



Evaluation of Optimal Cost Structure in Agriculture in Raigad District using Linear Programming Model

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Abstract

Agriculture bears a larger impact on India's economy, especially on the livelihoods of rural areas. While cultivating the crops, farmers have to keep in mind about the costs incurred in the whole process. This research studies about the costs invested in agriculture by farmers in order to optimize the costs using a mathematical model- linear programming. In particular Raigad district was taken for this research and a survey of 25 farms was conducted. This study resulted in minimum costs can be invested, if linear programming is applied, as compared to their traditional method. The analysis shows a significant difference in the costs invested in traditional method and linear programming method.

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Keywords: *Agriculture, Linear Programming, minimum costs, MATLAB.*

Introduction:

Agriculture is a practice of harvesting the land, cultivating crops and upraising animals. According to Merriam-Webster dictionary agriculture is the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products. For many decades, Agriculture has been an important sector to our country's economy. In the Agricultural sector, Maharashtra has been contributing crop cultivation at a higher level. Major crops that are harvested in this state are jowar, rice, bajra, wheat, moong, tur, urad, gram lentils and many other varieties of pulses. And not only these but many fruits are cultivated here according to the seasons. Agriculture is a main source of livelihood for rural people in India. The rural areas are majorly relied on this occupation. Farming is one of the main sources of food for people in rural areas. Agriculture contributes to nearly 25% of Gross Domestic Product, almost 82% of the rural population depends on agriculture for livelihood. The crops that are cultivated throughout the season are being consumed for the whole year. Agriculture holds the accountability of contribution for household food and nutritional safeguard to our population.

Agricultural planning is an important aspect as it gives the optimal crop pattern for minimization of costs or maximization of profits. Linear programming is one such tool used for minimization or maximization of objective function and it is used in various sectors including transportation, industrial activities, and allocation problems. This research is being carried out to study the agricultural expenditure, their costs, and the required outcome in Raigad district. Here in Raigad the agriculture is dependent on rainfall, there are no water resources available. However, the farmers are concerned with the cost required to do the farming. The cost includes labors, fertilizers and seeds. Thus, this research studies on minimizing the cost keeping the profit same. Linear programming is a mathematical model for determining a way to achieve the best outcome (maximum profit or

lowest cost) in a given mathematical model. Moreover, linear programming is a technique for the optimization of a linear objective function, subject to linear equality and linear inequality constraints.

Origin of the Research Problem:

The main idea of this research project is to explore different problems faced by the farmers in terms of investment in their farming and optimize their cost in agriculture. In Raigad district, farmers mostly use their own cultivation for consumption rather than selling them. And hence it is necessary for them to optimize their costs. The farmers use the trial-and-error method to do the farming and as per this method they end up getting less profit and more cost is incurred in their farming every year. And hence planning of better allocation of resources in agriculture is necessary for either less cost input or more profit output. Agriculture planning and resource allocation is significant in optimizing farming costs. Thus, the study is carried out to analyze the crop pattern in the various fields of the Raigad district.

Rationale:

This research proposal investigates the problem arising in farmers' low-income source in agriculture, the expenditure is indirectly proportional to the profit. This proposal studies the high-cost investment by the farmers according to their expenses, resource material i.e., land, labour, seeds and fertilizer. This proposal analyses the cost minimization and optimal solution to this problem using a mathematical model. To evaluate the optimal cost structure and crop pattern per hectare, various factors are taken into account. As a result, the area of each crop is identified, so that, in combining them to derive minimum cost level. And hence it observes the production of which crops to be cultivated per hectare in order to minimize the cost. In this proposal, a linear programming method is used for optimizing costs, investigating whether, after applying the mathematical model, the cost decreased or not. The data collected for this proposal are from local farmers residing in the Raigad district. However, the practical application of this model is limited due to insufficient data and less awareness among the farmers about this approach. This requires data samples from many resources in order to see the efficiency of this model.

Interdisciplinary Relevance:

As this research studies minimizing the cost incurred in agriculture using limited resources such as land allocation, crop pattern, labor and fertilizers. Not only this has to be taken into account, the quality of soil and the nature of soil also plays an important in agriculture. The geographical condition of the land will help to understand more about the crops to be cultivated, which climatic condition is suitable for any particular crops. Along with this economic analysis is also required for agriculture. Maximization of profit has to be done then involvement of economic analysis is necessary. Thus, this research project has wide interdisciplinary connectivity and relevance in today's world.

Literature Review:

Thomas A. Miller and Charles W. Nauheim have applied linear programming model to cost minimizing farm management strategies with reference to the Great Plains wheat farms. They have demonstrated the use of minimum cost model via linear programming. It compares the minimum cost and profit maximizing strategies of management on the same farm.

In this paper mathematical model of optimal agri- cultural production plan is derived and applied on small farm which is located in west Vojvodina. In order to construct more realistic model of optimal crop distribution and deal with crop rotation, the special case of integer optimization, the knapsack problem is used. It is assumed that farmer on one plot sows only one type of crop In this paper mathematical model of optimal agri- cultural production plan is derived and applied on small farm which is located in west Vojvodina. In order to construct more realistic model of optimal crop distribution and deal with crop rotation, the special case of integer optimization, the knapsack problem is used. It is assumed that farmer on one plot sows only one type of crop In this paper mathematical model of optimal agri- cultural production plan is derived and applied on small farm which is located in west Vojvodina. In order to construct more realistic model of optimal crop distribution and deal with crop rotation, the special case of integer optimization, the knapsack problem is used. It is assumed that farmer on one plot sows only one type of crop Zoltan Pap (2008) has derived a mathematical model of optimal agricultural production plan and applied on small farm which is located in west Vojvodina. In order to

construct a more realistic model of optimal crop distribution and deal with crop rotation, the special case of integer optimization, the knapsack problem is used. It is assumed that farmer on one plot sows only one type of crop.

Scott R. Jeffrey, Ron R. Gibson & Merle D. Faminow discuss a technique that can be used with linear programming to obtain near to optimal solutions using computer software. This technique was demonstrated with a problem in agricultural planning and decision making: livestock ration analysis.

A V Gadge, A P Kedar and K R Aglawe (2014) applied the linear programming model to optimize the cost for farmers of cotton-based farming systems required for small, medium and large farms. It studies the seasonal cultivation broken in six months of duration and over 5-6 crops cultivation. It has used the linear programming model to compare their costs after applying this model. They have also compared the costs before and after applying the linear programming model. In this study, they have taken into account the geographical conditions as Vidarbha has less rainfall.

Alanoud Alotaibi and Farrukh Nadeem (2021) have reviewed application of linear programming to optimize agricultural solutions. They have acknowledged the importance of economizing on available resources among them being water supply, labour, and fertilizers. Their study has focused mainly on maximizing the profits.

Significance of the Study:

This study gives an analysis of cost incurred in agriculture and a comparative study of before and after applying linear programming in cost investment by the farmers. This study focuses on cost minimization rather than maximizing the profits as the farmers in Raigad district use the cultivation for their own consumption, hence it is beneficial for the farmers as their expenditure would be less in linear programming model than their traditional method. After applying linear programming to this problem, it will give the minimal costs required for the farm yields. The farmers would have to invest less than usual according to their expenditure. This method will also identify the crops which requires more costing and hence less production of those crops has to be cultivated. If this method is applied in agriculture, the farmers would gain an optimal amount in crop production.

This research will impact farmers for using this model in future in order to minimize their costs. This study can also be used by any other farmers in the country to minimize their costs keeping the profits same. This will also push for innovation in the agriculture sector by mathematical models such as linear programming. This will improve the avenues for the farmers, still many farmers are using their traditional way for crop production without knowing the optimal profit each crop is receiving. This research will create awareness about their revenues.

Objective:

1. To apply linear programming for optimal use of raw material in agriculture.
2. To minimize the costs with limited resources available.
3. To get an optimal production structure in order to minimize the costs.
4. To examine whether cost decreased after implementing the model.
5. To compare the cost invested before and after applying a linear programming model.

Research Methodology:

The methodology of the study includes sample size, sampling technique and survey, data collection procedure and analysis.

The data required for this research is collected from the local farmers residing in Raigad District. A survey has been conducted to collect the data from various farms and the questionnaire has been prepared for the same. The mathematical model that is being used by the investigator for this research is linear programming. We will compare the cost invested in agriculture by the traditional way and by linear programming model keeping the profit the same.

For formulating linear programming problems, we require decision variables (whose values are to be found out after solving), objective function, and constraints

Let $x_1, x_2, x_3, \dots, x_n$ be the n decision variables, then the mathematical formulation of linear programming is as follows:

$$\text{Minimize } Z = \sum_{i=0}^n C_i x_i \quad (1)$$

Subject to the constraints

(2)

$$\begin{aligned}
 \sum_{i=0}^n x_i &\leq b_j && \text{..... Land constraints} \\
 \sum_{i=0}^n a_i x_i &\leq b_j && \text{..... Labour constraints} \\
 \sum_{i=0}^n a_i x_i &\geq b_j && \text{..... Fertilizer constraints} \\
 \sum_{i=0}^n a_i x_i &\geq b_j && \text{..... Seeds constraints}
 \end{aligned}$$

And non- negative restrictions,

$$x_i \geq 0 \tag{3}$$

Where Z is the objective function to be minimized.

C_i is the cost incurred in crop per hectare.

x_i is the size of the farm per crop.

a_i is the quantity of resource required to produce per hectare of crop.

b_j is the amount of resources available.

Here the equation (1) is the objective function which is to be optimized, equations (2) are the constraints and equations (3) are non-negative restrictions.

The data collection regarding the resources such as availability of land, labour, seeds per hectare and fertilizers required for each of the cultivated crops. MATLAB software with optimization toolbox has been used to analyse the result of the linear programming model.

Firstly, a questionnaire has been built according to the data requirement. In the questionnaire, questions were regarding the crops cultivated, the area required for particular crops, amount invested overall for the cultivation as well as the for each crop, fertilizers to be used for every crop, number of labors required to do the farming and quantity of seeds required for every crop.

Next the data collected was analyzed in the linear programming model. The land required, seeds, fertilizers, labors, cost invested were constructed into the linear programming model as per our constraints and decision variables. For the analysis of the data, MATLAB with optimization toolbox was used and the data was analyzed.

After the analysis, a comparison was taken of a solution from Linear programming with the traditional method. In the comparison, it was found that there was a subsequent decrease in the amount invested.

Following is the analysis of data collected from a farm in Nere, Panvel:

Sr. no.		Farmers practice	LP solution
1.	Crop1(acres)	2	2
2.	Crop2(acres)	2	0
3.	Crop3(acres)	1	3
4.	Cost	9000/-	8000/-
	Minimization in costs		11.11%

Conclusion:

In this research, a linear programming model was used for the optimal cost structure in agriculture for the farmers of Raigad District, Maharashtra. The objective was to minimize the cost invested in farming by optimal resource allocation. The model suggested a decrease in the costs incurred by using the model compared to the traditional way used by the farmer. The comparative analysis showed a subsequent reduction implying this method can be used by the farmers in agriculture.

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