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THE TARGET OF FOOD PRODUCTION AND FARMERS' INCOMES IN BANTEN PROVINCE

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ABSTRACT

In 2021, the rice harvest area in Banten Province covered 319,558 hectares, yielding 1.63 million tons of unhusked rice. This study aimed to 1) optimize rice and corn production targets in Banten Province and 2) optimize farmers' income targets in Banten Province. A survey method with purposive sampling at the farmer level was used, with 123 rice farmers, 66 corn farmers, 29 soybean farmers, and 32 cassava farmers. Their data was analyzed both qualitatively and quantitatively. Qualitative analysis uses descriptive tabulation, while quantitative analysis uses goal programming. The results of this study were:1) The target of rice production in the Banten Province of 2.1 million tons of unhusked rice can be achieved with the optimal area of irrigated paddy of 299,755.7 ha and the optimal area of field/dry land of 87,750.9 ha. The target for corn production of 1.75 million tonnes in Banten Province can be achieved with an optimal planting area of 342,211.7 ha of dry land. 2) The optimal area of food crops to achieve the farmer's income target in Banten Province in 2018 is IDR. 8.79 trillion comes from the planting area of lowland rice covering an area of 391,222.1 ha, the corn planting area of 169,059.9 ha, the soybean planting area of 23,074.82 ha, and the cassava planting area of 2,832.77 ha.

KEYWORDS: Optimization, Targets, Goal Programming, Food Production, Farmers' Income.

1. INTRODUCTION

For overall agricultural development, including increased production and farmer benefits, land optimization is a key factor for sustainable growth, alongside technological advancements and social innovation (FAO, 2017). The size of farmland significantly influences the choice of rice farming systems (Ouattara et al., 2022). To optimize land use and enhance farmer benefits, the study recommends investment in irrigation infrastructure and organizational support for farmers. Additionally, efficient land use for agricultural production and water optimization are critical areas to manage, with water conservation being vital for achieving optimal irrigation outcomes in crop production (Zhai B. et al,2022).

According to CBS in 2022, Banten Province in Indonesia had 752,000 hectares of agricultural land, with 201,270 hectares (28.1%) rice fields and 515,054 hectares (71.9%) used for other crops. Of the total rice fields, 103,767 hectares (51.6%) are irrigated, with the most significant areas in Serang Regency (26,678 hectares, or 25.7%) and Tangerang Regency (24,857 hectares, or 24.0%). The remaining cities have smaller irrigated areas (CBS, 2022). Additionally, rainfed rice fields cover 97,469 hectares (48.4%), with the most significant areas in Pandeglang Regency (32,102 hectares, or 32.9%) and Lebak Regency (25,603 hectares, or 26.3%) (CBS, 2021).

In 2018, the harvested area for rice was 334,839 hectares, producing 1,643,046 tons of unhusked rice, with a productivity of 4.91 tons per hectare. For other food crops, maize had a harvested area of 66,356 hectares, yielding 331,865 tons of dried shelled corn, with a productivity of 5.00 tons per hectare. Meanwhile, soybeans were harvested from 23,594 hectares, producing 18,094 tons (CBS, 2019).

One of the government's goals is to ensure prosperous incomes for farmers. According to research by Siahaan and Rohmat (2019), the average income of farming households in Pandeglang Regency, Banten, is IDR 24,822,000 annually. Similarly, a study by Elpawati et al. (2019) on rice farmers diversifying with honey in the same region found that the average household income of these farmers is IDR 22,164,114 per year.

According to the CBS (2015), agricultural census, the average land owned by farming households in Banten was 0.54 hectares, with only 0.26 hectares (48.1%) being paddy fields. This highlights that limited land ownership is already a challenge for increasing production and income.

Therefore, optimizing the use of agricultural land and inputs for food crops to enhance production is achieve optimum results (Soebagyo et al. 1983). Goal Programming (GP), an extension of Linear Programming (LP), is one of the most practical multi-criterion decision-making tools available. It is used to solve problems involving multiple objectives across different dimensions. GP aims to optimize several goals simultaneously while minimizing deviations from both desired and conflicting objectives (Kendall and Lee, 1980; Dave, 2015; Latinopoulos and Mylopoulos, 2005; Moelyono, 2017; Rahmawati et.al, 2013; Schineiderjans and Wilson, 2019).

The term "optimization" in agriculture refers to strategies for maximizing productivity, trade, and commodity price stability while conserving land. Land-saving efforts focus on minimizing cropland usage, reducing spatial marginalization, and maximizing profits (Schneider, 2022). Optimizing agricultural land is crucial for improving the quality of life by increasing the income of farmers and other stakeholders (Doi and Supachai, 2014). Studies have shown that through optimization, farmers gain better options for sustainable farming practices, driven by their motivation. Optimization is necessary because resources are limited, and it helps achieve goals such as maximum production, profit, or minimizing costs (Antara and Suhardika,2014). In agriculture, goal programming has been applied to optimize crop yields in Sri Lanka, adjusting for varying levels of fertilizers and planting spacing under both monocropping and intercropping systems (Jeyavanan et.al, 2017).

To address the gap in land optimization, this study applies Multi-Objective Goal Programming to determine the optimum allocation of land use and inputs for food crops, aiming to increase food production. The research provided valuable insights into land optimization and farm inputs, which can be used to enhance food crop production and increase farmers' income. Their findings can serve as input for policy formulation to improve food production despite limited land resources. Additionally, parameters such as annual precipitation in production areas and other factors are considered in various scenarios. An extended goal programming approach and stochastic programming were used to solve the model. Finally, sensitivity analyses were conducted on key parameters (Kazemi et al,2021).

2. MATERIALS AND METHODS

2.1. Research Methods and Data Collection Methods

This researcher used a survey method aimed at collecting primary data. This data was gathered through interviews with rice farmers using a structured questionnaire. Secondary data was also obtained from literature studies, especially through internet browsing. Primary data at the farm level was collected using a purposive sampling method. The study was conducted concurrently with research on the "Effectiveness and Efficiency in the Management of Agricultural Machinery" (Siagian et al., 2018). In total, 123 rice farmers were surveyed through interviews with questionnaire. This article is based on parts of the author's dissertation, updated with the latest data and relevant bibliography (Siagian, 2021). Additionally, 66 corn farmers were sampled purposively: 33 respondents from Pandeglang Regency and 33 respondents from Lebak Regency, which are major corn-producing areas. Soybean farmers also sampled purposively in Pandeglang Regency, the largest soybean producer in Banten Province, with 29 respondents. Similarly, 32 cassava farmers from Lebak Regency, a key cassava production area, were sampledpurposively.

2.2. Location and Time

The study took place in Banten Province, specifically in four key rice-producing regions: 1) Tangerang, 2) Serang, 3) Pandeglang, and 4) Lebak. The research was carried out from January 2018 to December 2019. Banten Province covers an area of 9,662.92 km² with a number of residents of 12,927,316 people in 2019. The population density was 1,338 people per km², with an average household size of four people (CBS, 2020). Geographically, Banten Province is situated between 105°1'11" - 106°7'12" East Longitude and 5°7'55" - 7°1'1" South Latitude. Demographically, it is bordered by the Java Sea to the north, the Indian Ocean to the south, West Java and the Jakarta Special Region to the east, and the Sunda Strait to the west (CBS, 2021). The map of the geographical location and land use conditions of Banten Province r is shown in Figure 1 below.

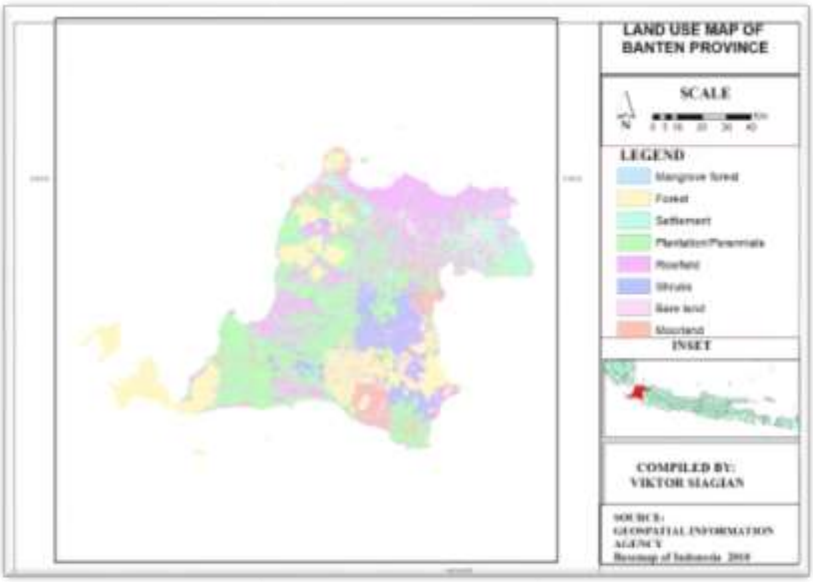

Figure 1: Land User Map of Banten Province. Source: Geospatial Information Agency, 2019.

2.3. Methods of Data Processing and Analysis

This study used both qualitative and quantitative analysis. Qualitative analysis utilized descriptive statistics, while quantitative analysis applied goal programming (GP). GP is a valuable tool for addressing multiple-objective scenarios, aiming to minimize costs and maximize profits (Dave, 2015). It is an extension of linear programming (LP). The general model for multi-objective (goal) programming is structured to achieve maximize or minimize objectives without prioritizing specific factors, with the equation formulated to achieve the optimum target (Charles and Timothy, 2022; Nasikh and Kamaludin, 2021; Damanik, 2013).

$Z = \sum_{i=1}^{m} Wi\ (di^{+} + di^{-})$ ---1)

$Z = \sum_{i=1}^{m} (Wi\ di^{+} + Widi^{-})$ ---2)

With subject to:

$$\sum_{j=1}^{m} a_{ij} X_j\ di^{-} - di^{+}\ b_i ,$$

for i = 1,2, … m, the goal---(3)

and X_j, di^{+}, $di^{-} \geq 0$-----(4)

Each GP model has at least three components: objective function, constraints of the goal, and non-negative constraints [14]. Thee objective functions:

Minimize Z = ∑_(i=1)m▒ 〖di⁻ + di⁺〗 --(5)
Minimize Z = ∑_(i=1)m▒ 〖Pk (〖di⁻ + di⁺] for k = 1,2,3 k –(6)
Minimize Z = ∑_(i=1)m▒ 〖Wki (〖di⁻ + di⁺] for k=1,2,3 k ----(7)

The first objective function is used if the differentiation variables (di- and di+) are not distinguished by priority or weight (without priority and weight), the second objective function is used if sequences (priorities) are required. The differentiation variables in each priority have the same weight. The third objective function is used if the objectives are ordered and the derivation variables at each priority level are used using different weights. The general form for the land optimization model and food crop inputs to increase farmers' production and income is as follows

Minimize Z = $\sum_{i=1}^{n} Gi + \sum_{i=1}^{n} (di^{+} + di^{-})$ –(8)

Minimize Z = $G_1 + G_2 + G_3 + d1^{+} + d1^{-} + d2^{+} + d2^{-} + d3^{+} + d3^{-}$ --(9)

Subject to:

$\sum_{j=1}^{m} a_{ij} X_j\, di^{-} - di^{+}\, b_i$, --(10)

for i = 1,2, … m goals, (11)

and X_j, di^{+}, $di^{-} \geq 0$ –(12)

Where

G_i= objective function

di^{-} = numbe of deivation units that are short of the goal

di^{+} = number of deviation units that are exercised to reach the goal

Wd_i^{-}= weight or scale (ordinal or cardinal) given to negative deivation

W d_i^{+} = weight or scale (ordinal and cardinal) given to positive deivation

a_{ij} = the technological coefficient of the objective constraint function, which is related to the objective of the decision-making variable

X_j = decision-making variables or activities that are now refered to as sub-goals.

b_i = goal or target to be achieved.

Based on the information above, developing an optimization model for land users and farming inputs is feasible to boost food production and farmers' income. The first step is to define the objective functions. There are three objectives, namely: maximizing rice production (G1), maximizing corn production (G2), and maximizing farm household income (G3). With these objectives in mind, a model for each function is then developed to achieve these goals.

Maximize rice production (G1):

Maximize: $\sum_{i=1}^{m}$ □ $C1X1 + C1X2 + C1X3 + C1X4 + C1X5 + C1X6$ ……………… 13)

Minimize: $\sum_{i=1}^{m} C1X1 + C1X2 + C1X3 + C1X4 + C1X5 + C1X6 + \sum_{i=1}^{m} (di^{-} - di^{+})$ ………. 14)

With subject to:

$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + a_{15}X_5 + a_{16}X_6 + d_1^{-} - d_1^{+} + d_2^{-} - d_2^{+} + d_3^{-} - d_3^{+} + d_4^{-} - d_4^{+}$

$+ d_5^{-} - d_5^{+} + d_6^{-} - d_6^{+} = b_1$ ……………………… 15)

$a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + a_{34}X_4 + a_{35}X_5 + a_{36}X_6 + \sum_{i=1}^{n}(di^{-} - di^{+}) = b_3$ ……………… 16)

and $X_1, X_2, X_3, \ldots X_j$, $d_i^{+}, d_i^{-} \geq 0$

Maximize corn production (G_2):

Maximize: $\sum_{i=1}^{m}$ □ $C2X1 + C2X2 + C2X3 + C2X4 + C2X5 + C2X6$

Minimize $\sum_{i=1}^{m} C2X1 + C2X2 + C2X3 + C2X4 + C2X5 + C2X6 + \sum_{i=1}^{m}(di^{-} + di^{+})$ ……. 17)

With subject to:

$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + a_{15}X_5 + a_{16}X_6 + d_1^{-} - d_1^{+} + d2^{-} - d_2^{+} + d_3^{-} - d_3^{+}$
$+ d_4^{-} - d_4^{+} + d_5^{-} - d_5^{+} + d_6^{-} - d_6^{+} = b_1$ ……………………… 18)

$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 + \sum_{i=1}^{n}(di^{-} - di^{+}) = b_2$ ……………… 19)

and $X_1, X_2, X_3, \ldots, X_j$, $d_i^{+}, d_i^{-} \geq 0$

Maximize Farmer Household Income (G_3):

Maximize: $\sum_{i=1}^{m}$ □ $C4X1 + C5X2 + C6X3 + C5X4 + C6X5 + C5X6$ ……………… 20)

Minimize $\sum_{i=1}^{m} C4X1 + C5X2 + C6X3 + C5X4 + C6X5 + C5X6 + \sum_{i=1}^{m}(di^{-} + di^{+})$ … … 21)

With subject to:

$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + a_{15}X_5 + a_{16}X_6 + d_1^{-} - d_1^{+} + d2^{-} - d_2^{+} + d_3^{-} - d_3^{+}$
$+ d_4^{-} - d_4^{+} + d_5^{-} - d_5^{+} + d_6^{-} - d_6^{+} = b_1$ ……………………… 22)
$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + a_{25}X_5 + a_{26}X_6 + \sum_{i=1}^{m}(di^{-} - di^{+}) = b_2$ ……………… 23)
and $X_1, X_2, X_3, \ldots, X_j$, $d_i^{+}, d_i^{-} \geq 0$

3. RESULTS AND DISCUSSION

3.1. Targets for Maximizing Rice Production in Banten Province

Goal Programming (GP) is a method used to achieve optimization. The model applied to maximize lowland rice production in Banten Province is outlined as follows (refer to Table 1):

Table 1: The Model Target for Maximizing Rice Production in Banten Province, Indonesia.

	W(d^+)	Priority(d^+)	W(d^-)	Prioty(d^-)	X_1	X_2	X_3		RHS
Goal/Subject to 1	1	1	1	1	6,030	5,472	3,333	=	2,100,000,000
Goal/Subject to 2	1	2	1	2	205,955.4	172,954.2	0	=	523,522
Goal/Subject to 3	1	3	1	3	25,8	27,8	40	=	11,243,730
Goal/Subject to 4	1	10	1	4	174.9	150	47.9	=	65,540,000
Goal/Subject to 5	1	9	1	5	0	4.23		=	1,530,000
Goal/Subject to 6	1	8	1	6	88	109.4	20	=	20.830.000
Goal/Subject to 7	1	7	1	7	139	89	11,3	=	27,100,000
Goal/Subject to 8	1	6	1	8	97.2	108	0	=	7,410,000
Goal/Subject to 9	1	4	1	9	47	68.9	26.3	=	366.13
Goal/Subject to 10	1	1	1	10	9.3	4.5	67.3	=	960
Goal/Subject to 11	1	5	1	11	25	2.65	0	=	33.100
Source: Primary data, processed, 2020.									

Minimizer Z = 6,030 X1 + 5,472 X2 + 3,333X3 + d- - d+ = 2,100,000,000

Where:

X1 = Optimal area of irrigated paddy field

X2 = Optimal area of rain-fed rice fields

X3 = Optimal area of dry land

RHS = Right Hand Sider, the value to achieve

di - = number of deviation units that are short of the goal

di+ = number of exercise units of deviation against the goal

With subject to (RHS):

1. Availability of land (Ha):

205,965,4X1 +172,954,2X2 + 7,0839,4 X3 + d- - d+ = 523,522 ha

Information:

- The value of 205,965 ha is the planned area of irrigated paddy fields in Banten Province
- The value of 172,954 ha is the planted area of rainfed rice fields in Banten Province
- The value of 70,839.4 ha is the planted area of the Company State of Industry Forest land in Banten Province
- The value of 523,522 ha is the area of agricultural land, including dry fields, plantations, and field/dry

land, fallow land.

2. Availability of rice seeds (kg)

25.8 X1 + 27.8X2 + 40 X3 + d- - d+ = 11,243,730 kg

Information:

- The value of 25.8 kg is the average user of paddy rice seeds per ha in irrigated paddy fields.
- The value of 27.8 kg is the average user of paddy rice seeds in paddy fields rainfed
- The value of 40 kg is the average user of paddy rice seeds in the field/dry land of Company State of Industry Forest (Perhutani)
- The value of 11,243,730 kg is the amount of rice seed availability.

Table 2: Results Summary of the Target for Rice Production Maximization in Banten Province, Indonesia.

Item			
Decision Variable Analysis	Value		
X_1	299,755.7		
X_2	0		
X_3	87,750.88		
X_4	0		
Priority Analysis	Non-achievement		
Priority 1	0		
Priority 2	0		
Priority 3	0		
Priority 4	25,305,480		
Priority 5	71,714,850		
Priority 6	21,726,240		
Priority 7	15,557,620		
Priority 8	8,833,511		
Priority 9	0		
Priority 10	0		
Priority 11	71,714,620		
Subject to Analysis	RHS	d^+ (row)	d^- (row)
Goal/Subject to 1	2,100,000,000	256	0
Goal/Subject to 2	523,522	67,951,990	0
Goal/Subject to 3	11,243,730	0	0
Goal/Subject to 4	65,540,000	0	8.909.468
Goal/Subject to 5	1,530,000	0	1.530.000
Goal/Subject to 6	20,830,000	7,303,516	0
Goal/Subject to 7	27,100,000	15,557,620	0
Goal/Subject to 8	7,410,000	21,725,250	0
Goal/Subject to 9	366.13	16,396,000	0
Goal/Subject to 10	960	8,692,402	0
Goal/Subject to 11	33,100	716,289.1	0
Source: Primary data, processed, 2020.			

3-8 as shown in Table 1.

9. Family labour (Work Man Day):

9.3X1 +4.5X2 + d- -d+ = 960

10. Availability of family hand tractor (Machine

Work Day)
2.5X1 + 4 X2 + d- - d+ = 33,100

According to Table 2, the rice production goal was met with an optimal area of irrigated rice fields (X1) at 299,755.7 hectares and dry land (X3) at 87,750.88 hectares. The primary target of producing 2.1 million unhusked rice was successfully achieved, along with the 2nd, 3rd, 9th, and 10th priority targets.

However, the 4th through 8th and 11th priorities were not met. For the primary target, there was an exercise of 256 unhusked ricer, while Variable X3 neither fell short (d-) nor exceeded there target (d+).

3.2. The Target of Corn Production Maximization in Banten Province

In Table 3, it is explained that the target of corn production in Banten Province in 2018 is 1.749 million tons of dry shelled. The target is obtained from the average production yield for each type of land (X1, X2, X3, X5) multiplied by each planting area.

Table 3: The Model Target for Corn Production Maximization in Banten Province, Indonesia.

	W(d^+)	Priority(d^+)	W(d^-)	Priority(d^-)	X_1	X_2	X_3	X_4	X_5		RHS
Goal/Subject to 1	1	1	1	1	4,526	2,691	5,112	0	3,345	=	1,749,386,000
Goal/Subject to 2	0	0	1	2	98,228	98,058	121,918	0	124,869	=	716,324
Goal/Subject to 3	1	2	1	3	16	15.2	15.7	0	16	=	2,066,480
Goal/Subject to 4	1	3	1	4	78.05	0	79.4	0	21.8	=	66,540,000
Goal/Subject to 5	1	4	1	5	39.1	24.5	21.2	0	136.3	=	20,830,000
Goal/Subject to 6	1	5	1	6	54.7	9.1	29.5	0	266	=	27,100,000
Goal/Subject to 7	1	6	1	7	14.9	25.1	20	0	59.3	=	366.1
Goal/Subject to 8	1	7	1	8	31.1	30.4	20.6	0	4.88	=	840
Goal/Subject to 9	1	8	1	9	1.18	0	1.09	0	1.42	=	90,000
Source: Primary data, processed, 2020.											

Table 4: Summary of Corn Production Maximization Target Results in Banten Province, Indonesia.

Item				
Decision Variable Analysis		Value		
X_1		0		
X_2		0		
X_3		342,211.7		
X_4		0		
X_5		0		
Priority Analysis		Non Achievement		
Priority 1		0		
Priority 2		3,306,243		
Priority 3		0		
Priority 4		39,368,390		
Priority 5		13,575,120		
Priority 6		23,848,640		
Priority 7		7,048,721		
Priority 8		0		
Priority 9		218,178.7		
Subject to Analysis		RHS	d^+ (row)	d^- (row)
Goal/Subject to 1		1,749,386,000	128	0
Goal/Subject to 2		716,324	41,721,050,000	0
Goal/Subject to 3		2,066,480	3,306,244	0
Goal/Subject to 4		66,540,000	0	39,368,390
Goal/Subject to 5		20,830,000	0	13,575,110
Goal/Subject to 6		27,100,000	0	17,004,760
Goal/Subject to 7		366.1	6,843,868	0
Goal/Subject to 8		840	7,048,721	0
Goal/Subject to 9		90,000	283,010.8	0
Source: Primary data, processed, 2020.				

The limiting factor or resource subject to is the land area of 716,324 ha (Subject to 1), the number of corn seeds (Subject to 2) is 2,066.48 tons, which is obtained from the target planting area multiplied by the corn requirement per ha, which is 16 kg. And so on with other resource constraints whose variables are the same as the linear programming (LP) model. The difference is that in GP the production target has been determined, which is 1.749 million tons, while in LP this value is sought.

From the description in Table 4, it can be explained that the maize production target can be achieved at the planting area of maize on dry land (X3), covering an area of 342,211.7 ha.

Their priority target was achieved as indicated by a value of zero (0), the same thing also happened to their third priority target (availability of corn seeds) and their 8th (availability of family labour), and an exercise of 128 kg of dry flakers.

3.3. Model Target for Rice Farmers' Income Maximization in Banten Province, Indonesia

Based on Table 5, the farmers' income target to be achieved is IDR. 8.065 trillion by multiplying the rice planting area with the average income of rice farmers, IDR. 16.63 million/ha, plus the multiplication of the maize planter area with the average income of farmers on maize IDR. 12.44 million/ha and added with the multiplication of soybean planting area with the average income of plant farmers soybeans IDR. 3.84 million/ha and added with the multiplication of cassava planting area with the average income of cassava farmers, which is IDR. 15.19 million/ha.

Table 5. Model Target for Maximizing Farmer Income in Banten Province, Indonesia.

	Wt (d+)		Priority(d+)	Wt (d-)	Priority(d-)	X_1	X_2	X_3	X_4	RHS
Goal/Subject to 1	1		1	1	1	16,629,870	12,438,650	3,845,961	15,188,660	8,798,816,000,0000
Goal/Subject to 2	0		0	1	2	382,914.6	66,356	23,594	3,187	522,746
Goal/Subject to 3	1		3	1	3	25.8	0	0	0	10,184,920
Goal/Subject to 4	1		4	1	4	0	15.7	0	0	2,654,240
Goal/Subject to 5	1		5	1	5	0	0	80.9	0	943,760
Goal/Subject to 6	1		6	1	6	0	0	0	10,000	63,740,000
Goal/Subject to 7	1		7	1	7	169.1	81.7	83.2	13	65,540,000
Goal/Subject to 8	1		16	1	16	1.3	0	0	0	1,630,000
Goal/Subject to 9	1		8	1	8	94.4	13.7	28.8	15	20,830,000
Goal/Subject to 10	1		9	1	9	137.6	23.6	4.3	133.6	28,100,000
Goal/Subject to 11	1		10	1	10	70.8	904.7	228	3,972.7	1,432,648,000
Goal/Subject to 12	1		11	1	11	106	0	0	45.4	7,410,000
Goal/Subject to 13	1		12	1	12	1.94	1	1	1	3
Goal/Subject to 14	1		13	1	13	53.9	21	16.4	40.8	105,608,600
Goal/Subject to 15	1		14	1	14	7.7	16.2	15.3	6.6	105,608,600
Goal/Subject to 16	1		15	1	15	2.25	1	5	0	99,300
Source: Primary data, processed, 2020.										

In Table 6, it is explained that the optimal area for food crop cultivation to meet the incomer target of farmers in Banten Province in 2018, which is IDR 8.79 trillion, comes from planting areas as follows: 391,222.1 hectares of lowland rice, 169,059.9 hectares of corn, 23,074.82 hectares of soybeans, and 2,832.77 hectares of cassava. Priority values 1 to 6 have a "0," indicating that the target was met, while priorities 6-15 were not achieved.

The 6th priority refers to the remaining 35,412,320 cassava seed stems, meaning only 55.5% of the total 63,740,000 stems were utilized. Similarly, for the 10th priority (or 11th goal) regarding the availability of manure, out of 1,432,648 tons, 1,238,057 tons (86.4%) remained unused. This is due to the low user rate of manure on rice, corn, and soybeans, with application rates of 70.8 kg/ha for rice, 904.7 kg/ha for corn, 228.6 kg/ha for soybeans, and 2,972.7 kg/ha for cassava. The same pattern applies to priorities 7, 8, 9, and 11-15.

Based on the net revenue derivation value (d-), the 1st goal has not entirely achieved its revenue target, and there is still a shortfall of IDR. 58.19 billion, but this amount is relatively small (only 0.67% of the total target) compared to the target achievement. Likewise, with the third goal, namely, the use of lowland rice seeds, 91.389 tons of rice seeds have not been produced from 10,184.9 tons of rice seeds. Corn seeds were also only 0.5 kg in excess (d+ = 0.5 kg) of the target achieved.

While the soybean seeds (namely the 5th goal) have been used completely, meaning that the derivation value is zero. The 8th objective is that the user of ZA.

Fertilizer resources are also relatively larger, or the net energy derivation value (d-) is relatively larger, namely 1,021.4 tons (66.75 % remaining). The user of ZA fertilizer is relatively small at an average of 1.3 kg/ha only for lowland rice plants. Then the 11th goal, namely solid organic fertilizer (Pertrogernic), also has a larger positive derivation value of 34,188.1 tons, meaning demand exceeds its availability (461.4%). The use of family and rental labor (destinations -13 and 14) is still relatively larger, while the use of leased hand tractors has exceeded its capacity, namely 1,065,384 machine working days (MWD) or more than 1072.9% of its availability. According to research conducted in 2017, Goal Programming (GP) was used to optimize monoculture and intercropping production between green chili and chickpea plants. In a monoculture system, green chili production over two planting seasons in a year yields 58.0 tons/ha and 51.25 tons/ha. Under an intercropping system, during the first planting season (PS), green chili and chickpea production reached 28 tons/ha and 17.28 tons/ha, respectively. In the second planting season (PS II), production amounted to 21.25 tons/ha for green chili and 14.29 tons/ha for chickpeas (Jeyavanan et.al., 2017).

Table 6: Summary of Results of Targeted Maximization of Farmers' Income in Banten Province, Indonesia.

Item			
Decision Variable Analysis	**Value**		
X_1	391,222.1		
X_2	169,059.9		
X_3	23,074.82		
X_4	2,832.77		
Priority Analysis	Non-achievement		
Priority 1	0		
Priority 2	0		
Priority 3	0		
Priority 4	0		
Priority 5	0		
Priority 6	35,412,320		
Priority 7	16,976,170		
Priority 8	19,457,130		
Priority 9	31,681,050		
Priority 10	1,238,057,000		
Priority 11	34,559,000		
Priority 12	80,288,980		
Priority 13	102,734,800		
Priority 14	1,068,972		
Priority 15	1,021,411		
Subject to Analysis	RHS	d^+ (row)	d^- (row)
Goal/Subject to 1	8,798,816,000,000	0	58,195,970,000
Goal/Subject to 2	522,746	161,575,700,000	0
Goal/Subject to 3	10,184,920	0	91,389
Goal/Subject to 4	2,654,240	0,5	0
Goal/Subject to 5	943,760	0	0
Goal/Subject to 6	63,740,000	0	35,412,320
Goal/Subject to 7	65,540,000	16,384,500	0
Goal/Subject to 8	1,530,000	0	1,021,411
Goal/Subject to 9	20,830,000	19,126,800	0
Goal/Subject to 10	27,100,000	31,199,660	0
Goal/Subject to 11	1,432,648,000	0	1,238,305,000
Goal/Subject to 12	7,410,000	34,188,150	0
Goal/Subject to 13	105,608,600	0	80,477,460
Goal/Subject to 14	105,608,600	0	99,485,680
Goal/Subject to 15	99,300	1,065,384	0

A research paper published in 2005 focused on the optimal allocation of land and water resources in irrigated agriculture using goal programming, specifically in the Loudias River Basin in Greece. The main objective of this study was to develop, evaluate, and implement a model aimed at maximizing farmer welfare while also addressing the environmental impact. To achieve balanced solutions, the study applied weighting and objective programming techniques to optimize land and water distribution across different crops under various scenarios (Latinopoulos and Mylopoulos, 2005).

In 2007, a study investigated the application of fuzzy goal programming to solve agricultural land allocation challenges in India. This research proposed an optimal strategy for land distribution for cultivation and suggested yearly farming plans for different crops. Their approach incorporates goals like crop yield, net profit, water and labor needs, and machine usage, employing fuzzy logic to manage uncertainties within the decision-making process (Sharma et al., 2007).

Their study applied a pre-emptive GP approach to determine the optimal land allocation for five crops: cowpea, black gram, finger millet, corn, and soybeans in Anuradhapura District, Sri Lanka. The results showed that all five crops achieved the expected production targets. However, the optimization reduced the experimental planting area for black gram in the Yala dry season from 510 hectares to 636.36 hectares and in the Maha rainy season from 6,750 hectares to 5,202.48 hectares. In contrast, the planting area for finger millet in the Maha season increased significantly, from an expected 2,675 hectares to 13,051.2 hectares after optimization (Gamaghe, 2017).

Goal programming (GP) is applied to identify the optimal mix of various Muslim clothing products while taking into account multiple objectives, such as maximizing revenue, minimizing production costs, and maximizing machine utilization [34]. Goal programming was utilized to optimize plant-livestock integration in Tanah Laut Regency, Central Kalimantan Province, using WinQSB software. The research findings indicated that the initial optimization recommended cultivating 0.20 hectares of rice, 0.30 hectares of rubber, 0.28 hectares of peanuts, and 0.22 hectares of sweet corn. Their objectives achieved include economic benefits, with an income of IDR 11,836,614 per year, and an increase in livestock numbers by 4.25 AU per year (Rohaerni et.al, 2014).

The research applied GP and Analytic Hierarchy Process (AHP) methods to assess plantation suitability in Iran, resulting in the following suitable plantation areas: Acer velutinum (810 hectares), Alnus subcordata (348 hectares), Pinus taeda (235 hectares), Tilia begoniifolia (165 hectares), Quercus castanifolia (149 hectares), Pinus nigra (110 hectares), and Fraxinus excelsior (0 hectares) (Osthadhasemi, 2014).

Additionally, a 2014 study utilized AHP and GP approaches to optimize land use at the watershed level in the Hulu Langat Basin, Selangor, Malaysia. This study identified four optimal land development alternatives: A1, A2, B1, and B2. From a water conservation perspective, alternatives A1 and B1 were found to be more desirable, while alternatives B1 and B2 were found to be more suitable in terms of socio-economic and environmental conditions (Memarian et.al., 2014).

Their study evaluated the sustainability of the rice (Oryza sativa L.) agricultural production chain in Brazil and Cuba, using a conceptual model based on five sustainability sectors and employing goal programming as a multicriteria analysis tool. A synthetic sustainability indicator was created to support decision-making through benchmarking, enhancing the environmental, economic, and social sustainability of rice farming.

The results indicated that Brazil showed greater sustainability due to better access to environmental resources for rice cultivation, a lower relative environmental impact, and stronger economic and productive outcomes.

However, Brazil's factors related to employment and wage policies, along with higher social satisfaction levels regarding richer demands. In contrast, Cuba struggles with limited environmental resources, a higher relative environmental impact, and weaker economic and productive outcomes, but benefits from more favorable employment and wage policies, despite unmet social demand for richer (Roberto et al., 2021).

Their findings showed that adjusting irrigation levels and fertilizer application rates within certain ranges can improve crop yields and grain quality. The ideal nitrogen application rate was determined to be 80 and 140 kg/ha, with water consumption ranging from 5,000 to 8,000 m^3/ha. It was also observed that excessive water and fertilizer inputs could lead to negative outcomes (Liu, 2019).

Based on the literature study conducted, research on the optimization of rice and corn production, as well as farmers' income using goal programming analysis is very rare or almost never carried out in Banten Province or Indonesia, so it is relatively difficult to relate the results of relevant studies to this study.

4. CONCLUSIONS AND POLICY IMPLICATIONS

4.1. Conclusion

The rice production target of 2.1 million tons of unhusked rice in Banten Province can be met with an optimal irrigated paddy area of 299,755.7 ha and an optimal dry land area of 87,750.9 ha. For corn production, the target can be reached with an optimal dry land planting area of 342,211.7 ha.

To achieve the 2018 farmer income target of IDR 8.79 trillion in Banten Province, optimal planting areas include 391,222.1 ha for lowland rice, 169,059.9 ha for corn, 23,074.82 ha for soybeans, and 2,832.77 ha for cassava.

Due to the limitations of research, it is necessary to conduct further research on the optimization of agricultural land in general and especially irrigation fields and dry lands to increase rice, corn, and soybeans production.

The model of this study can also be carried out on an Indonesian scale to find out what the optimal target of food production can be achieved and also the optimal income target of farmers with limited resource constraints and until now no one has done the research.

4.2. Policy Implications

Maximizing rice production is carried out by optimizing the area of irrigated rice fields, while maximizing corn production is carried out by optimizing dry land in the Province of Banten. Income maximization is carried out by optimizing the rice planting area and cassava planting area in the Province of Banten. To increase food production, increasing the crop index in irrigated rice fields is very necessary by optimizing the use of agricultural machinery.

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