Optimization of land use of agricultural farms in Sumedang regency by using linear programming models

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Abstract. Land is one of the most important assets for farmers in Sumedang Regency. Therefore, agricultural land should be used optimally. This study aims to obtain the optimal land use composition in order to obtain maximum income. The optimization method used in this research is Linear Programming Models. Based on the results of the analysis, the composition of land use for rice area of 135.314 hectares, corn area of 11.798 hectares, soy area of 2.290 hectares, and peanuts of 2.818 hectares with the value of farmers income of IDR 2.682.020.000.000,-/year. The results of this analysis can be used as a consideration in decisions making about cropping patterns by farmers.

1. Introduction

Land is one of the most important assets for farmers. If a land has a good quality, it will have good potential also for the welfare of the surrounding population. If a land is used for non-agricultural development, it will cause some problems such as food self-sufficiency, environment, and employment. For example, declining agricultural yields, pollution from waste, floods, and increasing unemployment. Also bad for the health of local people, due to the pollution. In West Java, there are several types of land, namely Wetland, Non-Rice Farming Land, and Non-Agricultural Land. The paddy field consists of irrigated rice fields, which are not planted with rice, and while not cultivated. While non irrigated rice field consists of planted with rice, which is not planted with rice, and which temporarily not cultivated. A broad understanding of land is a surface area of the Earth whose characteristics encompass all the identifiers of both a sufficiently steady and predictable nature of the biosphere, atmosphere, soil, geology, hydrology and plant and animal populations, and the results of the activity human beings in the past and the present, as far as the identification marks have an influence over the human use of land in the present and future. [1]

Productive land use is crucial to the productivity of agricultural commodities, especially food crops, as a source of carbohydrates to ensure the food security of people in West Java. Food crops consist of grains and crops. Rice is one of the most important cultivation plants in civilization. Rice production in the world ranks third of all cereals, after maize and wheat. However, rice is a major source of carbohydrates for the majority of the world's population. [2]

A problem will be solved to obtain optimum results in accordance with the given constraints. If the problem is formulated appropriately, it can give the optimum decision variable value. Once the

optimum solution is obtained, the problem is often re-evaluated under different conditions to obtain a new settlement. [3]

Previous research that discusses the optimization of land use linear programming is Bisschop. Discusses a farmer who owns a plot of land and must make a decision about what type of plant to plant in the field. Limitations used are the area of land, the amount of labor comprised of family labor, wage labor, and temporary labor, and also constraints of water limitations. The ultimate goal is to maximize profits.

In this paper discuss about how to formulate optimization model of agricultural land use in order to obtain optimal results.

2. The basic concept of optimization
Optimization is the act of getting the best results under certain circumstances. In the design, construction, and maintenance of engineering systems, engineers must take many technological and managerial decisions at several stages. The ultimate goal of all decisions is to minimize the effort required or to maximize the desired benefits. [4] In everyday life, whether consciously or unconsciously, people always do the optimization to meet their needs. The optimization done by ordinary people is more based on intuition than optimization theory.

Linear programming is a way to solve the problem of allocation of limited resources such as labor, raw materials, machine work hours and the like in the best way possible to obtain optimal results. [5]

Linear programming has become the basis of manufacturing decisions, marketing, bank loans, stock quotes, taxi fares, coordination transport, telephone charges, computer access, optimization of land and other practical issues. [6]

The general form of Linear programming model can be described as follows:

Objective function: max/min $Z = \sum_{j=1}^{n} C_j x_j$ (1)

Subject to

$$\sum_{i=1}^{m} a_{ij} x_j \{\leq, =, \geq\} b_i$$

$$x_j \geq 0$$

The solution to meet these linear constraints is called a feasible solution. Three elements in linear programming are decision variables, constraints and objective functions.

3. Model of Land Use Optimization
The model of land use optimization is implemented on Sumedang Regency Farm where the parameters are:

3.1. Parameterization
Index
c plants / commodities
t month
Parameter of the plant

p_c c plant price [Rp / ton]
Parameter of land
L available land area [ha]

l_{tc} land area in month t [ha]
Labor parameters
V available labor [people]

v_c labor needed c plant [person]

V^P female labor [person]

V^L male labor [person]

r^P annual wage rate for female labor [Rp / person]

r^L annual wage rate for male labor [Rp / person]

Parameter of fertilizer

F annual amount of fertilizer available [kg]

f_c fertilizer needed for plant c [kg]

p^F fertilizer price [Rp / kg]

Decision Variables

x_c the number of each c plant grown [ha]

V^P number of female workers [people]

V^L number of men [man]

s_c sale from c plant [ton]

p_c the price of each plant c [Rp / ton]

3.2. Numerical Calculation

Sumedang has a land area of 152.220 hectares consisting of rice fields and non-rice fields. While, the data used in the agricultural land use model of Sumedang Regency are as follows:

Table 1. Planting area (ha)

Rice	80.261
Corn	11.798
Soy	2.290
Peanuts	2.818
Total	**97.167**

Table 2. Cropping area (ha)

Rice	74.933
Corn	10.207
Soy	2.288
Peanuts	2.915
Total	**90.343**

Table 3. Analysis of Farming.

Commodities	Result (kg)	Price (Rp/Kg)	Value of Results / Production (Rp)	Total Production Cost (Rp)	Farm Income (Rp)	R/C
Rice	5.510	4.800	26.448.000	16.910.000	9.538.000	1,56
Corn	6.500	1.800	11.700.000	8.215.000	3.485.000	1,42
Soy	1.571	3.800	5.969.800	5.570.000	399.800	1,07
Peanuts	1.230	8.300	10.209.000	9.480.000	729.000	1,08

Table 4. Total labor.

	Man			Woman			Total
	Hired worker	Family	Total	Hired worker	Family	Total	
Rice	118	16	134	85	6	91	225
Corn	70	13	83	58	4	62	145
Soy	54	12	66	-	1	1	67
Peanuts	120	22	142	144	6	150	292
Total	362	63	425	287	17	304	**729**

Table 5. Volume Fertilizer of each Commodity.

	Volume (Kg)				Total
	Urea	SP -36	KCl	NPK Phonska	
Rice	200	100	75	50	425
Corn	150	50	50	50	300
Soy	50	100	50	50	250
Peanuts	100	200	100	-	400
Total					**1.375**

Table 6. Price of Fertilizer.

Type of Fertilizer	Price (Rp)
Urea	1.800
SP-36	2.000
KCl	2.000
NPK	2.000

The purpose of this study is to maximize the profits of farmers for a year, with revenue from sales minus the costs incurred. While the obstacles used in this study are limited land, labor needs, and fertilizer needs.

Based on (1), and referring to [7], the above problem can be formulated as follows:

Max
$$\sum_c p_c s_c - r^L V^L - r^P V^P - p^F f_c x_c$$

subject to

$$\sum_c x_c \leq L$$

$$\sum_c l_{tc} x_c \leq L \qquad \forall t$$

$$\sum_c v_c x_c \leq L\left(V^L + V^P\right) \qquad \forall t \qquad\qquad (2)$$

$$\sum_c f_c x_c \leq LF$$

$$x_c \geq 0 \qquad \forall c$$

$$V^P \geq 0$$

$$s_c \geq 0 \qquad \forall c$$

Based on data obtained from Dinas Pertanian, Peternakan, dan Perikanan Kabupaten Sumedang in 2016 which has been described above, it can be obtained a formula for Linear Programming optimization model as follows:

Objective function: Max $\quad z = 19128000x_1 + 6985000x_2 + 3149800x_3 + 1459000x_4$

subject to:

$$x_1 + x_2 + x_3 + x_4 \leq 152220$$
$$x_1 \geq 80261$$
$$x_2 \geq 11798$$
$$x_3 \geq 2290$$
$$x_4 \geq 2818$$
$$225x_1 + 145x_2 + 67x_3 + 292x_4 \leq 110968380$$
$$425x_1 + 300x_2 + 250x_3 + 400x_4 \leq 209302500$$
$$x_1, x_2, x_3, x_4 \geq 0$$

(3)

where

x_1 = Rice land area

x_2 = Corn land area

x_3 = Soy land area

x_4 = Peanuts land area

The optimal solution of equation (3) is obtained by using the simplex table is to arrange the equations in a table, the simplex table. The initial simplex table for this problem is as follows:

Table 7. First Simplex's Table.

VB	z	x_1	x_2	x_3	x_4	s_1	s_2	s_3	s_4	s_5	s_6	s_7	NK
z	1	-19128000	-6985000	-3149800	-1459000	0	0	0	0	0	0	0	0
s_1	0	1	1	1	1	1	0	0	0	0	0	0	152220
s_2	0	1	0	0	0	0	1	0	0	0	0	0	80261
s_3	0	0	1	0	0	0	0	1	0	0	0	0	11798
s_4	0	0	0	1	0	0	0	0	1	0	0	0	2290
s_5	0	0	0	0	1	0	0	0	0	1	0	0	2818
s_6	0	225	145	67	292	0	0	0	0	0	1	0	110968380
s_7	0	425	300	250	400	0	0	0	0	0	0	1	209302500

To get the optimal result, the above problem is solved by 4 iteration process. Thus, using the help of LINDO's software, obtained optimal results of the area of rice area of 135.314 ha, corn area of 11.798 ha, soy area of 2.290 ha, and peanuts area of 2.818 ha. The optimal income obtained from the pattern of land area is IDR 2.682.020.000.000,-/year.

4. Conclusion

From the description above can be concluded that the income earned by farmers of IDR 2.682.020.000.000,-/year, if farmers grow rice, corn, soy, and peanuts with the following land size: 135.314 ha of rice area, 11.798 ha of corn area, 2.290   ha of soy area, and 2.818 ha of peanuts. Thus, it can be used as a consideration of the farmers for the planning of land use patterns.

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