, generate, validate and transfer technologies against non-tie up farmers who did not enter into such agreement. This study aims at estimating the economics of production of pulpwood trees grown predominantly in two districts of Tamil Nadu. The estimation of cost of cultivation of eucalyptus and casuarina indicated that cultivation of these pulpwood trees are profitable and financially feasible. The tie-up farmers were able to realize higher profit due to the farmer-industry interface. Moreover, the production function estimates indicated that the cultivation is labour intensive and inputs like density of planting irrigation, fertilizer and plant protection chemicals significantly influenced the cultivation of both the pulpwood

Introduction

Most of the traditional paper industries use bamboo as the basic raw material. The shortage of this raw material is one of the chronic problems in paper industries. Henceforth, bagasse, an industrial waste in the manufacture of sugar, was used in paper and pulp industries. Later, these industries started using pulpwood like eucalyptus and casuarina in the manufacture of paper and other products. The paper consumption in India is projected to reach 43.9 million tonnes in 2026-27 and the anticipated production of paper could reach 39.7 million tonnes leaving behind a huge gap in supply and demand. Farmer-industry interface is collaboration between two entities in order to share costs, risks and benefits and implement activities to achieve common objectives.

This partnership is thus a new institutional innovation to bring synergy, mobilize resources, generate, validate and transfer technologies (Mahmood, 2012). All these, if mutually imbibed and internalized, will add to run-away success of any industry-interface model (Kapoor, 2007).

Promotion of pulpwood cultivation in Tamil Nadu

In Tamil Nadu, there are about 39 paper mills. Among these, Tamil Nadu Newsprint and Papers Ltd (TNPL) and Seshasayee Paper Board (SPB) are the major pulpwood based paper industries. These units use pulpwood from tree like eucalyptus, casuarina, bamboo and *Malai vembu*.

Implementing of the tree farming activity outside the forest area is thus a significant step towards converting the underutilized degraded wastelands into green cover. Further, by establishing pulpwood raw material outside the forest area, the same amount of natural forest remains protected without disturbance for pulpwood and firewood.

The objectives of this study includes to estimate economics of production of pulpwood trees cultivated by farmers under Farmer-Industry Interface (tie-up) mode and also through other means of production (non-tie up)

Materials and Methods

There are seven agro-climatic zones in Tamil Nadu. Among these zones, the farmers in Cauvery Delta zone were found to cultivate the eucalyptus and casuarina on commercial basis.

The cultivation is done both with tie-up arrangements with paper industries and non-tie up arrangements. Among the eight districts, in Cauvery Delta Zone, based on the proportionate area under pulpwood cultivation, two districts namely Cuddalore and Pudukottai were selected for the study. In the next stage of sampling, using the same criteria of area coverage under pulp wood trees, three blocks were selected from each district. In each block, three villages were selected at random and from each selected village, ten farmers who had entered a contract with the any one of two major players for supply of pulp wood tress (Tie-up Farmers) were selected randomly from the list obtained from these firms. Thus, 90 farmers were selected from each district for each pulpwood tree.

In addition to these respondents, 30 non-tie up farmers, who did not have any pre-arrangement for selling the pulpwood to the identified industries, were also selected from each district. The data from the sample respondents were collected through personal interview method during the months of December 2016 to May 2017.

The economics of production of eucalyptus and casuarina was estimated by fitting Cobb-Douglas production function. The following estimable model was specified.

$$Y = a\, X_1^{b_1}\, X_2^{b_2}\, X_3^{b_3}\, X_4^{b_4}\, X_5^{b_5}\, X_6^{b_6}\, Ut$$

Where,

Y - Yield of pulpwood (Tonnes/ha)

X_1 - Human labour (man days/ha.)

X_2 - Machine (hrs/ha)

X_3 - Quantity of Seedlings (numbers/ha.)

X_4 - Quantity of inorganic fertilizer (kg/ha.)

X_5 – Number of Irrigations/ha

X_6 - Quantity of plant protection chemicals (litre/ha)

Ut- Error term

$a, b_1, b_2 \ldots b_6$- Parameters to be estimated

Findings

Cost and Return

The costs and returns in eucalyptus cultivation were worked out and the results are presented in Table 1.

The total cost of cultivation per hecatare cultivation of eucalyptus was Rs. 1, 60,557 and Rs.1, 37,881 among tie up farmers and non-tie up farmers respectively. The share of fixed cost to the total cost of cultivation was 29.55 per cent in case of tie up farmers and 30.96 per cent in case of non-tie up farmers. The average yield obtained by tie-up farmers was 74 tonnes/ha and non-tie up farmers was 61 tonnes/ha. The industries paid Rs.3500 per tonne of pulpwood to the tie-up farmers and non-tie up farmers were able to sell @ Rs.3000/tonnes. The tie-up farmers by sale of pruned materials, which is unfit for pulpwood production, are sold to other private parties at Rs.13, 000/ha and non-tie up farmers sold @ Rs. 8000 per hectare.

Thus, the gross return obtained from eucalyptus cultivation was Rs. 2,72,000 per hectare 1,91,000 per hectare by tie-up and non-tie up farmers respectively.

The net profit realized by tie-up farmers was Rs.1, 11,443/ha and the non-tie up farmers realized a net profit of Rs. 53,119. The net profit realized per annum was Rs. 27, 861/ha and Rs. 13, 280/ha by tie-up and non-tie up farmers respectively.

Based on the above estimates, the cost of production thus worked out to Rs.2170/tonne and Rs. 2260/tonne by tie-up and non-tie up farmers respectively.

The costs and returns in casuarina cultivation were worked out and the results are presented in Table 2.

The total cost of cultivation of casuarina was Rs. 2,00,030/ha and Rs.1,16,890/ha among tie-up farmers and non-tie up farmers respectively. The share of fixed cost to the total cost of cultivation was 22.00 per cent in case of tie up farmers and 33.01 per cent in case of non-tie up farmers. The average yield obtained by tie up farmers was 80 tonnes/ha. and non-tie up farmers was 65 tonnes/ha. The industries paid Rs.4000 per tonne of pulpwood to the tie-up farmers and non-tie up farmers were able to supply @ Rs.3500/tonnes.

The tie-up farmers by sale of pruned materials, which is unfit for pulpwood production, are sold to other private parties at Rs.16, 000/ha. and non-tie up farmers @ Rs. 8000 per hectare. Thus, the gross income obtained from eucalyptus cultivation was Rs. 3, 36,000 per hectare 2, 35,500 per hectare by tie-up and non-tie up farmers respectively.

The net profit realized by tie-up farmers was Rs.1, 35,970/ha and non- tie up farmers realized a net profit of Rs. 1, 18,610. The net profit realized per annum was Rs. 45, 323/ha and Rs. 39, 537/ha by tie-up and non-tie up farmers respectively. The cost of production thus worked out to Rs.2500/tonne and Rs. 1798/tonne by tie-up and non-tie up farmers respectively.

Financial Feasibility

The financial feasibility of the long-term investment is normally measured through three parameters namely Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR). In this study, a discount rate of 12 per cent is considered. The results are presented in Table 3.

In case of eucalyptus cultivation by tie-up farmers, at 12 per cent discount rate the NPV is still positive (Rs. 1,02,372) and the discounted benefit cost was estimated to be

2.18. The IRR was around 60 per cent implying the financial worthiness of the investment made. Similarly, the investment made in cultivation of eucalyptus by non-tie up farmers had also indicated the financial worthiness as the NPV, BCR and IRR were in the order of 54,583, 1.65 and 42 per cent respectively. However, between tie-up and non-tie up farmers, the former achieved a higher financial worthiness than the latter.

Table.1 Costs and Returns in eucalyptus cultivation

(Per hectare)

S. No.	Cost and Return	Tie-up	Non-tie up
1.	Fixed cost (Rs)	47,444	42,700
2.	Variable cost (Rs)	1,13,113	95,181
3.	Total Cost (Rs)	1,60,557	1,37,881
4.	Yield (Tonnes)	74	61
5.	Price (Rs/Ton)	3500	3000
6.	Income by sale of wood (A)	2,59,000	1,83,000
7.	Value of Pruned material during II and III year (B)	13,000	8,000
8.	Gross Return (A+B)	2,72,000	1,91,000
9.	Net Profit after 4 years (Rs)	1,11,443	53,119
10.	Net Profit per annum (Rs)	27,861	13,280
11.	Cost of production (Rs/Tonne)	2170	2260

Table.2 Costs and Returns in casuarina cultivation

(Per Hectare)

S. No	Cost and Return	Tie-up	Non-tie up
1.	Fixed cost (Rs)	44,016	38,590
2.	Variable cost (Rs)	1,56,014	78,300
3.	Total Cost of cultivation (Rs)	2,00,030	1,16,890
4.	Yield (Tonnes)	80	65
5.	Price(Rs/Ton)	4000	3500
6.	Income by sale of wood (A)	3,20,000	2,27,500
7.	Value of Pruned material during II and III year (B)	16,000	8000
8.	Gross Return (A+B)	3,36,000	2,35,500
9.	Net Profit after 3 years (Rs)	1,35,970	1,18,610
10.	Net Profit per annum (Rs)	45,323	39,537
11.	Cost of production (Rs/Tonne)	2500	1798

Table.3 Financial Feasibility of Eucalyptus and Casuarina cultivation

S. No.	Financial Indicators	Eucalyptus		Casuarina	
		Tie-up	Non-tie up	Tie up	Non-tie up
1.	NPV (Rs)	1,02,372	54,583	1,70,631	98,556
2.	BCR	2.18	1.65	2.93	2.15
3.	IRR (%)	60	42	135	91

Table.4 Regression coefficient of Cobb-Douglas Production Function - Eucalyptus

S. No	Explanatory Variables	Tie-up			Non-tie up		
		Regression Co efficient	Standard Error	t-ratio	Regression Co efficient	Standard Error	t-ratio
1.	Constant	2.73191	0.206	13.278	3.63122	0.918	3.955
2.	Human Labour (man days/Ha)	0.15921***	0.022	7.104	-0.066	0.046	-1.438
3.	Machinery (hrs/Ha)	-0.011**	0.005	-2.405	0.00674	0.008	0.857
4.	Seedling (Nos./Ha)	0.00183	0.015	0.121	0.20986**	0.107	1.965
5.	Fertilizer (kg/Ha)	0.17169***	0.017	10.274	-0.2426***	0.039	-6.165
6.	Number of Irrigations/ha	-0.0428	0.022	-1.909	0.06462**	0.029	2.194
7.	Plant protection(lit/Ha)	-0.0081***	0.003	-3.076	0.02153	0.018	1.223
8.	R^2	0.62841			0.65433		
9.	Adjusted R^2	0.60278			0.56415		
10.	F	24.521			7.256		
11	N=94				N=30		
12.	**Durbin-Watson = 2.185**				**Durbin-Watson = 1.344**		

***- Significant at one per cent level and **- Significant at five per cent level

Table.5 Regression coefficient of Cobb-Douglas Production Function – Casuarina

S. No	Explanatory Variables	Tie-up			Non-tie up		
		Regression Co efficient	Standard Error	t-ratio	Regression Co efficient	Standard Error	t-ratio
1.	Constant	3.62422	0.166	21.876	11.2041	8.476	1.322
2.	Human Labour (man days/Ha)	0.05983***	0.021	2.813	-0.0581	0.072	-0.812
3.	Machinery (hrs/Ha)	-0.0057***	0.002	-3.624	-0.0261***	0.005	-4.903
4.	Seedling(Nos./Ha)	-0.0258***	0.004	-6.137	-0.8612	1.043	-0.826
5.	Fertilizer (kg/Ha)	0.10927***	0.021	5.299	0.12546***	0.050	2.517
6.	Number of Irrigations/ha	0.01805***	0.003	7.058	-0.0751***	0.023	-3.275
7.	Plant protection(lit/Ha)	0.0058**	0.003	1.987	-0.0035	0.008	-0.465
8.	R^2	0.58155			0.76323		
9.	Adjusted R^2	0.55426			0.70146		
10.	F	21.309			12.357		
11.	N = 99				N = 30		
12.	**Durbin-Watson**	2.588			**Durbin-Watson**	2.093	

***- Significant at one per cent level and **- Significant at five per cent level

In case of casuarina cultivation, with respect to tie-up farmers, the NPV, BCR and IRR were in the order of Rs.1,70,631, and 2.93 and 135 per cent respectively and among non- tie up farmers, the indicators were Rs. 98,556, 2.15 and 91 per cent respectively. Thus, eucalyptus and casuarina cultivation is financially viable investment in the study area. However, between tie-up and non-tie up farmers, the former achieved a higher financial worthiness than the latter in both the pulp wood trees.

Production function

Production functions were fitted separately for crop wise and also for tie and non-tie up farmers in order to evaluate the factors influencing pulpwood cultivation and examine their relative influences. The Cobb-Douglas type of production function was used and the production elasticity was estimated accordingly. The production function was estimated by using Ordinary Least Squares (OLS) method. The estimated values of the regression coefficients were tested for statistical significance with the help as‘ t ’ test and the significance of the equation was tested by R^2. The independent variables used in eucalyptus and casuarina pulpwood production were human labour (man-days/ha), machine hours (hrs/ha), quantity of seedlings (number of seedlings/ha), inorganic fertilizer (kg/ha), number of irrigations/ha) and quantity of plant protection (litre /ha).

The results of production function analysis relating yield of pulpwood and factors influencing the yield of crop are presented in Table 4 and 5

It could be seen from the Table 4 that the coefficient of multiple determination (R^2) among tie-up farmers was 0.62 revealing that about 62 per cent of the variations in Eucalyptus yield is influenced by the explanatory variables included in the model. Among the various explanatory variables identified in the model, human labour and fertilizer were positively and significantly influencing yield of the crop. The variables like machinery hours, and plant protection chemicals engaged were negatively influencing the yield of the crop.

In terms of efficiency of inputs, engagement of additional man power by one per cent from existing mean level, *ceteris paribus* could increase the yield of Eucalyptus pulpwood by 0.05 per cent.

The coefficient of fertilizer was positive and significant with a coefficient value of 0.17. This implies that *ceteris paribus* a one per cent increase in fertilizer would increase the yield by 0.17 per cent. In the estimated production function for tie-up farmers, machinery and plant protection chemicals were found to be negatively and also significantly influencing the yield of crops.

It could be also seen from the Table 4 that the coefficient of multiple determination (R^2) among non-tie up farmers was 0.65 revealing that about 65 per cent of the variations in eucalyptus yield is influenced by the explanatory variables included in the model. Among the various explanatory variables identified in the model, seedlings and irrigation were positively and significantly influencing yield of the crop. The variable like fertilizer was negatively and also significantly influencing the yield of the crop.

In terms of efficiency of inputs, additional planting of seedlings and more irrigation by one per cent from existing mean level, *ceteris paribus* could increase the yield of eucalyptus pulpwood by 0.20 per cent and 0.06 per cent respectively. The coefficient of fertilizer was negative and significant with a coefficient value of 0.24. This implies that *ceteris*

paribus a one per cent increase in fertilizer would reduce the yield of the crop by 0.24 per cent.

It could be seen from the Table 5 that the coefficient of multiple determination (R^2) among tie-up farmers was 0.58 revealing that about 58 per cent of the variations in casuarina yield is influenced by the explanatory variables included in the model. Among the various explanatory variables identified in the model, human labour, fertilizer, irrigation and plant protection chemicals were positively and significantly influencing yield of the crop. The variables like number of seedlings and machinery engaged were negatively influencing the yield of the crop.

In terms of efficiency of inputs, engagement of additional man power by one per cent from existing mean level, *ceteris paribus* could increase the yield of casuarina pulpwood by 0.05 per cent. Similarly, an increase in one per cent level of fertilizer would increase the yield by 0.10 per cent *ceteris paribus.* The coefficient of irrigation and plant protection were positive and significant with a coefficient value of 0.02 and 0.01 respectively. This implies that *ceteris paribus* a one per cent increase in irrigation would increase the yield of the crop by 0.02 per cent and one per cent increase in plant protection would increase the yield by 0.01 per cent. In the estimated production function for tie-up farmers, machinery and seedlings were found to be negatively and also significantly influencing the yield of crops.

It could be also seen from the Table 5 that the coefficient of multiple determination (R^2) among non-tieup farmers was 0.76 revealing that about 76 per cent of the variations in casuarina yield is influenced by the explanatory variables included in the model. Among the various explanatory variables identified in the model, fertilizer was positively and significantly influencing yield of the crop. The variables like machinery and irrigation were negatively and also significantly influencing the yield of the crop.

In terms of efficiency of inputs, additional application of fertilizer by one per cent from existing mean level, *ceteris paribus* could increase the yield of casuarina pulpwood by 0.12 per cent. The coefficient of machinery and irrigation were negative and significant with a coefficient value of 0.76 and 0.02 respectively. This implies that *ceteris paribus* a one per cent increase in machinery and irrigation would reduce the yield of the crop by 0.76 per cent and 0.02 per cent respectively.

The tie-up farmers sold their output to the paper industries and non-tie up farmers sold their output to timber merchants and paper industries.

The local trader played a major role in marketing of the pulpwood in the case of non-tie up farmers**.** In case of tie-up farmers, the research institutions also played significant role in advising site-specific clones coupled with the technical support on pre and post plantations activities which helped both the growers and Plantation Supervisors posted by the industries. Tree Insurance programme was introduced and the protection covers damages due to almost all biotic and abiotic components which attracted many farmers towards tree husbandry.

The existing value chain on industrial agroforestry involved multipartite stake holders wherein the farmers or growers got the minimal revenue and the middleman along with the traders are getting maximum benefits out of this supply chain. Hence, the interface on industrial agroforestry has been introduced wherein the growers get maximum

benefit. Therefore, current tie-up resulted in maximum net revenue to the growers besides getting additional revenue from the value addition due to briquetting technology.

The estimation of cost of cultivation of eucalyptus and casuarina indicated that cultivation of these pulpwood trees are profitable and financially feasible. Compared to non-tie up farmers, the tie-up farmers were able to realize higher profit due to the farmer-industry interface. However, between tie-up and non-tie up farmers, the tie-up farmers achieved a higher financial worthiness than the non-tie up farmers in both the pulp wood trees Moreover, the production function estimates indicated that the cultivation is labour intensive and inputs like density of planting irrigation, fertilizer and plant protection chemicals significantly influenced the cultivation of both the pulpwood.

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