Study of Optimization Planting Patterns of Irrigation Areas Ciujung Ciruas District Using a Linear Program

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Abstract

Ciujung Irrigation Area (DI) has an area of 21,350 ha. The Ciujung Irrigation Area Irrigation Network is still found to be quite high sedimentation, so that the distribution of water for agricultural needs and other community needs has not been able to be carried out optimally. The purpose of optimizing the planting pattern is to determine the maximum price of the crop that a field with different types of crops can produce. Optimization in this study used a linear program using the POM QM application. In this optimization study, 4 alternatives were planned with 2 different crops, namely corn and peanuts. In the planting pattern, alternative 1 starts planting in December I, alternative 2 starts planting in December II, alternative 3 starts planting in January I, alternative 4 starts planting in January II. The alternative planting pattern chosen is alternative 2 by producing an area of MT I Rice covering an area of 21,350 ha, MT II Rice covering an area of 3671.62 ha, Palawija covering an area of 84.98 ha and the maximum profit obtained in a year is IDR 595,113,300,000

Keywords: Optimization, Planting pattern, POM-QM, Profit

1. Introduction

Ciujung Irrigation Area (DI) has an area of 21,350 Ha. The Ciujung Irrigation Area Irrigation Network is still found to have a fairly high sedimentation, so that the distribution of water for agricultural needs and other community needs cannot be carried out optimally [1]. It is necessary to conduct research and planning analysis. Optimization of irrigation water use is expected to meet the water needs of plants. In addition, it regulates a more optimal planting pattern based on the type of plant, land area and water availability [2] [3]. The objectives obtained from writing this final project are:

A. To find out the irrigation water needs of the Ciujung Irrigation Area (DI).
B. To find out the maximum profit from the production yield based on the planting pattern [4].

2. Literature Study

2.1 Planting Pattern

Planting pattern is an effort to plant on a piece of land by arranging the arrangement and order of plants in a certain period of time, both planting and non-planting periods. The
selection of planting varieties is important because it must be adapted to the conditions of water availability or precipitation. The purpose of applying the planting pattern is as follows:
1. Increased food production.
2. Establish a planting schedule to facilitate irrigation water management.
3. Avoiding non-uniformity of tanaman.
4. Knowing the water needs of plants [5].

2.2 Irrigation Water Requirements
Irrigation water needs are defined as the amount of water provided by nature through rainwater for the purpose of optimal growth of plant needs, and the contribution of groundwater to irrigated land, taking into account evaporation, water loss, and plant water needs. The amount of water needed to meet water needs calculate the irrigation water needs needed to be the basis for planning irrigation networks (channels and buildings) [6]. Irrigation water requirements are calculated based on the planned planting pattern and the following parameters:
1. The need for water for soil preparation.
2. Plant water needs.
3. Water needs due to water loss and water distribution plants (infiltration).
4. The need for water for flood replacement.
5. Effective rainfall.
6. Irrigated land area.

2.3 Optimization with Linear Programs
Linear programming is used in formulating mathematical models of optimization, including determining decision variables, goal functions, and constraint functions [7] [8]. The decision variable used is the land area for each alternative planting pattern that has been planned using a solver in the POM-QM application to benefit from the function of goals and constraints [9] [10].
3. Research Methods

3.1 Hydrological Data

Hydrological data is needed to calculate irrigation water needs and mainstay discharge [11]. Hydrological data in the form of daily rainfall obtained from the Cidanau-Cijung-Cidurian River Basin BBWS (Balai Besar Wilayah Sungai) [12].

3.2 Climatology Data

Climatology data can be used to calculate water requirements and irrigation water discharge including air temperature data, humidity data, duration of exposure to sunlight and wind speed. These data can be used to calculate evaporation and evaporation in plants.
4. Data Analysis and Discussion

4.1 Effective Rainfall Analysis (Re)

Hydrological data were obtained from the Cidanau-Ciujung-Cidurian BBWS (River Basin Center) in the form of monthly rainfall [13].

![Figure 2. Monthly Average Rainfall Data (mm)](source)

![Figure 3. Semi-Monthly Rainfall Data of Pamarayan Rainfall Station](source)

The annually aggregated monthly rainfall data is sorted from largest to smallest, then look for probabilities using the weibull formula [14].

![Figure 4. Semi-Monthly Rainfall Probabilities 50% and 80%](source)

Rainfall with a probability value of 80% is used to calculate effective rainfall in rice and rainfall with a probability value of 50% for palawija [15].
4.2 Analysis of Evapotranspiration Calculations (Eto)

Evaporation and transpiration events are simultaneously called evapotranspiration. The potential for evaporation is also commonly referred to as plant consumption needs, which is the amount of water needed to evaporate from the surface of the plant area. Climate plays an important role in determining these characteristics. Meteorological data include: temperature, humidity, wind speed and length of solar irradiation [16]. The evaporation potential can be calculated using the Penman method. Here is the calculation for Evapotranspiration:

4.3 Analysis of River Discharge Calculation by FJ Method. Mock

Calculation of The Mainstay Discharge using the FJ method. Mock simulates river flow calculations using effective rainfall data, potential evapotranspiration and hydrological characteristics of watersheds [17].
4.4 Calculation of Irrigation Water Needs

Alternative planting patterns in this optimization study are as follows:
1. Alternative 1: Start planting in December I
2. Alternative 2: Start planting in December II
3. Alternative 3: Start planting in January I
4. Alternative 4: Start planting in January II

In this optimization study, the author conducted 2 experiments in each alternative. By replacing the crops used, namely Corn and Peanuts.

1. Calculation of Water Needs in Rice Plants

There are 2 stages that are used when calculating the water needs of rice plants, namely soil preparation and growth.

The calculation of water requirements at the tillage stage uses the following formula:

\[ PL = \frac{M - \varepsilon^K}{e^{K-1}} \]

\[ K = \frac{M \times T}{S} \]

\[ M = 1,1 \times Eto + P \]

\[ NFR = PL - Re \]

Information:

- PL = Need for irrigation water in rice fields (mm / day)
- M = Water requirement to replace water loss due to evaporation and percolation in saturated rice fields
- T = Land preparation period (days)
- S = Need for saturated water coupled with a 50 mm layer of water
- P = Percolation (mm/day)
- Re = Effective Rainfall (mm.day)
- NFR = Water requirements in rice fields 1 mm / day

(0.116 liters/second/ha)
During the growth period of rice or palawija using the water balance equation to calculate the water needs needed in the rice field at the growth stage:

\[
\text{NFR (Padi)} = \text{ETc} + \text{P} + \text{WLR} - \text{Re}
\]

\[
\text{NFR (Palawija)} = \text{dll} - \text{re}
\]

Information:
- \(\text{ETc}\) = Consumptive use (mm/day)
- \(\text{P}\) = Percolation (mm/day)
- \(\text{Re}\) = Effective Rainfall (mm/day)
- \(\text{WLR}\) = Replacement of water layer (mm/day)

Figure 8. Irrigation Water Needs of Alternative Rice and Corn Crops 1
Source: Calculation 2022

Figure 9. Irrigation Water Needs of Rice and Peanut Crops Alternatives 1
Source: Calculation 2022
Figure 10. Irrigation Water Needs of Alternative Rice and Corn Crops 2
Source: Calculation 2022

Figure 11. Irrigation Water Needs of Alternative Rice and Peanut Crops 2
Source: Calculation 2022

Figure 12. Irrigation Water Needs of Alternative Rice and Corn Crops 3
Source: Calculation 2022
4.5 Analysis of Farm Business Results

The results of the Farming Business are the result of a farmer's net profit from the harvesting process. Revenue is production minus production costs, which brings you a net profit [18]. The performance of agricultural production in each rice field is multiplied by the price of its products. The following is an analysis of the results of farming:
Table 1. Production Yield and Production Cost per Hectare

|               | RICE  | CORN  | PEANUT |
|---------------|-------|-------|--------|
| Yield Production (Rp/ha) | IDR 36,000.00 | IDR 18,000.00 | IDR 11,400.00 |
| Cost Production (Rp/ha)    | IDR 12,250.00 | IDR 8,000.000 | IDR 6,750,000 |
| Profitability (Rp/ha)      | IDR 23,750.00 | IDR 10,000.00 | IDR 4,650,000 |

4.6 Planting Pattern Optimization
- Mathematical Model Optimization
  Based on the results of the analysis of water needs for each alternative and the mainstay denit so that it becomes an input for linear programs to obtain optimal planting pattern results.

- Purpose Function
  Maximize By Land Area
  \[ Z_{max} = (X_{A1} \cdot Y_{A1}) + (X_{B1} \cdot Y_{B1}) + (X_{C1} \cdot Y_{C1}) + (X_{D1} \cdot Y_{D1}) \]

- Constraint Function
  a) Mainstay Debit
  \[ DR \leq Q \]
  b) Maximum Area
  \[ Y_{A1} \leq A \]
  \[ Y_{B1} \leq A \]
  \[ Y_{C1} + Y_{D1} \leq A \]
  Where, Total = 21,350 Ha

- Non Negativitas
  \[ Y_{A1}, Y_{B1}, Y_{C1}, Y_{D1} \geq 0 \]

Information:
- \( Z_{max} = \) Maximum profit (Rp)
- \( X_{A1} = \) Mt I rice profit (Rp/ha)
- \( X_{B1} = \) Mt II rice profit (Rp/ha)
- \( X_{C1} = \) Corn Profit (Rp/ha)
- \( X_{D1} = \) Peanut Profit (Rp/ha)
- \( Y_{A1} = \) Rice Land Area MT. I (ha)
- \( Y_{B1} = \) Rice Land Area MT.II (ha)
YC1 = Corn Land Area (ha)
YD1 = Peanut Land Area (ha)
DR = Irrigation Water Needs Discharge (m3/sec/ha)
Q = Mainstay Discharge (m3/sec)

- Analysis of Optimization Results
Optimization analysis is based on 2 objectives, namely maximum broad purpose and maximum profit using the AUXILIARY POM-QM for Windows 3 program.

![Figure 16. Land Area Results and Alternative Profit Analysis 1 using POM-QM Application for Windows 3](image_url)

Optimum land area results using the POM-QM for Windows 3 program generate data on the optimum surface area for each plant type for each alternative planting pattern and generate maximum profits based on agricultural analysis. The profit value is generated from the total area of each type of plant.

Table 2. Comparison of Irrigation Water Needs and Advantages of Planting Patterns for Each Alternative

| Optimization Results Alternative | Advantage Rp                  | Irrigation Water Needs en/dt/ha |
|----------------------------------|-------------------------------|---------------------------------|
| 1                                | IDR 595,113,300,000           | 1.91                            |
| 2                                | IDR 556,274,900,000           | 2.03                            |
| 3                                | IDR 527,109,800,000           | 2.22                            |
| 4                                | IDR 517,333,900,000           | 2.22                            |
In the table above, it can be seen that alternative 1 which has a maximum profit of Rp. 595,113,300,000 compared to other alternatives and the maximum irrigation water needs are 1.91 lt / dt / ha.

5. Conclusions

The conclusions that can be drawn from the results of the calculation and analysis of the study are as follows:

1. The amount of irrigation water needs for each alternative planting pattern is as follows:
   - Alternative 1: 1.91 lt/det/ha
   - Alternative 2: 2.03 lt/det/ha
   - Alternative 3: 2.22 lt/det/ha
   - Alternative 4: 2.22 lt/det/ha

2. In the planting pattern with alternative 1 starting planting December I, alternative 2 starting planting December II, alternative 3 starting planting January I, alternative 4 starting planting January II. The alternative planting pattern chosen is alternative 1 by producing a land area of MT I Rice covering an area of 21,350 ha, MT II Rice covering an area of 3671.62 ha, Palawija covering an area of 84.98 ha and a maximum profit obtained in a year of Rp. 595,113,300,000.

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