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Classification of Climate and Land Suitability of Rice in East Sumba Regency, East Nusa Tenggara

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ABSTRACT
East Sumba Regency is an dry climate area, which has an impact on water availability, especially for agricultural production. Additionally, this area has a large area of land that can be optimize for productive agricultural areas. Several factors that affect productive land are climate, land management, and water availability. Climate classification can represent the right time for cultivation according to the availability of water. The aims of this research are to determine climate classification in East Sumba Regency. Further, land suitability for rice and planting season were determined. Mohr and Scmidth – Ferguson methods were used in this study to determine climate classification. While calculation of water demand war carried out using the Van de Goor and Ziljsha methods, depend on a constant rate in lt/sc/ha during the land preparation period. Meanwhile, some parameters such as organic matter, N total, climate criteria, water availability, topography, and soil fertility were collected to determine land suitability for rice production. Crop water requirement (CWR) of rice was calculated by using CROPWAT. According to Mohr's method, The East Sumba Regency included in V climate type with 4-5 months of what months and 6-7 months of dry months. While Scmidth – Ferguson method resulted that this area has type E (slightly dry) which has a Q value ranging from 100 – 167. Land suitability analysis had several components that need Analysis of land criteria based on physical conditions in the field, including the average temperature (°C) around 24.1 – 29.1, rainfall (mm/month) 0 – 262, humidity (%) 69 – 87, texture class slightly fine to fine, soil CEC (cmol/kg) 12.58 - 15.09, pH H_2O 7.06 - 7.18, C-Organic (%) 2.53 - 2.84, moderate total N, slope < 3, moderate landslide hazard very light. Based on these values, Sumba Regency is categorized as S1 (very suitable) for rice production. These results of this study are expected to increase rice productivity in terms of the technology used, climate and climatology analysis, determination of land suitability, and rice planting period.

Keywords: *Climate, Land suitability, Water demand, Mohr, Scmidth-Ferguso*

1. INTRODUCTION

Indonesia is a tropical country that has a lot of natural resources. One of them is land resources that can meet the food needs of the community. The main staple food is rice produced from the rice plant. Increased rice production is a strategy and government policy to build national food security. Rice production in 2020 increase around 0.08 percent from 2019 [1]. This estimated increase in rice production is projected to continue in 2021.

The East Nusa Tenggara has a dry tropical climate with a fairly long dry season [1]. The availability of water in this area is very limited, thus rice cultivation in East Nusa Tenggara needs more intensive handling. In the rice field system, water shortage conditions can inhibit rice growth, thus affecting crop yields. Meeting the water needs for rice fields requires an irrigation system and weir building. The water requirement for plants is known as irrigation water demand. If the need for irrigation water is known, it can predict either the availability of water meets or does not meet a plant.

As the population grows, the need for food increases. This causes the use of agricultural land to increase. Agricultural land has limitations on the ability of the soil to cultivate a variety of plants. Processing of agricultural production requires land suitability analysis to achieve a sustainable agricultural system. Determination of land suitability consists of criteria for climate, water availability, topography, and soil fertility.

In everyday life, climate plays an important role in plant growth in an area. Climate change causes inaccurate rainfall factors. Therefore, efforts are needed to determine strategies that can represent current climate conditions using climate classification. The existence of these representations can help determine the rice planting period in accordance with the climate and soil conditions. Can find out the right time to carry out plant cultivation activities according to the availability of water in plants using climate classification.

This research is carried out through the climate classification in East Sumba, East Nusa Tenggara using the Mohr method and the Scmidth-Ferguson method. This classification is based on rainfall data taken from the Meteorology, Climatology, and Geophysics Agency of Umbu Mehang Kunda, East Sumba, East Nusa Tenggara. The aims of this research were climate classification, suitability of productive land and the rice planting time determination. This study is intended to help determine cropping patterns according to the availability of water in the area.

2. METHODOLOGY

2.1. Material

This research requires tools and various data as follows:

2.1.1. Rainfall data

This data was obtained from the Umbu Mehang Kunda Meteorological Station. Rainfall data in the form of monthly rainfall data and rainy days per month.

2.1.2. Climatological Data

This data includes data on wind direction and speed, duration of sun exposure, humidity, temperature (maximum, minimum, average) in the period 2011-2020. This data comes from the Umbu Mehang Kunda Meteorological Station, which is in the form of monthly data.

2.1.3. Data on chemical and physical properties of soil

Soil chemical properties data were obtained from the results of the Laboratory of the Agricultural Environmental Research Institute which tested the pH of H_2O and KCl, CEC elements, C-organic elements, N-total. Soil physical properties data include water content, soil texture and structure, soil density, soil volume weight, and soil porosity. This data is processed in the Laboratory of the Agricultural Environmental Research Institute.

2.2. Research Stage

This research went through several stages, including literature study, field data collection, laboratory testing, and report preparation. The data used in this analysis are primary data and secondary data. The following flow chart is shown in Figure 1.

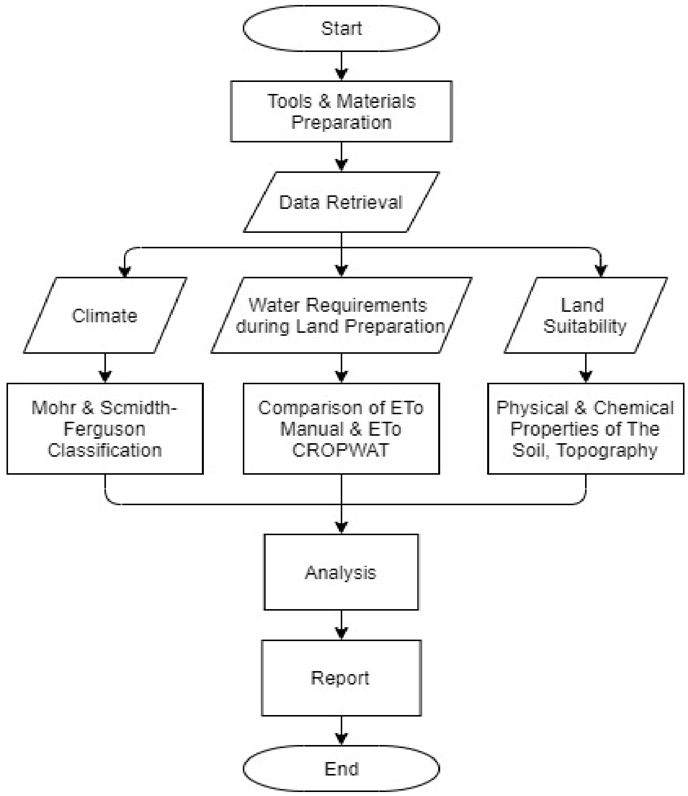

Figure 1. Research flow chart

2.3. Research Analysis Stage

Data analysis includes several stages, including:

2.3.1. Climate Classification

This analysis requires rainfall data for the last 10 years and can know the average Dry Month (DM) and Wet Month (WM). Using the methods, namely the Mohr Classification and the Scmidth–Ferguson climate classification. The following Table 1. shows the climate groups according to Mohr:

Table 1. Climate typer based on Mohr Classification

Climate Type	Total Wet Months	Total Dry Monts
Ia	12	0
Ib	7 - 11	0
II	4 - 11	1 - 2
III	4 - 9	2 - 4
IV	4 - 7	4 - 6
V	4 - 5	6 - 7

(Source: [3])

The Schmidt classification is based on the division of the total dry months by the total wet months in a year. The dry month is the amount of rainfall < 60 mm, the wet month is the amount of rainfall is 60 mm-100 mm, the wet month is the amount of rainfall > 100 mm. The classification of Schmidt-Ferguson climates depends on the value of Q, which is determined by dividing the average number of dry months by the average number of wet months.

$$Q = \frac{\text{Total wet months}}{\text{Total dry months}} \quad (1)$$

The known Q values will be divided into 8 climate types/classes, which are shown in Table 2.

Table 2. Climate Classification According to Schmidth-Ferguson

Climate Type	Dry Monts	Value of Q	Rain Type
A	<1,5	<0,14	Really wet
B	1,5 - 3,0	0,14 - 0,33	Wet
C	3,0 - 4,5	0,33 - 0,60	Slightly wet
D	4,5 - 6,0	0,60 - 1,00	Currently
E	6,0 - 7,5	1,00 - 1,67	Slightly dry
F	7,5 - 9,0	1,67 - 3,00	Dry
G	9,0 - 10,5	3,00 - 7,00	Very dry
H	>10,5	>7,00	Incredibly dry

(Source: [3])

2.3.2.Calculating Irrigation Water Needs

Using the method of Van de Goor and Ziljlsha (1968). This method relies on a constant water rate in lt/s/ha during the land preparation period.

2.3.2.1. Calculation of irrigation needs during land preparation

Using the method of Van de Goor and Ziljlsha (1968). This method relies on a constant water rate in lt/s/ha during the land preparation period. The formula is as follows:

$$IR = Mek/(ek - 1) \quad (2)$$

Description:
IR = irrigation water requirement at rice field level (mm/day)
M = Water requirement to replace water loss due to evaporation and percolation in saturated rice fields
e = Napier's Number (2.7183)
k = Constant

$$M = Eo + P \quad (3)$$

Description :
Eo = Evaporation of open water taken 1.1 ETo during land preparation (mm/day)
P = Percolation (mm/day)

$$k = M.T/ S \quad (4)$$

Description :
T = Period for land preparation (days)
S = Water requirement, for saturation added with a layer of water 50 mm

2.3.2.2. Calculation of irrigation water needs using percolation and seepage

The definition of percolation is the movement of water to deeper soil layers, and the process takes place by gravity. Percolation data can be used to calculate irrigation water needs on dry land and rice fields. The following is Table 2.4. shows the value of percolation based on soil type:

Table 3. Percolation Prices of Various Soil Types

No	Kind of soil	Percolation (mm/day)
1.	Sandy loam	3 - 6
2.	Loam	2 - 3
3.	Clay	2

(Source: [10])

2.3.3. Land Suitability Analysis

The method used to determine the physical properties of the soil is the descriptive quantitative method. Determination of the suitability level of irrigated land consists of 12 limiting variables, namely rainfall temperature, humidity, texture, CEC value, soil pH, soil organic C, total N nutrients, slopes, and hazards erosion. Determination of soil physical properties was carried out at the Soil Laboratory of the Faculty of Agricultural Technology, Universitas Gadjah Mada. The physical properties of the soil analyzed included texture, structure, specific gravity, volume weight, and soil porosity.

Table 4. Criteria for land suitability for rice commodity (*Oryza sativa L.*) irrigation

Terms of use Land characteristics	Land Suitability Class			
	S1	S2	S3	N
Temperature				
Average temperature	24 - 29	22 - 24	18 - 22	<18
Availability of water (wa)				
Rainfall (mm/month)	175 - 500	500 - 650 / 125 - 175	650 - 750 / 100 - 125	>750 / <100
Humidity (%)	30 - 90	30 - 33	<30 >90	-
Texture class	smooth, slightly	currently	rather rough	rough
Nutrient retention (nr)				
Soil CEC (cmol/kg)	>16	5 - 16	<5	-
pH H_2O	5,5 - 7,0	4,5 - 5,5 7,0 - 8,0	<4,5 >0,8	-
C- Organic	>1,2	0,8 – 1.2	<0,8	-
Nutri available (nr)				
N total (%)	currently	Low	very low	-
Landslide hazard (eh)				
Slope (%)	<3	3 - 8 (terraced)	8 - 30 (terraced)	>30
Landslide hazard	very low	Low	currently	heavy

(Source: Ministry of Agriculture no. 79 years 2013 [5])

Description: S1 = very suitable, S2 = quite suitable, S3 = marginally suitable, N = not suitable, (-) = not taken into account

3. RESULT & DISCUSSION

3.1. Climate Classification

The area of East Sumba Regency is a mostly dry climate, so the availability of water at certain times is very difficult to obtain. Climate classification is used to is used to identify the climate in the area. The data used in this analysis is rainfall data for a period of 10 years.

Table 5. Rainfall data for 2011-2020 Umbu Mehang Kunda Meteorological Stasiun, East Sumba

Month	Year										Average
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
January	216	199	243	50	158	155	188	286	273	169	193.7
February	316	182	249	183	142	68	232	231	100	262	196.5
March	272	253	76	120	169	199	138	174	195	127	172.3
April	154	64	93	81	127	34	73	19	83	104	83.2
May	10	78	62	0	3	89	3	0	1	134	38
June	0	0	92	0	0	63	3	0	0	2	16
July	0	0	9	0	0	20	0	0	0	0	2.9
August	0	0	0	0	0	11	1	8	0	0	2
September	0	2	0	0	0	9	0	0	0	0	1.1
October	2	0	0	0	0	12	13	6	0	2	3.5
November	40	47	103	13	0	7	203	129	33	19	59.4
December	78	176	258	101	166	64	189	58	24	142	125.6
Total	1088	1001	1185	548	765	731	1043	911	709	961	894.2

Based on Table 5. May, June, July August, September, and October show that there is a decrease in rainfall which allows El Nino to occur. The impact resulting from the El Nino phenomenon is causing extreme drought, thereby increasing crop failure [7]. Rainfall data for 2011 – 2020 was processed to classify the climate using the Smichdt - Ferguson and Mohr method. Based on Table 1., wet months, wet months, and wet months can be presented as follows.

Table 6. Total dry month, humid Month, wet month East Sumba Regency 2011-2020 period

Month Type	Year									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dry Months	7	6	4	8	7	6	6	8	8	6
Humid Months	1	2	4	1	0	4	1	0	1	0
Wet Months	4	4	4	3	5	2	5	4	3	6

Based on Table 6. and Table 1., the area of East Sumba Regency according to the Mohr Classification belongs to the climate group/type V. In Table 6. shows that the number of dry months is more than the number of wet months each year.

Calculation of climate classification according to Schmidt - Ferguson uses the number of Dry Months (DM) and the number of Wet Months (WM), then calculated using Equation 1. and is presented in Table 7.

Table 7. Value of Q East Sumba Regency 2011-2020 Period

	Year									
Q	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	175	150	100	266.67	140	300	120	200	266.67	100

The results of the Q calculation are compared in Table 2., so that it is obtained that the East Sumba Regency has an E climate type (rather dry). The Haharu Subdistrict, East Sumba Regency has a rainfall of 843.4 mm/year and 1 wet month, 3 humid months, and 8 dry months [9]. The dry months in the region tend to be longer than the wet months [9]. According to Mohr, the climate classification of the Haharu sub-district is classified as V climate type and according to the Schmidt-Ferguson method, it is classified as F type (extraordinarily dry). This shows that East Sumba Regency is an area with a dry climate type.

3.2. Irrigation Water Requirement

Determination of reference plant evapotranspiration (ETo) value can be found using the CROPWAT application using climate data [8]. This ETo data will be used to calculate crop water requirements. Table 8. shows climatological data taken from Umbu Mehang Kunda Station, East Sumba

Table 8. Climatological Data for Umbu Mehang Kunda Station, East Sumba 2020

Month	Humidity (%)	Max temperature (°C)	Minimum temperature (°C)	Wind velocity (km/day)	Sunshine (hour)
January	80	35.6	23.4	311.1	9.9
February	84	34.0	23.1	266.7	8.1
March	83	34.4	23.2	266.7	9.7
April	81	34.0	21.2	311.1	11.3
May	81	33.8	21.6	311.1	10.4
June	76	32.6	20.8	355.6	11.8
July	67	32.8	18.0	355.6	12.22
August	74	33.7	18.0	355.6	12.9
September	73	35.0	19.8	255.6	12.9
October	75	35.4	21.8	311.1	12.0
November	77	35.7	23.0	222.2	11.0
December	81	34.8	22.8	311.1	8.3

ETo calculation uses two methods, namely manually (Penman-Monteith Formula), and ETo CROPWAT. The following figure shows a comparison of manual ETo and CROPWAT calculations that have been applied to the formula for water requirements during land preparation.

The percolation value used in the calculation is based on Table 3. which is 2 mm/day because the soil has a clay texture. Based on Figure 2. shows that the value of irrigation needs during land preparation using manual ETo and CROPWAT ETo is almost close. The difference between the ETo values of these two methods is that the CROPWAT software can only enter data with 2 digits behind a comma. The Penman-Monteith method is recommended by FAO (Food and Agriculture Organization) and has a small standard error estimate of 0.32 [6].

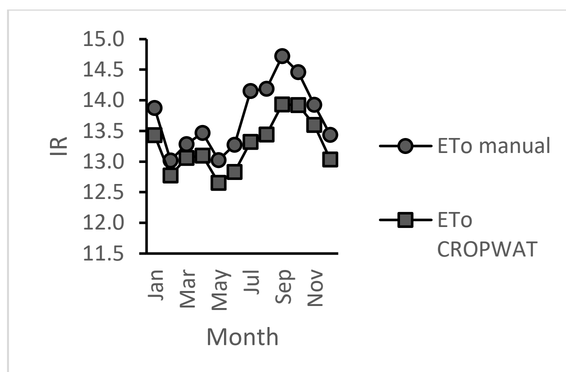

Figure 2. Comparative Graph of Calculation of Water Demand (IR) using ETo CROPWAT and ETo Manual

3.3. Land Suitability

Samples P1 and P2 were taken from paddy fields and P3 was a sample representing the irrigation area of Umbu Mehang Kunda Regency. The following are the results of the calculation of volume weight, specific gravity, and soil porosity, which are presented in Table 9.

Table 9. Data from the calculation of volume weight, specific gravity, and porosity

Sample	Soil volume weight (gr/cm^3)	Soil density (gr/cm^3)	Soil porosity (%)
P1	1.103	1.174	6.096
P2	1.204	1.753	31.30
P3	1.076	2.129	49.48

Table 9 shows that the soil density does not exceed 1.2 g/cm^3, except for sample P2. Another research journal states, if the volume weight is more than 1.2 g/cm^3, then the soil has undergone compaction [2]. This volume weight value is influenced by several factors, including texture and structure, soil management, plant species, organic content, and others. The journal states that the density of mineral soils is usually around 2.6 – 2.8 g/cm^3, while the specific gravity of soil organic matter particles ranges from 1.3 – 1.5 g/cm^3 [4]. From the calculation results, sample P3 has normal porosity in mineral soils. A high porosity value indicates that the soil infiltration rate is increasing [2].

The suitability of the land area of East Sumba Regency with quantitative descriptive methods further explains the data from measurements and observations in the field. The parameters used can be seen in Table 4. and will be presented as follows.

Table 10. Criteria for land suitability for rice commodity (*Oryza sativa L.*) irrigation

Land characteristics	Parameter Value	Land Suitability Class
Temperature		
Average temperature	24.1 - 29.1	S1
Availability of water (wa)		
Rainfall (mm/month)	0 - 262	S1
Humidity (%)	69 - 87	S1
Texture class	Smooth, slightly	S1
Nutrient retention (nr)		
Soil CEC (cmol/kg)	12.58 - 15.09	S2
pH H_2O	7.06 - 7.18	S1
C-Organic	2.53 - 2.84	S1
Nutri available (nr)		
N total (%)	currently	S1
Landslide hazard (eh)		
Slope (%)	< 3	S1
Landslide hazard	very low	S1

The topography in East Sumba Regency is generally flat, sloping to bumpy and hilly. Agricultural land has a flat area and does not apply a terracing system, thus minimizing the occurrence of landslides. Organic content in the soil can affect the physical and chemical properties of the soil. The relationship between organic content and soil physical properties is structural stability and soil porosity [2]. C-organic content is good for the soil around 4.56% to 9.12%. In another study, it was stated that the application of organic matter from salak biomass could increase the C-organic content 3 times (average 4%) compared to no application of organic matter (1.2% on average) [2].

4. CONCLUSION

Based on the research that has been done and data analysis, it can be concluded that climate classification in East Sumba Regency using the Mohr method belongs to climate group V, while the Schmidt-Ferguson method belongs to climate type E (slightly dry). Water requirements during land preparation using manual ETo and CROPWAT ETo are averaged 13.737 and 13.258. Analysis of land criteria based on physical conditions in the field shows that the land suitability class (S1) is very suitable according to several land-use requirements

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