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Efficient Cropping Pattern to Increase Production Yield in Manatuto Timor-Leste

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Abstract: *Irrigation plays a very important role in increasing agricultural yields to maintain national food security and improve the welfare of the Manatuto people in Timor-Leste. The purpose of this study is to determine the cropping pattern that can be applied effectively in the area. In order to plan an optimal cropping pattern, analysis of climatic and topographic data is very important to obtain information on evapotranspiration, effective rainfall, and irrigation water requirements. To determine effective rainfall, 10 years of data were used to obtain rainfall values at the research site. Meanwhile, the Blaney-Criddle method is used in the calculation of evapotranspiration. Through this analysis, an attempt was made to find the right time to start planting by assessing the required irrigation water requirements. The simulation results showed that the Laclo irrigation system was not able to meet the required water needs every month of the year. In further analysis, the K values obtained in alternatives 1 to 5 showed significant differences each month. The first alternative has the highest average K value, which is 0.51. Therefore, the first alternative was selected for land preparation in January first.*

Keywords: Efficiency and Cropping Pattern

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1. Introduction

Agriculture is an important sector in national development. With the increasing need for food and efforts to increase agricultural production. This includes the use of modern technology and sustainable farming practices. In addition, education for farmers and access to markets are also crucial so that they can produce efficiently and profitably. Therefore, agriculture not only fulfills food needs, but also supports the economy and well-being of the community.

Irrigation refers to the provision and management of water needed to support agricultural activities. Some of the types of irrigation included in this system are pump irrigation, groundwater irrigation, wetland irrigation, surface irrigation, and pond irrigation. The main objective of irrigation is to increase agricultural productivity, which in turn contributes to community welfare as well as national food security, especially the welfare of farmers. This can be achieved by ensuring the sustainability of existing irrigation systems.

Cropping patterns are efforts to optimally increase the use of agricultural land in all restrictions made by regulating crop patterns. Cropping patterns aim to increase farmer's income in the agricultural system and can reduce the risk of failure due to crop failure. Increasing production

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through high technical efficiency is very important because it can increase yields and farmer's income. (Manihuruk, et al., 2018).

Appropriate cropping patterns are needed to increase rice productivity, increase farmer's income, and support sustainable cultivation without damaging agricultural land. Efforts to utilize technological efficiency through optimal allocation of available resources will increase land and crop productivity, reduce agricultural (production) costs to the lowest possible level, and thus is expected to increase farmer's income. (Manihuruk, et al., 2018).

Thus, to apply good cropping patterns necessary to achieve food security and increase agricultural productivity, adequate water availability and proper selection of cropping patterns have great agricultural potential. It is important to understand water availability and cropping dynamics according to farmer's needs and environmental conditions.

2. Materials and Methods

The research has been conducted in Laclo irrigation area, one of the districts in Timor-Leste, Manatuto district and lasted for 6 months. The data used in the research are climatic data and topographic data as well as other supporting data. Blaney-Criddle method to calculate evapotranspiration.

Effective Rainfall

Effective rainfall refers to the amount of rainfall that can be utilized by plants for optimal irrigation needs. The unit used in measuring rainfall is millimeters (mm), and the first step in irrigation planning is to determine the necessary water requirements. To calculate the monthly effective rainfall used in irrigation, 70% of the minimum average monthly rainfall with a 5-year return period is taken (KP-01,2013).

$$R_e = 0{,}7 \text{ x } \frac{1}{15} \text{ R (half month)}$$

With :

R_e : Effective rainfall (mm/day)

R (half month)5 : Average minimum rainfall for the middle of the month with a return period of 5 years (in mm)

Irrigation Efficiency

Irrigation efficiency is the ratio between the amount of water used effectively by plants and the total calculated water, which is expressed as a percentage (%) (Sujarwadi, 1999). To assess water loss in the carrier channel, the efficiency of the channel can be calculated in the following way:

$$Ec = Wr/Wf \text{ x } 100\%$$

Description:

Ec : Water Carrier Channel Efficiency (%)

WF : Water reaching Irrigation Area (m3)

WR : Water flowing from the water source (m3)

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Paddy Field Water Requirement

Water requirements in rice fields include water needs for tillage, plant growth, water loss in the field, and water needs to achieve irrigation efficiency. The total amount of water required by rice fields can be calculated using the following equation: (Model of Pipe Irrigation Network System on Flat Land)

$$NFR = Etc + P - Re + WLR$$

Description:
WLR : Water layer replacement (mm/day)
Re : Effective rainfall (mm)
P : Percolation (mm/day)
Etc : Evapotranspiration (mm/day)
NFR : Net water demand in the field (mm/day)

Water Requirement for Plant Consumptive

In order to calculate the water requirement of plants for consumption, the following empirical formula is used:

$$Etc = Kc \times Eto$$

Description:
Kc : Plant coefficient
Eto : Evapotranspiration of reference plants (mm/day)
Etc : Plant evapotranspiration (mm/day)

Percolation

The percolation rate is strongly influenced by soil characteristics. In well-treated heavy clay soils, percolation rates can reach between 1 to 3 mm per day. Meanwhile, the perlocation velocity tends to be higher in lighter soil types. The results of on-farm research and research on the transition strength of water allow for the determination of percolation rates and provide recommendations for their use. To determine the correct percolation rate, the sum of the soil water levels must be considered. In addition, seepage occurs as water percolates through the rice field embankment.

Planting Pattern

In general, cropping patterns in an irrigated area must be regulated to produce consistent harvests and planting times. Limited water availability is the reason that affects the arrangement of annual cropping patterns (Suryadi, 2011).

Factor K

The K factor is the ratio between water application and irrigation water requirement. This value ranges from 0-1. The worst case is indicated by a value of 0 which means that the water requirement is not met at all and vice versa, indicated by a value of K = 1 which means that the water requirement has been met.

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3. Result and Discussion

Analysis of Water Requirement Calculation

Evapotranspiration calculation is needed to calculate irrigation water requirements. Evapotranspiration analysis using the Blaney-Criddle method and temperature data are required. Potential evapotranspiration (ETo) is calculated based on climate data analysis.

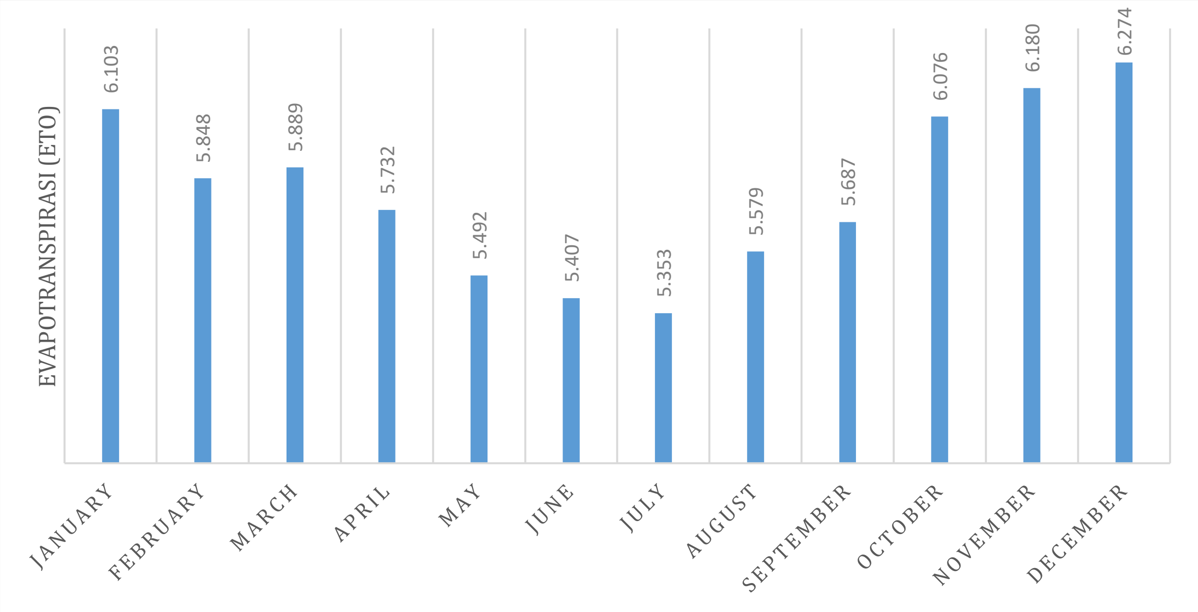

Figure 1: Recapitulation of ETo Value

The rainfall data used in the calculation will include monthly average rainfall values from one observation point from 2012 to 2022.

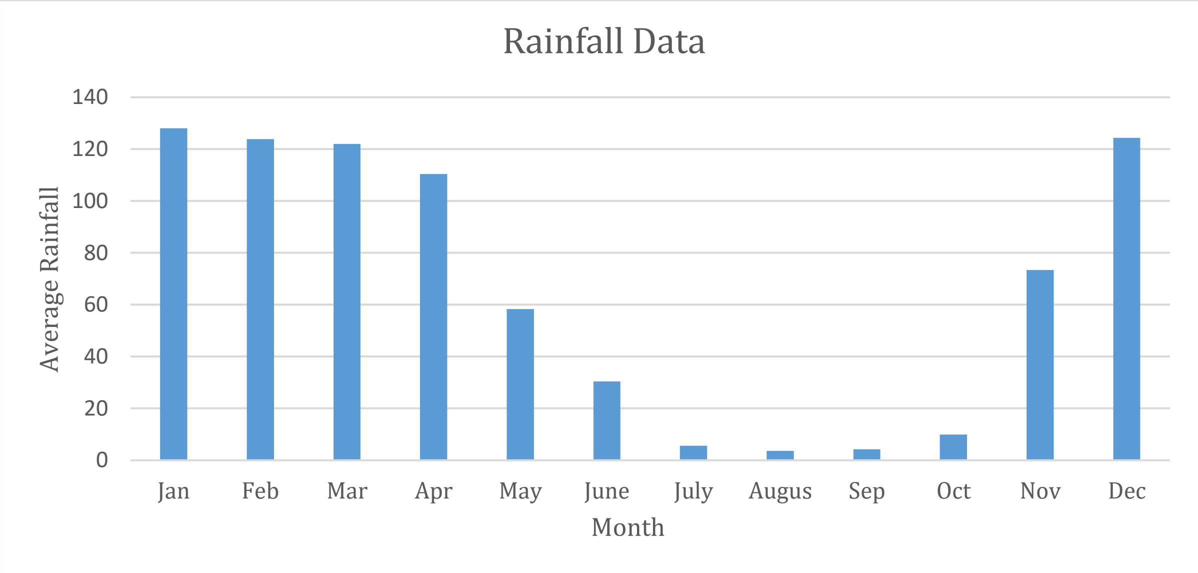

Figure 2: Average Rainfall Calculation

Effective rainfall is the portion of total rainfall that is optimally available to meet crop water requirements. The effective rainfall amount is estimated at 70% of the monthly average rainfall with a probability value of 80%.

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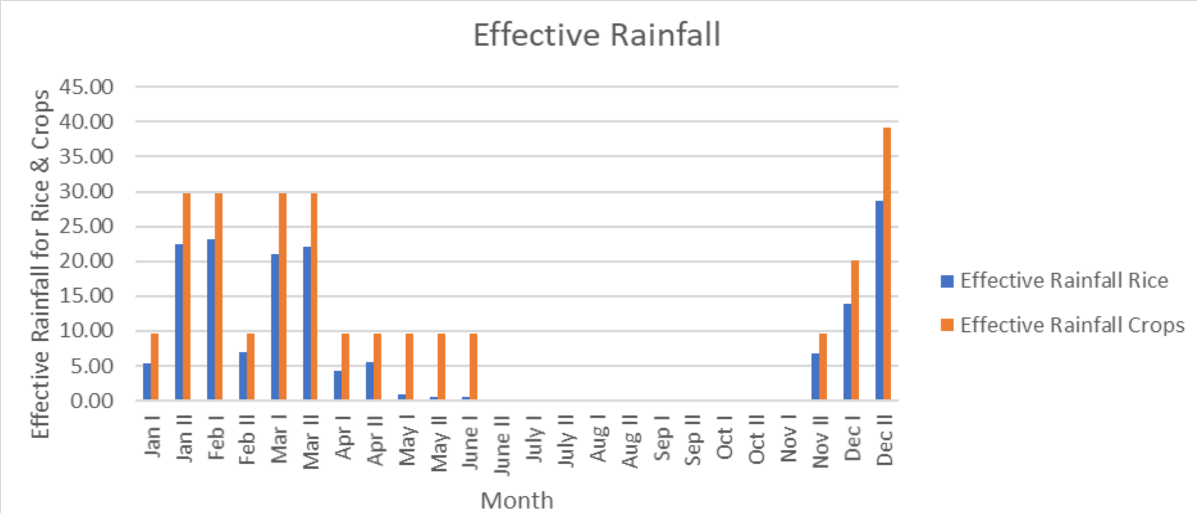

Figure 3: Recapitulation of Effective Rainfall Results

Irrigation water requirements are calculated using the Rice-Palawija-Palawija cropping pattern
The planting start time for alternative 1 takes place from January I to June II
The planting start time for alternative 2 takes place from November I to April II
The planting start time for alternative 3 takes place from November II to May I
The planting start time for alternative 4 takes place from December I to May II
The planting start time for alternative 5 takes place from December II to June I.
For example, based on the above water demand analysis, we come up with an initial planting plan:

Table 1: Early Planting Scheme for Rice-Cropping Pattern-Plant-Cropping Pattern

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
L		Rice										Crops I						Crops II					

Early planting scheme

To get a good initial planting plan by doing simulation one to simulation five to get the K factor. The following are the simulation results.

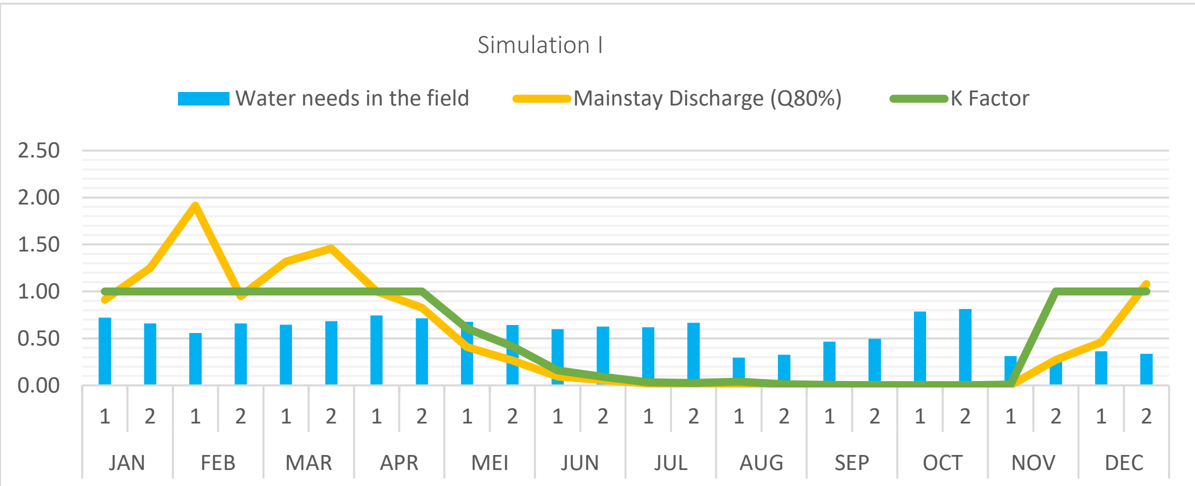

Figure 4: Simulation of Water Demand, Q and K factor for the beginning of planting in January I

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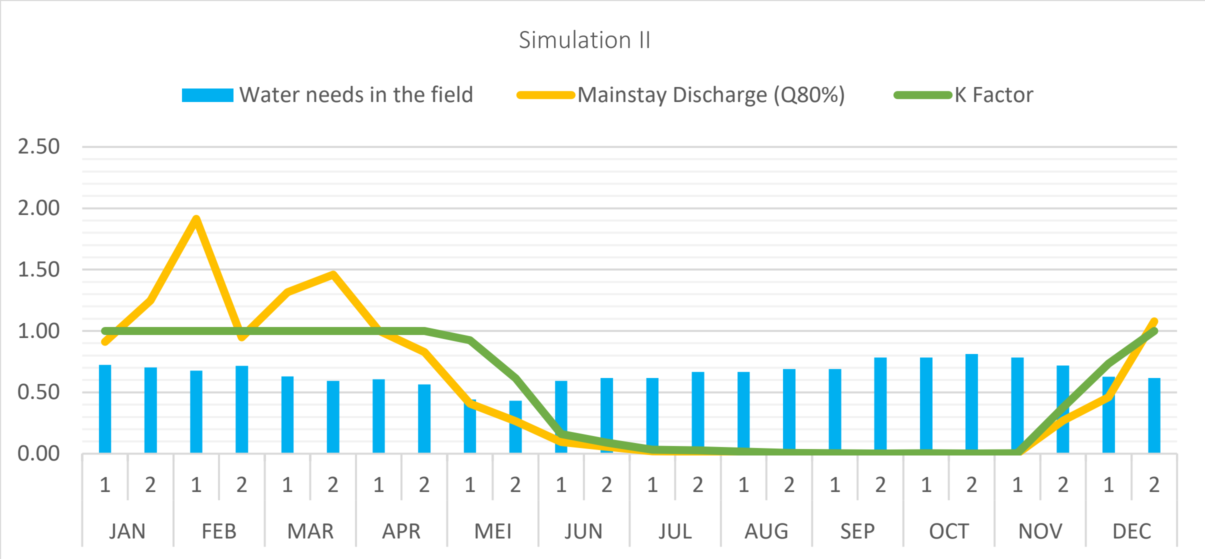

Figure 5: Simulation of Water Demand, Q and K factor for the beginning of planting in November I

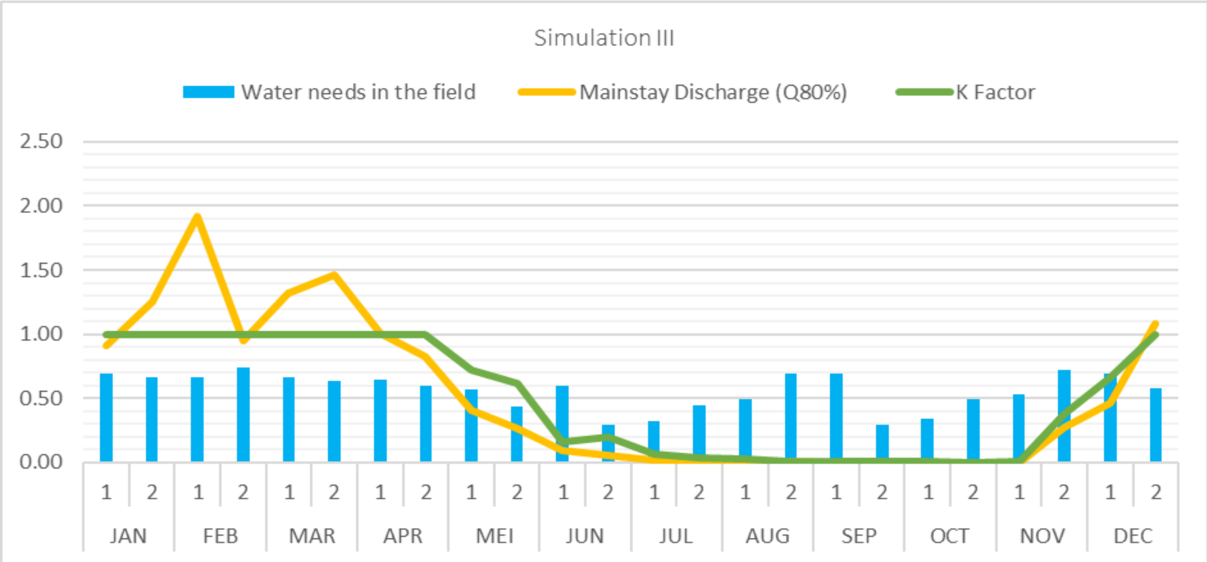

Figure 6: Simulation of Water Demand, Q and K factor for the beginning of planting in November II

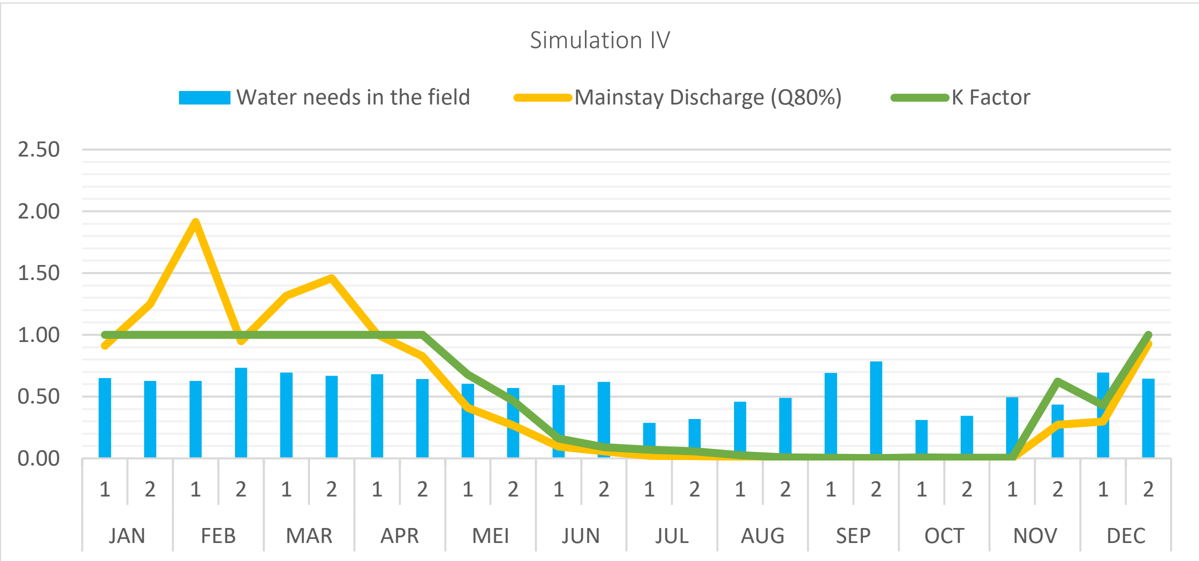

Figure 7: Simulation of Water Demand, Q and K factor for the beginning of planting in Desember I

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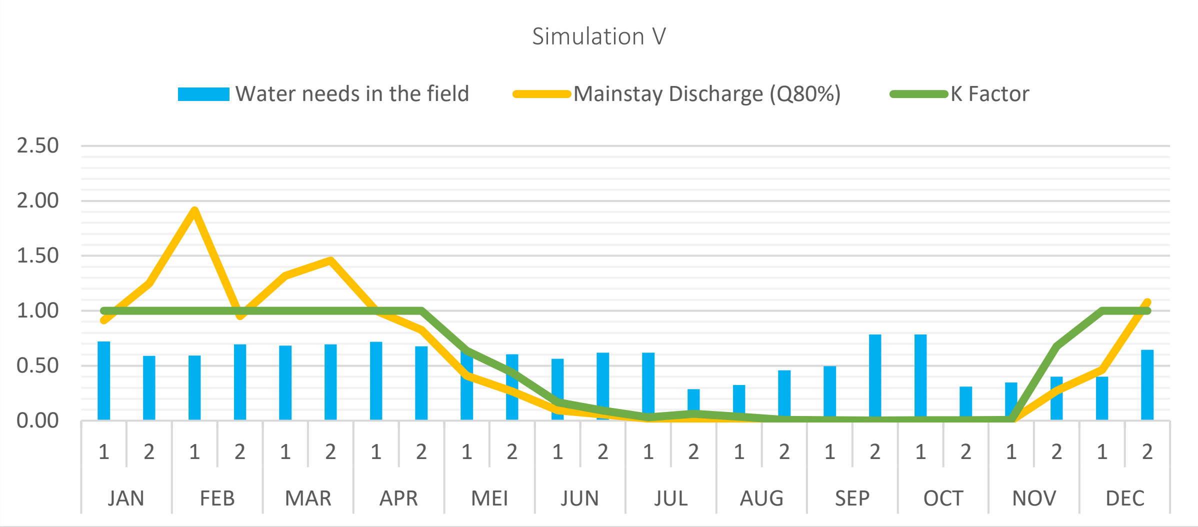

Figure 8: Simulation of Water Demand, Q and K factor for the beginning of planting in Desember II

The results of the k-value analysis for alternatives 1-5 show that the value of each month is different. The highest average K value is 0.51 which occurs in alternative I. Alternative I was selected for land preparation in January I

4. Conclusions and Suggestions

Conclusion

Analysis of rainfall data shows that the average maximum rainfall occurred in January at 128 mm, while the average minimum rainfall was recorded in August at 4 mm.

The results of the water supply simulation show that Laclo irrigation has not been able to provide water as needed every month throughout the year. This is shown every month from different k values.

From the results of the analysis using 5 alternative planting starts, the alternative used is alternative 1 because it has the highest average K value of 0.51. Alternative I was chosen for land preparation in January I

Suggestion

The analysis can be continued using 4-month-old rice so that a decreased water requirement can be expected.

Water shortages in September and October suggest looking for other sources of water, such as groundwater.

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