Linear Programming Approach- Application in Agriculture

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Abstract— In real scenario farm planning in terms of water management, the type of crop to be grown, the crop combination and different agricultural techniques applied to increase the farm production are the challenges faced by decision makers. These challenges are further being associated with socio -economic development and the scarcity of resources in particular region. To overcome these problems faced by farm linear programming technique is applied in order to optimize the farm's returns by allocating the available farm resources optimally. The aim of the study is to develop a farm model for Jaipur District of Rajasthan by using linear programming in order to determine the feasible optimal crop combination and how these crops will be allocated to increase the production.

Index Terms—crop combination, farm planning, linear programming

I. INTRODUCTION

Agriculture sector plays a vital role in social and economic development of India. The overall development of a sector depends on available land and water resources. Proper utilization of land and water resources is very important for optimum agricultural production. This requires proper allocation of resources in a farm. Farmers have to take a complex decision as to what to grow, suitable season, available farm techniques and the required quantity. Decisions are made subject to the prevailing physical and financial farm conditions but an uncertainty still prevails in a planning horizon ahead in this sector. Uncertainty may arise in the yield, cost of resources such as labor, seeds, manures and fertilizers. Due to the complexity of the agricultural sector a mathematical programming approach is applied to develop a farm model that represents complete farm subject to the constraints in terms of mathematical equations. Farm planning can assist the farmers in allocating the available resources in an optimal manner. Management of water resources and allocation of land under limited resources such as labor, fertilizers, seeds, etc.is one of the major issues in farm model that needs to be optimized. Generally, allocation of land under each crop is based on the land area that is used to be cultivated in previous season, depending on the availability of resources. Hence, both land and water resources for different crops needs to be optimized by allocating the resources efficiently to obtain the maximum production. But maximization of production does not guarantee the maximization of profit Thus, it can be concluded that linear programming approach is one of the tools to optimize the decision variables that provide us with the combination of farm enterprise that is feasible with respect to the set of fixed farm constraints.

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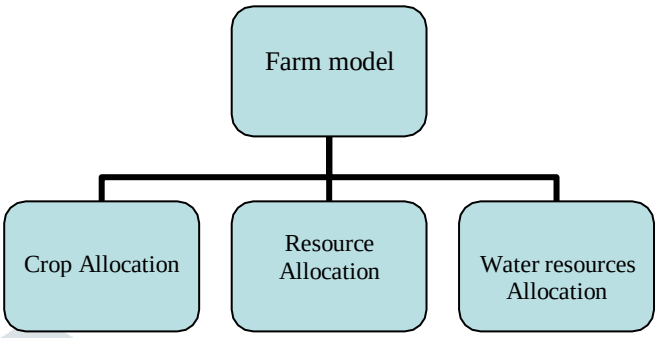

Fig1: Farm Model

II. LITERATURE REVIEW

Linear programming is an optimizing technique which is widely used to allocate the resources optimally in order to increase the production. Pap Zoltan [1] [2008] Developed a linear programming model for an agricultural farm to maximize the total gross margin by adopting crop rotation policy The results of the study reveals that the income obtain by applying linear programming model is more than that obtain by binary crop rotation model. Raniraghavay & Dr. Rao Tirupathi P. [2] [2012] develop three multi objective mathematical model for two seasons depending upon the availability of water resources and the results reveals that optimization approach improves the annual net benefits of the farm under study. MajekeF.et.al. [3] [2013] develops a linear programming model to overcome the problem of allocation of resources faced by the resettled farmers in Bindura, Zimbabwe in order to enhance the farm' income. Sofi, N. A. et.al. [4] [2015] use simplex algorithm to determine the solution of a linear programming model developed to determine the allocation of land to optimise the farm productivity. A linear programming crop mix model for a finite time planning horizon under limited available resources such as budget and land acreage, acrop-mix planning model was formulated in order to maximize the total returns at the end of planning horizon

[5] [Mohamad Hj. Nordin and Fatimah Said]. Kulshrestha S.K [6] observes that the growth of cereals depends on the wheat. The wheat production in Rajasthan is double than the cropped area shows that the yield had improved over a time.

III. STUDY AREA

Jaipur District is located at 26°55′10″ N to 75°47′16″ E Total geographical region of the state is 1106148 ha .Most of the people are engaged in primary sector especially those that resides in rural regions. Net sown area of the district is about 663167 ha and gross sown area is about 848313 ha. Major Kharif crops of the region includes Groundnut, Bajra, Kharif Pulses and the crops cultivated in Rabi season are Wheat, Mustard, Barley & Gram.

Tomato, Pea, Chili, Brinjal, Cabbage, Cauliflower etc. are

cultivated. Ber, Aonla, Bael, Guava, Lemon etc. are important fruit crops of the district [7].

Jaipur has a semi-arid climate. Temperatures vary in different seasons. In the summer months of April to June, average daily temperature of around 35ºC. May and June are the hottest months in Jaipur. Temperature reaches up to 40-45ºC in these months. Annually the rainfall is concentrated in the monsoon months between June (Last of June) and September. It receives over 500 mm (approx 20 inch) of rainfall an average. The winter months of November to February are mild and pleasant, with average temperatures in the 15-18ºC range and little or no humidity. December and January are the coldest months in Jaipur. Temperature varies between 5-10ºC in these months. There are however occasional cold waves that lead to temperatures near freezing [8].

Table 1: **Area, Production and Productivity of major crops cultivated in the district [7]**

Crop	Area (ha)	Production (ton)	Productivity (kg/ha)
Pearl millet	297162	486981	1639
Sorghum	40478	23175	573
Green Gram	76260	35740	469
Cowpea	8532	4342	509
Sesamum	6396	1682	263
Groundnut	36080	68333	1894
Cluster-bean	59525	61050	1026
Wheat	157649	502927	3190
Barley	60542	187003	3089
Gram	118627	86174	726
Pea	9064	19390	2139
Rapeseed Mustard	114503	117090	1023
Taramira	9988	4549	455
Onion	3551	8436	2376
Fenugreek	2554	2510	983

IV. METHODOLOGY

A Linear programming problem with "n "decision variables and "m "constraints is formulated as:

$$\text{Max.}Z=\sum c_i x_i \qquad i=1,2,3,\ldots,n$$

$$\text{s.t.} \quad \sum a_i x_i \leq \sum b_j \qquad j=1,2,3,\ldots,m$$

$$x_i \geq 0$$

$x_{i=}$ represents the decision variables (to be determined by policy makers)

c_i= represents the cost vector

a_i= represents activity coefficient

b_j= represents the available resources

The objective function is:

$$\text{Max.}Z = 3190\, x_1 + 1023\, x_2 + 2139\, x_3 + 726\, x_4$$

Subject to constraints:

Land:

$$157649\, x_1 + 114503\, x_2 + 9064 x_3 + 118627\, x_4 \leq 663167$$

Seeds & fertilizers:

$$x_1 + x_2 + x_3 + x_4 \leq 100000$$

Labor:

$$x_1 + x_2 + x_3 + x_4 \leq 200450$$

Non-negativity conditions:

$$x_1, x_2, x_3, x_4 \geq 0$$

x_1, x_2, x_3 and x_4 are the decision variables for wheat, rapeseed & mustard, peas and gram respectively .

V. Mathematical Formulation

The objective of the study is to maximize the farm returns by allocating the resources optimally. Only the crops grown in Rabi season i.e. wheat, rapeseed & mustard, peas and gram is considered for the study. The problem is to determine the suitable crop combination in order to get maximum profit. The land available for cultivation is 663167 hectares. Proper allocation of crops and the available resources is very important in order to increase the productivity and also for the efficient utilization of resources as Jaipur district of Rajasthan receives erratic rainfall. Therefore, the variation in cropping pattern is observed within district depending upon the availability of water resources. Farms with sufficient water prefer to cultivate peas and wheat more whereas the farms with less availability of water grow mustard and wheat as a major crops. Moreover, in order to increase the production farmers adopt different farming patters such as crop rotation, inter cropping and mixed cropping. It is observed that there is increase in production to about 25% by adopting theses crop policies Farmers especially the small farmers prefer to adopt mixed cropping that includes both livestock as well as cultivation of crops within the same farm. Livestock rearing contributes to increases the farm returns to great extent.

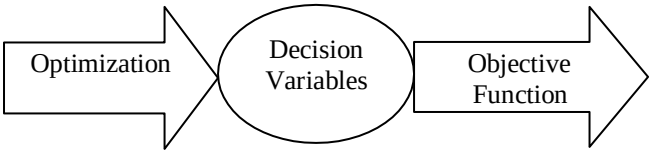

Fig2: Process of Linear Programming

Results

Result of the developed linear programming farm model is obtained by using EXCEL. Result of the problem shows that farmer can get a profit of 15,6499 Rs. The solution of the problem yields the following results:$x_{1=}$ 0, x_2=0, x_3= 73.164938 and x_4=0

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