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Bhawana Matsyapal
PG Student, Department of Agricultural Statistics and Social Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Lakhera ML
Professor, Department of Agricultural Statistics and Social Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Pathak H
Assistant Professor, Department of Agricultural Economics, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Correspondence
Bhawana Matsyapal
PG Student, Department of Agricultural Statistics and Social Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Determination of cropping pattern for marginal farmers of Dhamtari district of Chhattisgarh

Bhawana Matsyapal, Lakhera ML and Pathak H

Abstract
Linear programming approach has been used for studies in optimum resource allocation and resource requirements in many countries. Cropping pattern applied by the farmer is one of the key activity for improving his income. A survey was conducted to know the cropping pattern used by the farmers of Dhamtari district to know the optimum cropping pattern for them and thereafter its effect on income. Simple random sampling technique were applied to sample farmers of Dhamtari district. Optimum solution with the land holding capital investment and labour as constraints were found. Crops included in the model were Rice, Gram, til and arhar. The maximum profit may be gained according to the proposed optimal pattern. The simplex method of solution linear programming was applied for getting the optimal solution. The optimal solution found as cropping pattern Rice-arhar, Rice-til, Rice-gram was the best pattern. The results obtained by using the linear programming model were more superior. The hike in gross income was 3.33%.

Keywords: LPP, cropping pattern, optimal income

Introduction
Linear programming is a method to achieve the best outcome (such as maximum profit or minimum cost) in a mathematical model whose requirement are represented by linear relationship. Linear programming is a special case of mathematical programming. Linear programming can be applied to various fields of study. It is widely used in business and economics, and it is also utilized for some engineering problems. Linear programming techniques have been widely used by agricultural economists. Despite its limitations the method has proved very useful in studying the decision making process in the agricultural sector.

Marginal scale farmers are facing complex decision making problems in every growing season. Before going to field they has to decide the crop to grow and such cropping plan. Cropping plan may involve choice of crop, variety, fertilizer etc. Various modelling approaches have been applied to optimize the cropping pattern worldwide including the linear and nonlinear optimization models (Haouari and Azaiez 2001; Singh *et al.* 2001) [1, 13]. Hassan *et al*. (2005) [2] reported that farmers profit cannot be maximized without optimum cropping patterns, which ensure efficient utilization of available resources; and so the use of LP makes it possible to devise equilibrium solution, which include the specification of products levels, factor and product prices. Linear programming (LP) has proved a very flexible tool for modelling these kinds of complexities (Hazell and Norton, 1986) [4].

The quantities of yield produced from agriculture farms and demand for that commodity influence the market prices significantly. Generally farmers follow a traditional method for a cropping pattern or allocation of land to various crops varies depending on the available resources. Thus for each cultivation pattern of crops, maximization of the profit will be the major objective of any farmer. This study aimed to determine which of these cropping pattern is best suit for increase farmer's income level under limitation and constraints in Dhamtari.

Materials and Methods
Study area
Dhamtari district lies between 20°42' N Latitude and 81°33' E Longitude. Dhamtari district consists of four districts *viz.*, Dhamtari, Kurud, Nagari and Magarlod. The total area of the district is 2029 Sq. Km. The District is surrounded by District Raipur in North and District Kanker as well as Bastar in South, part of Orissa state in East and District Durg and Kanker in West. Mahanadi is the principal river of this district.The fertility of lands of Dhamtari district can be attributed to the presence of the rivers Pairy, Sondur, Kharun and Shivnath. The chief crop of this region is Rice. However, gram,til and arhar also grown in the district.

The crop farming pattern in the district is Rice sole, rice-arhar, rice-gram, and rice-til. Average annual rainfall of the district is about 1485mm.

The present investigation was carried out at the Department of Agriculture Statistics and Social Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during 2016-2017.

Selection of sample

The data are collected from 14 farmers from the Dhamtari district via face-to-face interview. These farmers are selected based on the reason that the major crops grown in the study area are cropped by these farmers. Simple random sample procedure was applied for the selection of the sample. A list of farmers from Dhamtari district was prepared. Out of the list samples were taken with the following technique. A pre study sample of 20 farmers was selected to know the variability among the farmers and then the final sample farmers were selected keeping 5% Margin of error. The confidence level was set as 95%. Hence using the following formula for sample size for the determination sample size for the study

$$n = \frac{z^2 \times S^2}{ME^2}$$

Where, z = 1.96,
S^2 =Estimated population variance and
ME = Margin of error

The model

Linear Programming Model of the following form is used as an analytical tool to explore the possibilities of optimizing farm returns.

Problem formulation

Maximize: $Z = \sum_{i=1}^{n} N_i X_i \; i = 1,2,3 \ldots \ldots \ldots n$

Where Z = The total net returns from all the crops (Rs)
N = The number of crops
N_i = The net return from *i*th crop (Rs)
X_i = The area under *i*th crop (ha)

Constraints

Subject to: (1) Land usage: $\sum_{i=1}^{n} X_i \leq TA$
where TA=Total land area under cultivation of crops in (ha)
(2) Capital: $Z = \sum_{j=1}^{n} C_i X_i \leq TC$

where C_i=Total capital requirement for *i*th crop (Rs)
TC = Total capital requirement for all the crops (Rs)
(3) Labor: $\sum_{i=0}^{n} L_i X_i \leq TL$

where L_i=Total labour requirement for *i*th crop (Rs)
TC = Total labour requirement for all the crops (Rs)

Non-negativity

$X_i \geq 0$ for i =1,2,3…., n

Results and Discussions

Table 1: Socioeconomic Characteristics of farm families

Variables	Minimum	Maximum	Mean	SD
Education	1	2	1.57	0.51
Age	28	75	52.5	12.84
Family size	2	4	2.87	0.86

Table 1 represent the socioeconomic characteristics of farm families which showed that the mean age was 52 years for farmers. The age in the study area was found to be minimum of 28 years and maximum of 75 years in marginal scale farmer. The trend can be attributed to the fact that due to urbanization the youth is more driven non-agricultural allied jobs. Since farming has been followed from age old days in the families the older age group are more involved in the farming activities. Nwaru (2004) [6] had earlier opined that the ability of a farmer to bear risk, be innovative and able to do manual work decreases with age. However, there is need to motivate and stimulate more youths to take up agriculture to stabilize this age gap. This opinion is truly following in present case.

The education in the study area was found to be minimally illiterate and maximum of primary school in marginal scale farmer. For education, the SD for marginal scale farmer was found to be 0.51 and it was 12.84 and 0.86 for age and family size respectively.

Table 2: Existing and Optimum Cropping Patterns of selected marginal farmers

No. of Farmers	Cropping Pattern	Existing pattern (ha)		Optimal Pattern (ha)	
		Size of Farm	Percentage (%)coverage	Size of Farm	Percentage (%)coverage
1	Rice, arhar	0.81	9.33	1.31	15.25
2	Rice, arhar	0.81	9.33	1.60	18.66
3	Rice, arhar	0.81	9.33	0.37	4.22
4	hybrid Rice	0.81	9.33	0.00	0.00
5	Rice, til	0.40	4.61	0.00	0.00
6	Rice, til	0.81	9.33	1.74	20.30
7	Rice, til	0.61	7.03	0.00	0.00
8	Rice	0.40	4.60	0.00	0.00
9	Rice	0.40	4.60	0.00	0.00
10	Arhar	0.40	4.60	0.00	0.00
11	Arhar	0.40	4.60	0.00	0.00
12	Rice,gram	0.40	4.60	1.00	11.73
13	Gram	0.81	9.33	0.82	9.50
14	Gram	0.81	9.33	1.73	20.30
	Total	8.70		8.57	

The average size of land holding was 0.62 hectares. Lack of irrigation facilities and traditional practices attributed to low cropping intensity and poverty. This shows that the land is intensely fragmented in the Dhamtari district which prevents the large scale production. The existing and optimum cropping patterns for the marginal farmers of Dhamtari district are presented in Table 2 Data revealed that Rice-arhar cropping system covers maximum area (0.81 ha) by marginal farmers. Rice-til cropping pattern is second pattern of choice of the farmers. Though Gram sole also covers 0.81 ha area by two farmers it has potential for getting more returns to the farmers. Optimal solution of the cropping pattern also suggested the Gram crop to include in the cropping pattern. It has been observed from the table that the cropping patterns Rice-arhar, Rice-til, Rice-gram was the best pattern. It suggested maximum profit may be gained through Rice-til followed by gram sole and Rice- arhar cropping system. Optimal solution also suggested that the sole crop pattern for rice, arhar should be avoided.

Similar study carried out by K.C. Igwe (2012) [5] The result suggested that 0.31 hectare of yam/maize/melon, 0.33 hectare of cassava/maize/cocoyam and 1.30 hectares of cassava/maize/melon/*mucuna floanei* while 0.14 of 500 birds (70.00 birds) of broiler II, 0.11 of 1000 fish (110.00 fish) of fish II and 0.07 of 15 pigs (1.05 pigs).

Table 3: Gross Margin for Existing and Optimum Plans for the marginal farmers Gross Margin for Existing and Optimum Plans for the farmers

Existing plan (`)	Optimal plan (`)	Increase/decrease (`)	Over
12,71,920	13,14,326	42,406	3.33%

Table 3 shows the gross margin for existing and optimum plans for selected farmers. Results revealed that optimum plans resulted in an increase in gross margin over the existing plan by 3.33%

Conclusion

Rice- arhar cropping pattern was the optimum cropping pattern. Rice, til cropping pattern was the second optimum option for the marginal farmers. Optimal solution also suggested that the sole crop pattern for Rice, arhar should be avoided. Optimal solution for marginal farmers gives the maximum profit gain. That increases the profit by 3.33%.

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