Optimization model of maize production in various land use in Banten province

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Abstract. The area of the maize harvest in Banten Province in 2020 was 16,676 ha with a production of 111,903 tons with productivity of 6,71 tons/ha. The objectives of this study are 1) To analyze the existing maize farm in Banten Province, and 2) To analyze the optimization of maize production in Banten Province. The study method used survey methods, with purposive sampling at the farmer level. Methods of data analysis using qualitative and quantitative analysis. The qualitative analysis used descriptive tabulation. Quantitative analysis using Geographic Information System (GIS), B/C ratio analysis and Linear Programming. The results of this study were: 1) The productivity of maize is 5,112 tons/ha, with the plant pattern being paddy - maize – fallow in rice field rainfed. The value of the B/C ratio5.6 it is mean that maize farming is profitable. 2) The optimum value of maize production in Banten Province is 1,533,600 tons of a dry shell, which is obtained from the average productivity of maize in upland areas of 5,112 kg/ha and the optimal planting area of 300,000 ha of upland land. Suggestions for maximizing maize production done by optimizing upland land.

1 Introduction

The area of agriculture fields in Banten Province in 2020 is 725,050.1 ha, of which 197,070 ha (27.2%) are paddy fields and 527,980.1 ha (72.8%) are not paddy fields [1]. The paddy field area is 94.9% found in the four main rice-producing regencies, namely the regencies: Pandeglang, Lebak, Tangerang and Serang. Based on the type of plants planted, 99.1% were planted with rice and the rest were non-rice [2].

If broken down by irrigation, the area of irrigated paddy fields is 97,048 ha (49.2% of the paddy field area), which is the widest in Serang regency, namely 23,933 ha (24.7%), second in Tangerang regency is 23,700 ha (24.4%), and the smallest in the other four cities [1]. The area of rainfed rice fields in Banten Province is 100,022 ha (50.8%), the largest is in Pandeglang regency, namely 32,104 ha (32.1%), second in Lebak, namely 26,769 ha (26.8%), third in Serang regency, namely 23,915 ha (23.9%), the fourth Tangerang regency, namely 12,382 ha (12.4%) and the remainder (4.8%) in four other cities [1]. National maize production in 2022 is 19,612,435 tons from a harvested area of 3,786,815 ha [1]. If it is related to national consumption, namely in 2015 it is estimated at 23,720,662 million tons [3] then

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Indonesia still lacks supply of 4.109 million tons in 2022. According to the Ministry of Agriculture, the national maize consumption level is 0.87 kg/ capita/year, with a population of 269,603 million, the national consumption requirement is 23.455 million tonnes [4]. So that it required imports of 3.84 million tons of maize. This shortage is met through imports from the United States, Argentina, etc. If seen from the selling price of maize at the farm level, the average is IDR. 5,000/kg, with a productivity of 5.0 tons/ha in Banten, the income at the farm level is IDR 25.0 million/ha during the planting season. The average import price (f.o.b) of maize in January 2023 is at an exchange rate of IDR 15,610/1 US$ of IDR 4,032/kg [5].

Maize is the second largest food crop in Prov. Banten. Maize production in Prov. Banten in 2021 amounts to 58,661.5 tonnes with a harvested area of 8,892 ha. When compared to maize production in 2019 amounting to 119,206 tonnes with a harvested area of 22,346 ha [6], there was a decrease in production of 103.2% and a harvested area of 151.3%. [6];[1]. Maize center production in Banten province is located in Pandeglang and Lebak regencies respectively with production of 37,182 tons and 9,792 tons. The typology of maize land in Lebak Regency is generally cultivated in dry land and paddy fields.

Besides land for agriculture, Banten province also has a state forest area with an area of 208,161.27 ha in 2013 consisting of 61.4% Forest Protection and Nature Conservation conversion forest, 4.6% protected forest, 19.8% production forest % and limited production forest 14.2% [7]. This forest is indirectly beneficial for agriculture as a water catchment area and cannot be used for agricultural business.

Banten Province had critical land in 2013 covering an area of 104,103.01 ha consisting of 2.0% very critical land, 65.3% critical land, 27.3% moderately critical land and 5.4% potentially critical land [7]. It is possible that these lands can still be used as agricultural land, namely secondary crops, horticulture (vegetables) and upland rice, especially on reforested land where the plants are still young.

The land that has been used for crops so far is the Banten Public Corporation (Perum) Perhutani Forest Management Authority (KPH) area of 78,487.64 ha in 2014. The forest plants cultivated are teak with an area of 51.1%, mahogany with an area of 18.9% %, Accasia mangium area of 30%. Land that can be utilized is young replanting plants [8].

The obstacles in increasing production except for limited land resources are the not optimal use of fertilizers,[9], the conversion of irrigated rice fields (agriculture) to non-agriculture where in the period 2003-2008, the area of agricultural land in Banten Province decreased by 50.3 thousand ha from 982.6 thousand ha to 932.3 thousand ha or a decrease of 5.1% [10];[11]). For this reason, optimizing the use of agricultural land and food crop inputs is needed to increase production. Optimization occurs because there are limited resources to be used to achieve certain goals for maximum production, maximum profit, or minimum costs [12]. Optimization is an effort to achieve the best certain goals [13]. Linear programming is an analytical technique for solving the problem of allocating limited resources among several competing activities, in the best possible way [14].

To find out how the optimal allocation of land use and input for maize crop so that maize production can be increased, it is necessary to conduct research. This research is useful for obtaining land optimization and farming inputs to increase food crop production. The benefits can be used as input in formulating policies in an effort to increase food production under conditions of limited land resources.

2 Methodology

2.1 Research method data collection data

The method used in this study was the survey method. The survey method was conducted for primary data collection. Primary data were collected by interview using a structured questionnaire to rice farmer respondents. It is also collected secondary data from a desk study that related to this study. Primary data collection at the farm level using a purposive sampling method. Because this research was conducted at the same time with the research of Effectiveness and Efficient in Management of Agriculture Machine Vehicle Study [15]. Total farmers respondents amounted to 123 respondents' farmers.

2.2 Location and Time

The assessment was conducted in Banten Province. The location of this study was conducted in four districts of rice producers: 1) Tangerang Regency, 2) Serang Regency, 3) Pandeglang Regency, and 4) Lebak Regency. This study had been conducted since January 2018-December 2018.

2.3 Methods Data Processing and Analysis

This study consisted of qualitative and quantitative analysis. The qualitative analysis used descriptive statistics and quantitative analysis used Linear programming The equation to get the optimum of the target is;[16];[17]):

$$Maximum: z_{j=1}^{n} = \sum CjXj$$

Or

$$Z = C_1X_1 + C_2X_2 + C_3X_3 + ... + CjXj \quad (1)$$

Where:
Z = Value to be optimized (Objective Function)
Xj = the variable of decision making or activity (which will be searched, the unknown)
Cj = coefficient of decision-making variables in the objective function (in this case the production of each farm, and farmer household income)

Linear Programming is suitable for resource optimization design with a single goal. The linear programming method has three quantitative components, namely: the objective function, the activity or process to achieve the goal and limited resources [18]. The objective function is a function that describes the objectives related to optimal management of resources to obtain maximum benefits or minimum costs. The general forms are as follows [18]; [19]):

$$with\ constrain: \sum_{j=1}^{r} aijxj \leq bj \quad (2)$$

For i= 1,2,3,……,r

To produce crops, resources are needed. Resources that owned by farmers are limited, among others amount of land, fertilizers, pesticides, labor, etc., then the problem is how to make optimal use of the resources owned by these farmers, which can be written as follows:

and $xj \geq 0$ for $j = 1,2,3,….n$

or:

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \ldots + a_1jxj &< b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_2jxj &< b_2 \\ \ldots\ldots \quad \ldots\ldots \quad \ldots \quad \ldots\ldots \quad &.. \\ aj_1x_1 + aj_2x_2 + \ldots + aijxj &< bj \end{aligned} \quad (3)$$

Where:
aij = technology coefficient of decision-making variables (the activity concerned is in constraint i)
bi = limited resources (for example land area, availability of labor, availability of seeds, availability of fertilizers, availability of pesticides, availability of herbicides, constraints on planting frequency, availability of irrigation water).

and
$X_1, X_2, X_3, \ldots, X_j, \geq 0$

To find out the benefits of each cost incurred in maize farming, Benefit Cost Ratio (B/C ratio) analysis is used. The B/C ratio value must be greater than one (> 1) for the farming business to be profitable or financially feasible. The equation is as follows [20];[21]:

$$B/C = \frac{\pi}{TC} \tag{4}$$

Where:
Π = farm income (IDR)
TC = Total Cost / Total Cost of Farming (IDR)

The value can be calculated as follows:

$$\Pi = TR - TC \tag{5}$$

where:
TR = Total Return of Farming (IDR)

The TR value can be calculated as follows:

$$TR = Px * X \tag{6}$$

Where:
Px = Price of Farming Output (IDR/kg)
X = Total Farming Output (kg)

The TC value can be calculated as follows:

$$TC = Pi * Qi \tag{7}$$

Where:
Pi = Price of goods from the i-th input (example: Price of Urea, SP-36, etc.)
Qi = The number of items used from the i-th input (example: Amount of Urea, SP-36, etc.).

If B/C > 1 means farming is financially profitable and vice versa if B/C < 1 means farming is not profitable. Existing data is processed computerized, for tabular analysis and B/C ratio processed with Excel program, for linear programming analysis used program QM for Window 5.3.

Table 1. Maize Production Maximization Model in Banten Province

	X_1	X_2	X_3	X_4	X_5	RHS
Maximize	4,526	2,691	5,112	0	3,345	
Constraint 1	98,228	98,058	121,918	60,964	124,869	716,324
Constraint 2	16	15.2	15.7	0	16	2,066,480
Constraint 3	78.05	0	79.4	0	21.8	66,540,000
Constraint 4	39.1	24.5	21.2	0	136.3	20,830,000
Constraint 5	54.7	9.1	29.5	0	266	27,100,000
Constraint 6	1	1	1	0	2	3
Constraint 7	14.9	25.1	20	0	59.3	366.1
Constraint 8	31.1	30.4	20.6	0	4.88	840
Constraint 9	1.18	0	1.09	0	1.42	66,200

The model used to maximize maize production in Banten Province is described in Table 1. The objective function is the maximization of maize production, what is the optimal area of each type of land for optimum production with existing resource constraints. So, there are 5 (five) decision variables (irrigated rice field /X1, rainfed lowland/X2, dry land/X3, plantation land/X4, and Industry Crops Forest land/X5. The details are described in Table 1.

Nine resource constraints, including the availability of land, seeds, Urea fertilizer, SP-36 fertilizer, etc. The details are described as follows:

$$\text{Maximum: } 4{,}526\ X_1 + 2{,}691X_2 + 5{,}112X_3 + 0X_4 + 3{,}345X_5 = Z$$

With constraint (bi):

1. Land availability (Ha):

$$98{,}288X_1 + 98{,}058X_2 + 121{,}918.2X_3 + 0X_4 + 124{,}869X_5 \leq 523{,}522$$

Explanation:

- The value of 98,288 ha is the area of irrigated rice fields in Province of. Banten
- The value of 98,085 ha is the area of rainfed lowland in Province of Banten
- The value of 121,918 ha is the area of dryland in Province of Banten
- The value of 60,964 ha is the area of plantation land in Province of Banten
- The value of 124,869 ha is the area of Industry Crops Forest in Province of Banten
- The value of 716,324 ha or Right-Hand Side/RHS is the area (avaibility) of
- agricultural land including moor, plantations, Field /huma, fallow land, wetland.

2. Availability of maize seeds (kg):

$$16X_1 + 15.2X2 + 15.7X_3 + 0X_4 + 16X_5 \leq 2{,}066{,}480$$

Explanation:

- The value of 16.0 kg is the average use of maize seeds per ha in irrigated
- Paddy/rice field.
- The value of 15.2 ha is the average use maize seeds in paddy fields rainfed
- The value of 15.7 kg is the average use maize seeds in dryland area
- The value of 15 kg is the average use maize seeds in Industry Crop Forest
- The value of 2,066,480 kg is the availability of maize seeds in Banten province
- (Right Hand Side)

3. Availability of Urea (kg):

$$78.05X_1 + 79.4X_3 + 21.8\ X_5 \leq 65{,}540{,}000$$

Explanation:

- The value of 78.05 kg a is the average use of Urea/ha in irrigated rice fields,
- The value of 79.4 kg is the average use of Urea/ha in the dryland.
- The value of 21.8 kg is the average use of Urea/ha in Industry Crop Forest
- The value of 65,540,000 kg is the availability of Urea in Banten province

4. Availability of SP-36 Fertilizer (kg):

$$39.1X_1 + 24.5X_2 + 21.2X_3 + 136.3X_5 \leq 20{,}830{,}000$$

Explanation:

- The value of 39.1 kg is the average use of SP-36/ha in irrigated rice fields,
- The value of 24.5 kg is the average use of SP-36/ha in rice fields rainfed
- The value of 21.2 kg is the average use of SP-36/ha in the dryland.
- The value of 136.3 kg is the average use of SP-36/ha in Industry Crop Forest.
- The value of 20,830,000 kg is the availability or Right Hand Side of SP-36 in
- Banten Province

5. Availability of Ponska NPK Fertilizer (kg):

$$54.7X_1 + 9.1X_2 + 29.5X_3 + 266X_5 \leq 27,100,000$$

Explanation:
- The value of 54.7 kg is the average use of NPK Ponska/ha in irrigated rice fields,
- The value of 9.1 kg is the average use of NPK Ponska/ha in rice fields rainfed
- The value of 29.5 kg is the average use of NPK Ponska/ha in the dryland.
- The value of 266 kg is the average use of NPK Ponska/ha in Industry Crop Forest.
- The value of 27,100,000 kg is the availability of NPK Ponska in Banten Province
- (Right Hand Side)

6. Planting frequency (times):

$$1.0X_1 + 1.0X_2 + 1.0X_3 + 2.0X_5 \leq 3$$

Explanation:
- The value of 1 time is the frequency of maize planting in irrigated rice field
- The value of 1 time is the frequency of maize planting in rice fields rainfed
- The value of 2.0 time is the frequency of maize planting in Industry Crop Forest.
- The value of 3 time is the availability of the frequency of maize planting.

7. Availability of Hired Labor (WMD):

$$14.9X_1 + 25.1X_2 + 20X_3 + 59.3X_5 \leq 366.1$$

Explanation:
- The value of 14.9 WMD is the average use of hired labor /ha in irrigated rice
- fields,
- The value of 25.1 WMD is the average use of hired labor /ha in rice fields
- rainfed
- The value of 20.0 WMD is the average use of hired labor/ha in the dryland.
- The value of 59.3 WMD is the average use of hired labor/ha in Industry Crop
- Forest.
  The value of 366.1 WMD is the availability of hired labor/ha in Banten
- Province (Right Hand Side)

8. Family labor (Work Mand Day/WMD):

$$31.1X_1 +30.4 X_2 + 20.6X_3 + 4.88X_5 \leq 960$$

Explanation:
- The value of 31.1 WMD is the average use of family labor /ha in irrigated rice
- fields,
- The value of 30.4 WMD is the average use of family labor /ha in rice fields
- rainfed
- The value of 20.6 WMD is the average use of family labor/ha hn the dryland.
- The value of 4.88 WMD is the average use of family labor/ha in Industry Crop
- Forest.
  The value of 960 WMD is the availability of family labor/ha in Banten Province
- (Right Hand Side)

9. Availability of family hand tractors (Machine Work Day/MWD)

$$1.18X_1 + 1.09 X_3 + 1.42 X_5 \leq 66,200$$

Explanation:
- The value of 1.18 MWD is the average use of family hand tractor /Ha in irrigated
- Rice fields,

- The value of 1.09 MWD is the average use of family hand tractor/ha in the
- dryland,
- The value of 1.42 MWD is the average use of family hand tractor/ha in Industry
- Crop Forest.
- The value of 66,200 MWD is the availability of family hand tractor in Banten
- Province (Right Hand Side)

3 Results and Discussion

3.1 Land Use Analysis

The area of Banten Province in 2017 was 9,662,920 km^2 or 966,292 ha, of which 720,358 ha (74.5%) of agricultural and non-agricultural land was 245,934 ha (25.5%). The details were the widest in Lebak Regency, namely 3,426.56 km^2 (35.46%), the second Pandeglang regency namely 2,746.89 km2 (28.43%), the thirdly Serang Regency, namely 1,734.28 km^2 (17.95%), and the remain were the four cities namely 743.33 km2 (7.7%). For agricultural land, the details are shown in Table 2.

Table 2. The extent of agricultural land according to its use in Banten Province for the period 2009-2017

No.	Type of Land	2009 (ha)	2017 (ha)	Increase/ Decrease (%)
1.	Irrigation wetland	111,416	104,437	-6.3
2.	Rainfed rice	86,114	98,632	14.5
	Sub Total of wetland	*197,530*	*203,183*	*5.6*
3.	Dry land	170,267	127,031.8	-25.4
4.	Estate	50,687	60,391.8	19.1
5.	Field/huma	85,878	70,963.2	-17.4
6.	Society Forest	65,277	126 ,612	94
7.	Pasture	3,485	1,972.6	43.4
8.	Fallow land	19,644	68,073	246.5
9.	Pond	9,834	0	-100
10.	Fishpond/	2,387	0	-100
11.	Other	27,655	10,888.1	60.6
	Sub Total Not wetland	*435,114*	*517,175*	*18.8*
	Total	632,644	720,358	13.9

Source: [10,22]

Based on the Map of Indonesia (RBI) in 2019 with 2010 data, it is known that the area of all land in Province of Banten both agricultural land in general and non-agricultural is 909,480.16 ha with details in Figure 1. As in Table 5, the raw area of rice fields is 237,094.63 ha, while non-rice fields are plantations/gardens covering an area of 278,022.05 ha and moor/fields covering an area of 50,191.91 ha. The land use map of Banten Province is presented in Figure 1.

3.2 Maize Farming Analysis

Based on the enumeration results, the average productivity of maize in Banten Province during the 2017/2018 Rainy Season (RS) was 5,324 tons of dry shelled/ha. With an average harvest price of IDR 2,615.1/kg, revenue of IDR 13,922,792.4/ ha was obtained. The total production cost is IDR 2,116,599.3/ha so the income earned is IDR 11,806,193.1/ha. Based on the B/C ratio analysis, it is known that the value is 5.6 based on financial prices. This means that maize farming is financially profitable. Detailed analysis of maize farming in Rainy Season (RS) 2017/2018 is presented in Table 3.

Tabel 3. Analysis of Maize Farming per Ha on Rainy Season 2017/2018 in Banten Province

No.	Type of Input/Output	Volume	Proce/Unit (IDR)	Value (IDR)
1	Seed (kg)			
	a. labeled	15.8	5,000	79,000
2	Fertilizer (kg):			
	a. Urea	81.7	128.9	10,531.1
	b. SP-36	13.7	1,512.2	20,717.1
	c. KCL	0.1	15,000	1,500
	e. NPK Ponska	23.6	1,729.6	40,818.6
	f. Manure	904.7	97.6	88,298.7
	g. Solid leaf fertilizer (kg)	0.13	21,500	2,795
	h. Fluid leaf fertilizer (ltr)	0.57	70,588.2	40,235.3
3	Pesticide:			
	a. Solid (kg)	0.67	15,000	10,050
	b. Fluid (ltr)	0.74	118,818.2	8,745.5
4	Herbicide:			
	b. Fluid (ltr)	1.0	51,566.7	51,566.7
5	Other:			
	a. Land and building tax			3,026.2
6	Cost of hired labor:			
	a. Human hired labor (WMD)	21	51,473	1,080,933
	b. Human family labor (WMD)	16.7	0	0
	c. Wage of tractor service	1.1	577,587.6	635,346.4
	d. Cost of tractor family	0.5	76,071.4	38,035.7
	e. Wage of buffalo service	0.1	50,000	5,000
7	*Total Cost*			2,116,599.3
8	Return	5,324	2,615.1	1,392,2792.4
`10	Income			11,806,193.1
11	R/C			6.6
12	B/C			5.6

Explanation: n = 33 respondents.

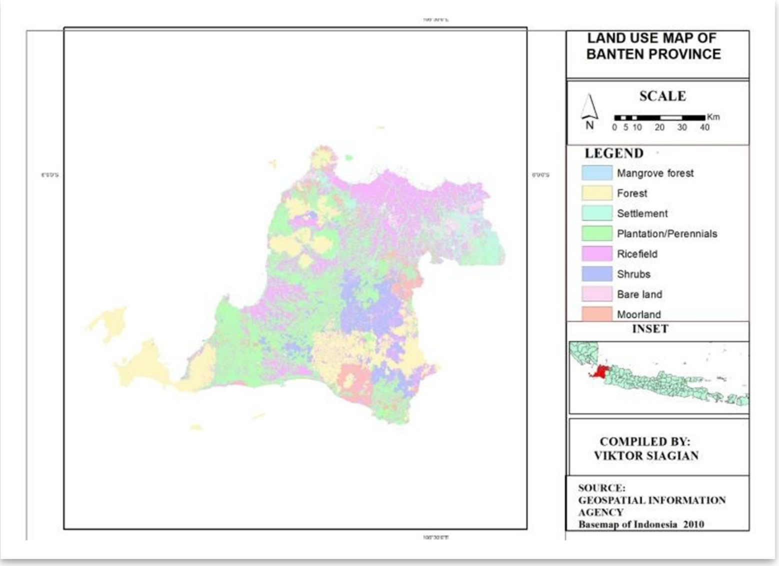

Fig. 1. Map of Banten Province land use in 2010 based on the Earth map of Indonesia 2010 year

The cropping pattern in the survey area (dry land) is generally maize-maize- fallow. While the cropping pattern in rice field rainfed generally paddy - maize – fallow.

3.3 Maximization of Maize Production in Banten Province

Table 4. Results of Linear Programming to Maximize Maize Production

	X_1	X_2	X_3	X_4	X_5	RHS	Dual
Maximize	4,526	2,691	5,112	0	3,345		
Constraint 1	98,228	98,058	121,918	60,964	124,869	716,324	0
Constraint 2	16	15.2	15.7	0	16	2,066,480	0
Constraint 3	78.05	0	79.4	0	21.8	66,540,000	0
Constraint 4	39.1	24.5	21.2	0	136.3	20,830,000	0
Constraint 5	54.7	9.1	29.5	0	266	27,100,000	0
Constraint 6	1	1	1	0	2	3	5,112
Constraint 7	14.9	25.1	20	0	59.3	366.1	0
Constraint 8	31.1	30.4	20.6	0	4,88	840	0
Constraint 9	1.18	0	1.09	0	1.42	66,200	0
Solution	0	0	300,000	0	0	15,336,600	

Based on Table 4, it can be expressed that the optimum value of maize production in Banten Province is 1,533,600 dry shelled tons, which is obtained from the average maize productivity on upland land of 5,112 kg/ha and the optimal planting area of upland land (X_3) 300,000 ha. Meanwhile, real production in 2019 was 119,206 tons obtained from a harvest area of 22,326 ha [6]. Meanwhile in they researched in Sumbawa regency, West Nusa Tenggara province, Indonesia found that the maximum productivity of maize obtained was 701,984 tons with cultivated paddy fields of 44,198.5 hectares and 55292.5 hectares for non-paddy fields [23].

Table 5. Optimization of the Use of Resources / Maize Farming Input

Variable	Status	Value
X_1	Non Basic	0
X_2	Non Basic	0
X_3	Basic	300,000
X_4	Non Basic	0
X_5	Non Basic	0
Slack 1	Basic	350,570
Slack 2	Basic	2,066,433
Slack 3	Basic	66,539,760
Slack 4	Basic	20,829,940
Slack 5	Basic	27,099,910
Slack 6	Non Basic	0
Slack 7	Basic	306.1
Slack 8	Basic	778.2
Slack 9	Basic	66,196.73
Optimal Value (Z)		1,533,600

Based on Table 5, it is known that all the limited resources used are still in excess, land resources are still in excess namely 350,570 ha, seed resources namely 2,066,433 kg, and family labor resources amount of 840 WMD, and so on.

3.3.1 Sensitivity Analysis

The analysis is used to determine the extent to which a model is sensitive to changes that occur in the coefficient of the objective function (variables X1, X2, X3, X4, X5) and resource capacity. As long as the change is still between the lower limit (Lower Boundary) and the upper limit (Upper Boundary), there is no problem because it does not change the optimal value (Z) and vice versa.

Based on Table 6, it is known that if the productivity of maize in irrigated rice fields and rainfed lowlands decreases to infinity, it will not affect the optimum value (Z) and if it increases to 5.112 kg/ha then the optimum value will not change. On the other hand, if the dry land decreases to 4,526 kg/ha and increases to infinity, the optimum value does not change.

Table 6. Sensitivity Analysis of Maize Farming Resource Utilization / Input Optimization

Variable	Value	Reduced	Original Value	Lower Boundary	Upper Boundary
X_1	0	586	4,526	-Infinity	5,112
X_2	0	2,421	2,691	-Infinity	5,112
X_3	3	0	5,112	4,526	Infinity
X_4	0	0	0	-Infinity	0
X_5	0	6,879	3,345	-Infinity	10,224
	Dual Value	Slack/Surplus	Original Value	Lower Boundary	Upper Boundary
Constraint 1	0	350,570	716,324	365.754	Infinity
Constraint 2	0	2,066,433	2,066,480	47.125	Infinity
Constraint 3	0	66,539,760	66,540,000	240	Infinity
Constraint 4	0	20,829,940	20,830,000	64	Infinity
Constraint 5	0	2,099,910	27,100,000	88	Infinity
Constraint 6	5,112	0	3	0	5.875457
Constraint 7	0	306.1	366.1	60	Infinity
Constraint 8	0	778.2	840	61.79999	Infinity
Constraint 9	0	66,196.73	66,200	3.273438	Infinity

and vice versa. Inland resources (b_1), if the use decreases to 365,754 ha and increases to infinity, the optimum value does not change. In the seed resource, if it decreases to 47.1 kg its use will not affect the Z value and if it increases to infinity, it will not affect the Z value. As described in Table 6.

4 Conclusions

The total area of Banten Province in 2017 is 966,292 ha, of which 720,358 ha (74.5%) of agricultural and non-agricultural land covering an area of 245,934 ha (25.5%). Large agricultural land in Banten Province increased by 13.9% between 2009 and 2017. The optimum value of maize production in Banten Province is 1,533,600 tonnes of shelled dry, which is obtained from the average productivity of maize in upland areas of 5,112 kg/ha and the optimal planting area for upland 300,000 ha. Efforts to prevent the decrease in the area of irrigated rice fields need to be done either by providing incentives to farmers who are tenants in the form of land and building tax benefits, consequently implementing the Perpetual Agricultural Land Law. The maximization of maximizing maize production is done by optimizing dry land.

References

1. CBS, *Banten Province in Figures 2022*. (Central Bureau of Statistics of Banten Province, Serang, 2022)
2. CBS, *Banten Province in Figures 2019*. (Central Bureau of Statistics of Banten Province, Serang, 2019)
3. A. Suryana, A. Agustian, J of Agric Pol. Anal. **12**, 2 (2014)
4. CADIS, *Food Consumption Bulletin*. (Center for Agricultural Data and Information Systems, Ministry of Agriculture, Jakarta, 2021)
5. AD. Darmawan, *The price of maize on the international market is IDR 4,036.2 per kg*. (https://databoks.katadata.co.id/datapublish/2023/01/06, downloaded on 10th March 2023)
6. CBS, *Banten Province in Figures 2020*. (Central Bureau of Statistics of Banten Province, Serang, 2020)
7. CBS, *Banten in Figures 2015*. (Central Bureau of Statistics of Banten Province, Serang, 2015)
8. CBS, *Banten Province in Figures 2019*. (Central Bureau of Statistics of Banten Province, Serang, 2019)
9. V. Siagian, I. Setyowati, R. Sintawati, D. Widiastuti, T. Mulyaqin, *Impact Increase in Input and Output Prices on Farmers' Production and Income in Banten Province*. Assesement Institute for Agricultural Technology of Banten, Serang, 2014)
10. CBS, *Banten in Figures 2009*. (Central Bureau of Statistics of Banten Province, Serang, 2009)
11. CBS, *Banten in Figures 2014*. (Central Bureau of Statistics of Banten Province, Serang, 2014)
12. M. Antara,N. Suardika. J Econ Applied Quant **7**, 1 (2014)
13. P. Soebagyo, M. Asril, TH. Handoko, *Basics of Operation Research: Issue 2*. (BPFE Publisher, Yogyakarta,1983)
14. V. Devani, *Optimizing cropping patterns on dry land in Pekanbaru City with using the multi-objective (goal) programming method*. J Sci. Tech. Indust. **11**, 2 (2012)
15. V. Siagian, S. Rukmini, T.Mulyaqin, A. Wahyu, *Study of Use Effectiveness Assisted Alsintan and UPJA Institutions in Increasing Production Rice in Banten Province*. (Assesment Institute for Agricultural Technology Research of Banten, Serang, 2018)
16. BD. Nasendi, A. Anwar, *Linear Programs and Operations*. (Gramedia Corp., Jakarta, 1985)
17. J. Supranto, *Operations Research for Decision Making*. (University of Indonesia Publisher, Jakarta, 1988)
18. L. Siswati, R. Nizar, J Indon. breeders. **14**, 2 (2012)
19. NHN. Mustapha, NMH. Hashim, FA. Hassan, J of Bus and Soc Dev. **2**, 1 (2014)
20. [20]. Soekartawi, *Basic Principles of Agricultural Economics*: *Theory and Application*.
21. (Publisher PT. King Grafindo Persada, Jakarta, 2002)
22. Suratiyah, K. *Farming Science.* (Self-Help Spreader. Jakarta, 2006)
23. CBS, *Banten Province in Figures 2018*. (Central Bureau of Statistics of Banten Province, Serang, 2018)
24. T. Susilawati, Mikhratunnisa, J. Phys.: Conf. Ser. 1315 012063 (2019)