



Research Paper

## OPTIMIZATION OF COST FOR FARMERS OF COTTON BASED FARMING SYSTEM BY LINEAR PROGRAMMING MODEL

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This paper illustrates the use of minimum cost linear programming technique for optimizing resources for the Vidarbha farmers. It compares the optimum farm planning developed by minimum cost strategies of management on small medium and large categories of farms and discusses the interrelationship between crop allocations made by the LP model and the existing farmer's practice.

**Keywords:** Linear programming, Profit maximization, Cost minimization, Agricultural crops

### INTRODUCTION

Productivity of a system is the output produced per unit of input injected into it. In agricultural systems too, the concern is of increasing output per unit of input. If the present resource use by the farmers is inefficient (Majumdar and Gole, 2007) then the production could be increased by making suitable adjustments in the use of factors of production in the optimal direction. On the contrary, if the present resource use is efficient then the production can be increased by technological intervention. Vidarbha region in Maharashtra is mainly rainfed (i.e., agriculture depends on monsoon rains, and there is few or no irrigation facilities available for cropping activities), the profit levels are low as compared to irrigated crops. Therefore, optimum cropping pattern must be developed for maximizing profit in this area.

However, with the recent escalation in agricultural input costs and the consequent rise in cost of production, the farmers are greatly concerned with strategies for minimization of cost. The cropping pattern followed by the farmers of the region has been evolved through experience gained and inherited through generations. A critical examination from a scientific point of view is necessary to evolve optimal agricultural production patterns. Resource allocation is one of the major elements in reorganizing cropping systems.

An effort is made in this study to suggest optimum cropping plans with minimum cost for the Cotton based cropping systems of Vidarbha region, where cotton is the main crop along with other subsidiary crops. The plans are developed for average Small,

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Medium and Large farms, with the objective of minimization of the cost of cultivation from the available resources of Land, Labour (male, female, bullock pair), Irrigation and Capital. The study is based on farmers' data on cost of cultivation of prevalent crops in the region. Input-output coefficients were worked out for all enterprises for the small and medium average farm situations. The data were analyzed using the Linear Programming (LP) technique for minimization of cost (Miller and Nauheim, 1964).

## MATERIALS AND METHODS

A Linear Programming (LP) approach has been used for the farming situations and the constraints in the region. The benefits of using LP have been demonstrated by several researchers (Sankhayan and Cheema, 1991; and Goswami, 2002). Data on cost of production, yield, prices, availability of labour (male, female, bullock pair), irrigation and capital, were collected from 100 farmers in twin villages of Telgaon and Tishti in Nagpur district by simple random sampling method. Linear programming models were constructed for minimization of cost in the objective function. Plans were developed for an average small, medium and large sized farms consisting of 4.3, 9.6 and 24.3 acres gross cultivated area respectively. Agriculture in Vidarbha is entirely dependent on rain in summer months. In winter 0.6, 2.9 and 8.6 acres of small, medium and large sized farms group respectively, could be irrigated by well and other sources on the farms in the study area. Popular crops in rainy season (kharif) are cotton intercropped with pigeonpea (8:1 rows), sorghum, and soybean; and wheat, chickpea in winter (rabi). Cotton+pigeonpea are annual crops i.e., they extend into winter (rabi) months and do not vacate field for cultivation of subsequent winter month crops of wheat and chickpea. The latter crops can

be grown after soybean in rainy season (kharif) which terminates early and vacates field for these crops. Therefore, the winter (rabi) crops of wheat and chickpea can be grown provided land equal to the area of these crops will be grown in winter, is left either fallow (vacant) in kharif or is cultivated with soybean or sorghum. Seven crop activities considered in the plan are Cotton+pigeonpea, sorghum, soybean, fallow-wheat, fallow-chickpea, soybean-wheat and soybean-chickpea.

The initial run of the LP model revealed that most of the available male labour and bullock labour remained unutilized and available capital and female labour were the only two limiting resources causing under-utilization of all other resources in all the farming situations. Therefore, available female labour was broken into six periods of crop growing activity i.e., April-May, June-July, Aug-Sept, Oct-Nov, Dec-Jan and Feb-March, and respective female labour constraint added into the model to see where it was most limiting and needed to be supplemented by hiring additional female labour. Consequently, six female labour hiring activities were incorporated into the model causing complete utilization of the available capital. Study was made with minimization of variable cost per unit area of the cropping activities in the objective function of LP model. Keeping the profit level same as the existing farmer's practice to test the existence of resource allocative inefficiencies.

## RESULTS AND DISCUSSION

**Small farms:** The small farms were found to be more efficient in allocating their limited resources. Because of their small size the labour provided by family and bullock power available was not found to be a limiting factor to maximization of profit. The farmers tried

to allocate the entire land 4.3 acres available with him to the crops viz., 3.3 acres to cotton-tur, 0.1 acre to jowar, 0.3 acre to soybean & 0.5 acres to fallow-wheat. However, in the LP run only 3.51 acres are allocated to cotton-tur only out of 4.3 acres. It means that the existing resources could be sufficient for 3.51 acres of land to reach the level of profit as got by the farmer. In order to bring in the entire land under cropping the farmers has to borrow money in his existing plan. No resources needed to be hired in either of the plan. With the use of cost minimizing model under LP for small farm the percentage reduction in cost with existing plan was found to be 9.59 %.

**Medium farms:** In the initial run of the model, cotton-pigeonpea and fallow-chickpea entered the plan with 4.24 acres of kharif land and 2.9 acres of rabi land respectively. Land in rabi, and female labour resources were completely consumed, however all other resources i.e., kharif land, capital, male labour and bullock pair remained underutilized. Female labour constraining periods could be identified by breaking the availability into different periods and incorporating female labour hiring activities in these periods. In the farmers plan, the entire land of 9.3 acres is brought into cultivation by allocating various crops as shown in table 2. However, the minimization of cost by LP utilizing existing resources, limits the area allocation to only 6.17 acres having 3.13 acres vacant, still maintaining the same level of profit for the farmer. In order to bring the entire land under cultivation the farmer in this existing plan has to hire 256 female labours as against the 44 in the LP model. Loans, He needed to borrow Rs. 8804 as loan at 10 % interest rate to do so. With the use of cost minimizing model the cost percentage reduction for medium farms was found to be 37 % with existing farmers plan.

**Large farms:** Crop allocation for large farm is shown in table 3 for the existing practice of the farmer and the LP model for minimization of cost. It can be seen that with minimization LP model only cotton-tur enters the optimum plan with 7.34 acres in the kharif & the entire rabi irrigated land of 8.6 acres is allocated to fallow-gram with the available resources at current levels of returns. The plan only allocates 15.9 acres of land as against 22.6 acres allocated to various crops by the farmer. However, in the process he hired 1086 female labour days against as 477 in the LP run. This also necessitated him to borrow a capital of Rs. 27496 at 10 % interest rate. The cost reduction by using LP model is 31 % for existing farmers plan.

Base Model		m
	Minimize	$C = \sum_{i=1} C_i x_i$
		i = 1
Subject to:-		
	7	
	$\sum x_i \leq L$	for all i
Land Constraint	i = 1	
	7	
	$\sum x_i \leq IL$	for all i = 4,5,6,7
Irrigation Constraint	i = 1	
	7	
	$\sum P_i x_i \rightarrow K$	for all i
Capital Constraint	i = 1	
	7	
	$\sum m_i x_i \leq MD$	for all i
Male Labour Constraint	i = 1	

7

$$\sum_{i=1}^7 flix_i \leq \text{FLD for all } i$$

Female Labour Constraint

$i = 1$

7

$$\sum_{i=1}^7 blix_i \leq \text{BD for all } i$$

Bullock Labour Constraint

$i = 1$

and

$$X_i \geq 0 \text{ for all } i$$

Where:  $i$  = Subscript used for crop activities ( $i = 1, 2, \dots, 7$ )

Decision Variables

$C$  = Variable costs for crop activities.

$x_i$  = Area to be allocated for  $i$ th

crop

Table 1 Small farms

Table 2 Medium Farms

Table 3 Large Farms

Sl. No.	Particulars	Farmers Existing Practice	Minimization of cost With LP
1	Cotton+Tur (acres)	3.3	3.51
2	Jowar (acres)	0.1	0
3	Soybean (acres)	0.3	0
4	Fallow-Wheat (acres)	0.5	0
5	Soybean-Wheat(acres)		0
6	Interest on Capital Borrowed (Rs)	90.1	0
7	Labour hired (female days)	0	0
8	Cost, Rs.	20401	18444.72
9	% reduction in Cost, Rs.		9.59

**Table 2: Comparison for Medium Size Farms**

Sl. No.	Particulars	Farmers Existing Practice	Minimization of cost With LP
1	Cotton+Tur (acres)	5.7	3.27
2	Jowar (acres)	0.1	0
3	Soybean (acres)	0.8	0
4	Fallow-Wheat (acres)	2.1	0
5	Fallow-Chana (acres)	0.6	2.9
6	Soybean-Wheat(acres)	-	0
7	Soybean-Chana (acres)	-	0
8	Labour Hired (female days)	256	44
9	Capital Borrowed (Rs)	8804	0
10	Cost Rs.	44689	28056.72
11	% Reduction in Cost. Rs.		37

**Table 3: Comparison for Large Size Farms**

Sl. No.	Particulars	Existing Plan	Minimization of cost With LP
1	Cotton+Tur (acres)	12.1	7.34
2	Jowar (acres)	0.7	0
3	Soybean (acres)	2.9	0
4	Fallow-Wheat (acres)	4.6	0
5	Fallow-Chana (acres)	2.3	8.6
6	Soybean-Wheat(acres)	-	0
7	Soybean-Chana (acres)	-	0
8	Labour Hired (female days)	1086	477
9	Capital Borrowed (Rs)	27496	0
10	Cost, Rs.	103992	71547.20
11	% reduction in Cost, Rs.		31

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