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A STUDY ON OPTIMAL CROP ALLOCATION USING LINEAR PROGRAMMING APPROACH

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Abstract:
Agriculture is essential to a country's growth in both its economy and society. A method of linear programming is used to determine the optimum crop allocation, crop combination, and crop yield. All of these factors must be tuned not less than once every growing season. Crop rotation is a widespread strategy among farmers to increase the production of crops. A linear programming method is used to arrive at the solution for the suggested farm model. The study's purpose is to enhance output to ensure marginal and small holders make more money.
Keywords: Rotation of crops, Crops Allocation, Optimizing, linear programming Approach.

1. Introduction:

In the Indian economy, agriculture is very important. Throughout the growing season, decisions need to be made regarding crop type, amount, crop selection, and crop combinations. A mathematical framework is given to analyze harvest distribution and management potential. Agricultural planning is currently significant as a consequence of increasing demand for agricultural commodities as the population increases. Using a optimization model, agricultural strategists need to determine the optimal crop pattern for maximum yield and profit. This type of problem may be handled utilizing optimization techniques like the use of linear programming, programming with dynamics, and goal programming. The linear programming technique has become increasingly popular as a result of the proportional nature of the allocation difficulties.

2. Literature Review:

The feasibility of decision parameters is determined by the application of the linear programming (LP) technique. The dynamic strategy proposed by Boyabath et al. [1] calls for the allocation of farmland among many crops. A decision support model that helps farmers and allocates commodities optimally was created by Dury et al. [2]. To address this unpredictability, Dai & Li [3] developed a multi-stage water distribution strategy for agriculture. Seasonal differences in agricultural productivity and economic output due to altered watering patterns, consumer demand, and the availability of water resources sometimes provide decision-makers with new issues every growing season. A statistical analysis of the advantages of technology for the senses in a variety of agricultural operational jobs was conducted by Li and Wang [4].The results of the study indicate that information produced by wireless sensor networks may be used to predict how long a product will last on the shelf. A multi-objective water utilization model was introduced by Li and Guo [5]. The idea is to optimize the social, economic, and environmental benefits of a given area. A linear programming method was devised by Mohamed et al. [6] to evaluate the acceptability of choice variables. The two guiding concepts of the method are crop rotation and agricultural planning. A very accurate technique for allocating water resources was developed by Sabouni et al. [7] in accordance with the planted crop's irrigation needs. Researchers are concentrating on long-term growth as well as increased productivity in agriculture due to the rising demand for food and technological developments in the field. Consequently, given the objective to efficiently allocate resources and enhance agricultural output, Sofi et al. [8] employed a linear programming technique to allocate a mix of crops. A position that yields the highest or lowest value for an objective function within the feasible range of a linear programming problem is called an optimum solution. A position that yields the highest or lowest value for an objective function within the feasible range of a linear programming problem is called an optimum solution.

3. Methodology:

- The method of Linear Programming (LP) has been applied to assess the agricultural model's viability. Data is acquired through an interview with an agricultural staff. The study's purpose is to discover farmers' cultivation designs, plant variants, and supplies in order to determine the most practical and effective answer for the mode produced.
- Optimal solutions always bring about zero cost.
- Considering the components and are not contributing to the optimal conclusion, the more affordable vectors would be modified if a single unit of the cost associated with picking one of them had been incorporated in the solution.
- Whenever all resources are used efficiently, the surplus variable or slack variable indicates that more instances of the cost vector are needed for optimal outcomes.
- A value that is not positive for the surplus variable or slack variable indicates that the constraint is unnecessary and might be removed.

4.Model Formulation:

The former has 8.02 hectares of land utilized for paddy, maize, and black gram farming. The objective is to find the best agricultural combinations and allocate farm resources optimally. crop variety, quantity produced, and processes used to decrease input costs. A farmer with expertise organized his property to assign 4.81 ha for paddy and 1.92 ha for maize.

Let x_1, x_2, x_3 be the Paddy , Maize and Black gram respectively.

Table 1: Existing Farm Model

$Maximize\ Z = 6500x_1 + 3238x_2$				
	Activities	**Sign Constraint**	**Requirement Vector**	**Resources**
Constraints	$4.81x_1 + 1.92x_2$	$\leq$	8.02	Land
	$250x_1 + 200x_2$	$\leq$	500	Labor
	$1000x_1 + 1500x_2$	$\leq$	2500	Water
	$x_1 + x_2$	$\leq$	100000	Cost: seeds and fertilizers

Non-Negativity Constraints	$x_1, x_2 \geq 0$

x_1 represent the paddy (kg) produced per hectare,
x_2 represent the paddy Maize (kg) produced per hectare
Therefore, $x_1 = 1.365439 \; and \; x_2 = 0.756374$

Table 2: Optimized farm model

$Maximize\ Z = 6500x_1 + 5875x_2 + 4285x_3$				
	Activity	**Sign Constraint**	**Requirement Vector**	**Resources**
Constraints	$4.81x_1 + 1.8x_2 + 2x_3$	$\leq$	8.02	Land
	$250x_1 + 150x_2 + 150x_3$	$\leq$	800	Labor
	$1000x_1 + 1500x_2 + 900x_3$	$\leq$	2500	Water
	$x_1 + x_2 + x_3$	$\leq$	100000	Cost of seeds and fertilizers
Non-Negativity Constraints	$x_1, x_2, x_3 \geq 0$			

x_1 represent the paddy (kg)produced per hectare
x_2 represent the maize (kg) produced per hectare
x_3 represent the black gram (kg) produced per hectare
Therefore, $x_1 = 0.351224$, $x_2 = 0 \; and \; x_3 = 3.165307$

Table 3: Optimal solution of the existing and optimized cropping pattern

Existing Cropping Pattern			**Fuzzy Optimized Cropping Pattern**		
Crops	**Decision Variables**	**Optimal Values**	**Crops**	**Decision Variables**	**Optimal values**
Paddy	x_1	1.365439	Paddy	x_1	0.351224
Maize	x_2	0.756374	Maize	x_2	0
-	-	-	Black Gram	x_2	3.165307
Optimal Returns(Rs)		11324.49	Optimal Returns(Rs)		15846.29

Results and Discussion:

The study found that for farming, returns climbed. The use of linear programming has become a strategy that determines the amount of variance in area based on harvest and other data, thereby improving farm revenues. The reduced value linked with each cost vector in the objective function demonstrates the variation that may be used to establish upper and lower bounds for costs parameters, enabling the optimal value to be improved. But the simplex technique for solving linear programming problems provides an iterative technique that optimizes the most effective value of the decision variables with each iteration that follows. The operational costs will be lower provided a corps belongs to the same family.

Conclusion:

Introduction of a paddy and black gram as plants enhances the production process.Based on the above illustrations, we can clearly identify that the linear programming problem is not only helpful in determining cropping patterns but can also help in reducing costs for the same. The results indicate that the linear programming model is appropriate for the fuzzy optimization of agricultural resource allocation, including farm land, water, labor, and others, among crops of any kind.

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