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Failure Analysis of Irrigated Areas as a Drought Reflection to Strengthen Food Security

Iman Handiman[1], Pengki Irawan[2], Novia Komala Sari[3], Asep Kurnia Hidayat[4]
[1, 2, 3, 4]Civil Engineering Department, Siliwangi University, Tasikmalaya, West Java, Indonesia
Email: asepkurnia @ unsil.ac.id

Abstract— *Drought in the irrigated area will cause paddy fields to not produce well or land failure which in turn will cause crop failure. Harvest failure will weaken food security and will become a national problem if it occurs simultaneously. Land failure analysis can avoid this problem, at least reduce the losses that occur because the land cannot be harvested. Drought occurs because of an imbalance in demand and availability of water in the field. The formula for regulation of water balance so as to produce optimum agricultural production has not been verified under existing conditions. Formula built with reliable discharge factors, irrigation water requirements, efficiency of irrigation channels, water losses in irrigation channels, cropping patterns and planting schedules. The result of the research is the analysis of the prediction of land failure verified by the existing conditions, namely the recommended area to be reduced or planted with palawija based on the cropping pattern and planting schedule of the optimum regulation results. Besides that, it also produces effective rainfall for the Cimulu irrigation area, optimum water requirements, and production yield estimates based on the analysis of minimum land failure predictions.*

Keywords— *Drought, food security, irrigation water, land failure, water balance*.

I. Introduction

The failure of agricultural crops, especially paddy, is caused by many things, one of which is due to drought which causes the land to fail to produce optimally. Land failure can be predicted and analyzed from the occurrence of water imbalance between supply and demand for irrigation water . An imbalance condition where the water supply is less than the need for irrigation water will cause the land to not produce optimally. This condition can be interpreted as a reflection of drought. Water balance is the ratio between demand and availability of water which is considered to exceed the critical point or is in the danger threshold of a water deficit if it reaches a level above 75% (4). The failure analysis of irrigated area offers a solution and revitalization of the existing irrigation area so that the irrigation area can be predicted earlier regarding the land area that causes water imbalance.

The decrease in rice field harvested area and rice production on the north coast of West Java was 77.00 ha / year and 926.10 tonnes / year (13). Drought in agricultural land also occurs because the need for irrigation water will increase, as said, Sangam Shhrestha, 2017 stated that the need for irrigation water in the future shows a very high increase due to evapotranspiration. the formula for reflecting between failure and drought is still rare. This is probably because irrigated agricultural land simulations generally do not have a key interaction between water demand from crops and water supply from the irrigation system (8). The water resource development project is faced with a unique set of physical conditions that are handled specifically, so that standard plans that provide a simple solution, which refers to the manual are rarely used (9).

II. Research Methodology

A. Location

The research location was conducted in Cimulu irrigation area from Cimulu weir. Location in Tawangsari Village District Tawang Tasikmalaya City West Java Province with geography coordinates at 7°19'14.34" LS and 108°13’17.55 " BT, with an area of 1546.2 ha.

B. Material and Tools

This study uses mathematical equations that have been formulated previously, analysis using Visual Basic for Application (VBA). Besides that also interviewed farmers to get drought data.

C. States of Art

1) The Need for Irrigation Water in the Land (KAI_L)

$KAI_L = f(Et_c, P, WLR)$ (1)

Where KAI_L is the water requirement at the time field preparation, Et_c is evapotranspiration, P is the percolation, and WLR is the replacement of the water layer.

2) Netto Field Water Requirement (KAI-P / NFR)

$KAI_p = Etc + P + WLR + HE80\%$ (2)

Where KAI_p is netto field water requirement (mm/day), Etc is the consumptive uses (mm/day), WLR is the replacement of water layer (mm/day), and HE80% is the effective rainfall (mm/day).

3) Effective Rainfall and Mainstay Discharge

Effective rainfall and reliable discharge are calculated based on the probability of a number of observational data. Analysis with the Weibull’s formula.

$P = (m/n+1)x100\%$ (3)

Where P is probability of exceedance (defined as 80%), m is rank of the event, and n is the number of years record.

4) Benefits of Per Hectare Plants Per Year and Existing Drought

The basis for determining land pre-failure is by looking at the optimum land area which is predicted by plants to grow well based on water requirements. The conversion of land area failure and agricultural land production profit are in the form of rupiah value. The existing drought conditions were obtained from interviews with farmers.

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5) Discharge of Irrigation Water Requirements

QAI_p = (Et c + P + WLR + HE 80%) X (4)

Where X is the area of rice fields (ha). The discharge of irrigation water intake (5).

QAI_{pt} = f (QAI_{pt} , Losses, Efficiency) (5)

Where losses represents the water loss in the channel and efficiency represent the efficiency of the irrigation system.

6) System Analysis

Advantages of agricultural products from the irrigation area what t is formulated as follows.

$MAX = \Sigma C_j X_j - Rgl_{ijT}$ (6)

Where CijT is the profit per hectare obtained from each type of plant I with a planting schedule of j in one growing season T (Rp / ha), XijT is the decision variable (optimal area of each type of crop I with planting schedule j in one growing season T) (ha), RglijT is the cost of the risk of failure of planting land for each type of crop I with a planting schedule in one planting season T (Rp).

$Rgl_{jhx} = \ln.Rga(1 - (Re)^{QAI\text{-}pt/Qreliable}).X.C$ (rupiah) (7)

Where Rgl_{jhx} is the risk cost of crop failure for planting schedule T in effective rain h% and planting area X ha (Rp), In is the risk index for failure to provide water, Rga is the risk of failure to provide water, Re is the reliability, QAI-pt is the discharge of irrigation intake building (m3/s), Qreliable is the average definitive discharge (m^3/s), X is the area (ha), C is the profit per hectares (Rp / ha).

D. Research Procedure

The research procedure is a step or process of data interaction that is analyzed in order to obtain the desired results. The research procedure is an illustration of the process from start to finish. The following fig. 1 illustrates the research procedure in order to obtain the pre-failure prediction results from the land failure analysis.

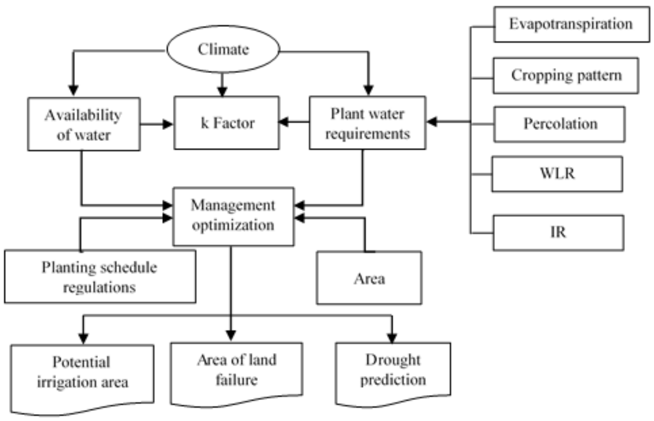

Fig. 1. Research procedure

E. Research Flow

The following fig. 2 shows the research flow.

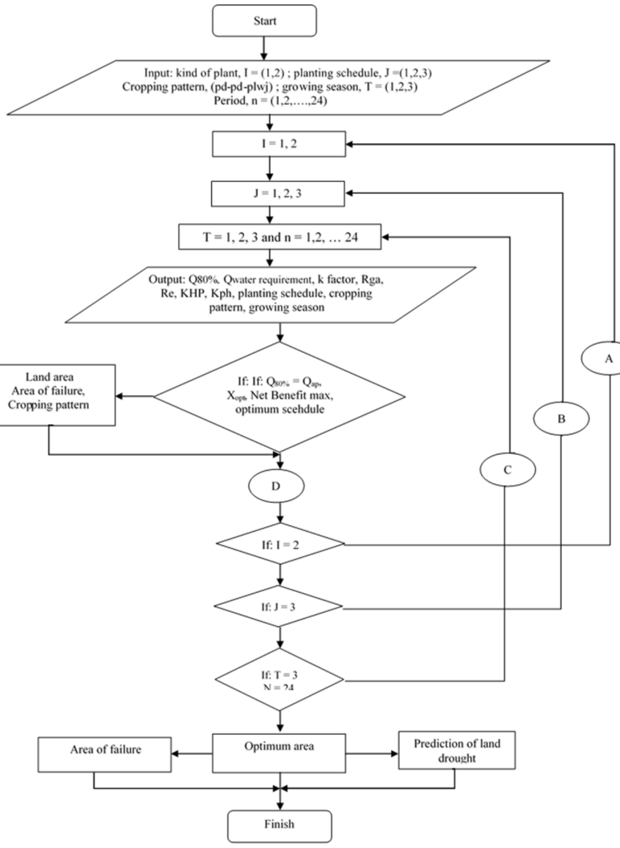

Fig. 2. Research flow

III. Results and Discussion

A. Effective Rainfall and Evapotranspiration

Table I and II show the results of the analysis of effective rainfall and evaporation in the Cimulu irrigation area.

TABLE I. Effective rainfall

Station	Jan		Feb		Mar		Apr	
	I mm	II mm	I mm	II mm	I mm	II mm	I mm	II mm
RE Paddy	4.1	5.4	4.9	4.7	6.9	5.3	4.8	2.7
RE Palawija	2.9	3.8	3.5	3.4	4.9	3.8	3.4	1.9
Station	May		Jun		Jul		Aug	
	I mm	II mm	I mm	II mm	I mm	II mm	I mm	II mm
RE Paddy	3.5	1.2	1.6	0.2	0.1	0.1	0.0	0.0
RE Palawija	2.5	0.8	1.1	0.1	0.1	0.1	0.0	0.0
Station	Sep		Oct		Nov		Des	
	I mm	II mm	I mm	II mm	I mm	II mm	I mm	II mm
RE Paddy	0.0	0.0	0.1	0.6	3.5	4.8	4.7	3.9
RE Palawija	0.0	0.0	0.1	0.4	2.5	3.5	3.4	2.8

TABLE II. Evapotranspiration

	Jan	Feb	Mar		Apr	May	Jun
Eto	5.75	5.45	5.52		5.32	5.13	4.97
	Jul	Aug	Sep		Oct	Nov	Des
Eto	4.98	5.04	5.10		5.37	5.52	5.61

B. Discharge of Water Availability

Availability discharge for Cimulu area irrigated as presented in the following table III.

TABLE III. Discharge of water availability

Period		Unit	Discharge availability	Period		Unit	Discharge Availability
Jan	I	m^3/s	2.07	Jul	I	m^3/s	1.31
	II	m^3/s	2.09		II	m^3/s	1.56
Feb	I	m^3/s	2.64	Aug	I	m^3/s	1.44
	II	m^3/s	2.56		II	m^3/s	1.22
Mar	I	m^3/s	2.75	Sep	I	m^3/s	1.17
	II	m^3/s	2.53		II	m^3/s	1.17
Apr	I	m^3/s	2.35	Oct	I	m^3/s	1.26
	II	m^3/s	2.21		II	m^3/s	1.31
May	I	m^3/s	1.93	Nov	I	m^3/s	1.90
	II	m^3/s	1.90		II	m^3/s	2.81
Jun	I	m^3/s	1.80	Des	I	m^3/s	2.13
	II	m^3/s	1.83		II	m^3/s	2.39

C. Result of Analysis of Land Failure Prediction

Analysis based on mathematical equations with the help of the Visual Basic for Application (VBA) produces land failure predictions as in the following table IV.

TABLE IV. Prediction of land failure

Early Planting	Cropping Pattern	Optimal area	Risk of Failure	K Factor	Net Benefit (Rp)
Jan-2 / May-2 / Sep-2	Pd-Pd-Pd	1489.2	0.4816	0.7014	23,856,984
Feb-1 / Jun-1 / Oct-1	Pd-Pd-Pd	1438.4	0.3877	0.7185	23,043,168
Feb-2 / Jun-2 / Oct-2	Pd-Pd-Pd	1387.8	0.3366	0.7395	22,230,452.8
Mar-1 / Jul-1 / Nov-1	Pd-Pd-Pd	1430.8	0.3856	0.7212	22,919,862.1
Feb-1 / Jun-1 / Oct-1	Pd-Pd-Plwj	1525.8	0.3701	0.7807	20,216,850

D. Failure of Existing Land and Drought

The following data are the results of a survey from several farmers regarding the farmers' yields in normal (water adequacy) and dry conditions.

TABLE V. Percentage of crop failure

No.	Name	Area (ha)	Production (ton)		% failed harvest
			Normal Condition	Dry Condition	
1	Noni	0.14	1.2	0.8	33.33
2	Eje	0.16	1.6	0.8	50.00
3	Muh	0.42	2.1	0.8	14.29
4	Mamat	0.17	1.4	1.0	28.57
5	Eem	0.35	1.7	1.0	41.18
6	Yani	0.17	1.2	0.8	33.33
7	Dudung	0.35	1.8	0.9	50.00
8	Ipah	0.70	3.0	2.7	10.00
9	Herman	0.42	2.4	1.8	25.00
10	Danang	0.56	2.8	2.0	28.57
Sum					314.27
Average					31.43

The percentage of crop failure ranges from 10.00% to 50.00% depending on the adequacy of water supply. The average percentage of crop failure was 31.43%.

Drought data for various villages in 2 sub-districts that are Cimulu irrigation areas, namely Manonjaya and Cibeureum sub-districts were recorded at the Citanduy River Region office in 2017. Drought data in Manonjaya sub-district is greater than in Cibeureum sub-district, as shown in table VI.

TABLE VI. The area of drought

Village	Districts		Sum (Ha)
	Manonjaya (Ha)	Cibeureum (Ha)	
Kamulyan	40.00		
Margaluyu	40.00		
Margahayu	50.00		
Manonjaya	6.00		
Kalimanggis	70.00		
Pasir Panjang	90.00		
One thing		3.00	
Kersanagara		1.00	
Ciherang		3.00	
Ciakar		1.00	
Margabakti		2.00	
Sum	296.00	10.00	306.00

E. Discussion

The paddy-paddy-palawija cropping pattern on the Feb_2 planting schedule produces the best optimum land area of 1525.8 ha with a risk of harvest failure of 37.01%, this condition is in accordance with the results of the survey on the average harvest failure conditions in the field, that is, 31.43%. In general, land failure analysis can be used as an initial reference for predicting and reflecting on drought in the field

Data in 2017, the drought was recorded as covering 306 ha, with improved planting schedule regulations, the drought could be improved. Table shows that the percentage of failure can be corrected by regulating the planting schedule and pattern.

IV. Conclusion and Recommendations

A. Conclusion

Prediction of land failure can reduce losses at the farm level because by knowing the land that is expected to experience drought, farmers can plant other crops that require less water. Land failure can be minimized as much as possible with an alternative cropping pattern and a predicted planting schedule to regulate the occurrence of water balance. The condition of minimun land failure will occur when the water balance is reached.

B. Recommendation

The prediction of land failure results from the analysis needs to be verified every time land failure occurs in the field. Alternative cropping patterns and planting schedules in each planting season will always change according to changing climates, so there needs to be analysis updates periodically.

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