Analysis of land suitability of leading commodities tomato and chili in the sub-district of Moyo Hilir, Sumbawa Regency, West Nusa Tenggara

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ABSTRACT
Land evaluation is assessing land resources for a specific purpose using a tested approach. Tomato and Chili plants can be planted in rice fields or dry fields, lowlands and highlands, and during the dry and rainy season. This study aimed to determine the land suitability of the superior vegetable commodities of tomatoes and chilies in Moyo Hilir District, Sumbawa Regency, West Nusa Tenggara using the Geographic Information System (GIS). This research method uses descriptive analysis. Namely, the research data is displayed in tables and maps. The data includes rainfall and temperature, nutrient retention (pH H_2O, CEC, and organic C), salinity, N-total, texture, and drainage. The results of the evaluation of land suitability were categorized into four classes, namely, highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (N). The overlays obtained in Moyo Hilir District for land suitability for tomato and chili commodities are in two classes, namely highly suitable (S1) and moderately suitable (S2), with an area of S1 tomato 19315.52 ha, S2 tomato 813.03 ha, S1 chili 19310.26 ha, and chili S2 818.29 ha.

Keywords: *Chili, Land Suitability, Tomato.*

1. INTRODUCTION

According to Agency [1], Moyo Hilir District is one of the 24 sub-districts in the Sumbawa Regency. Of the total area, more than 20% is used as paddy fields, 6690 ha, while the rest is dry land, 11989 ha. The number of paddy fields is indirectly influenced by natural factors such as climate and artificial elements such as dams.

BPS 2020 data states that most of the people of Moyo Hilir District depend on the agricultural sector. In the agricultural sector, Moyo Hilir District has an area of 6690 ha of rice fields, and the yield of vegetable crops in Moyo Hilir District in 2019 was 557 ha. Based on these data, the use of paddy fields in Moyo Hilir District for vegetable commodities is still very lacking, for it is necessary to map out land suitability to take advantage of large enough rice fields and get maximum production results. To achieve maximum production, the plants to be planted or produced must be adjusted to the land suitability class.

Not suitable land use will hurt agricultural products and cause land damage. Land suitability assessment is a land evaluation method that identifies the main limiting factors for cultivating particular crops [2]. Land suitability can be assessed for its current condition (actual land suitability) based on data on soil biophysical properties or land resources before the land is given the necessary inputs to overcome obstacles or after improvements (potential land suitability). Potential land suitability describes the land suitability that will be achieved if improvement efforts are made.

The potential of vegetable crops to be planted in the Moyo Hilir district is based on the harvested area and production, namely red chili and tomatoes. Both vegetables are vegetables with the highest harvested area and production each year. A Geographic Information System (GIS) is a unique information system that manages spatial information (spatially referenced) data. GIS is a computer-based information system to store, manage, analyze, and retrieve geographically referenced data. With this technology, land mapping will be more

A. D. Saputro et al. (Eds.): ICOSEAT 2022, ABSR 26, pp. 47–54, 2023.
https://doi.org/10.2991/978-94-6463-086-2_8

straightforward, one of which is mining land [3]. The use of ArcGIS in this research was carried out to see that ArcGIS has a high ability to make digital maps for spatial analysis.

This study aimed to determine the land suitability of the superior vegetable commodities of tomatoes and chilies in Moyo Hilir District, Sumbawa Regency, West Nusa Tenggara using the Geographic Information System (GIS).

2. MATERIALS AND METHODS

2.1. Materials

The material used in this research is in the form of data. The data used is secondary data collected from various relevant sources. The data includes agro-climatic data such as rainfall and temperature; topographical data in the form of altitude, land slope, and land use processed from topographic map data issued by the Geospatial Information Agency (BIG); soil data in the form of soil Cation Exchange Capacity (CEC), pH H_2O, C-Organic, total N, salinity, and soil texture. At the same time, the tools used hardware, including laptops, scanners, printers, and software ArcGIS.

2.2. Methods

This study collects the required data such as temperature, rainfall, drainage, soil texture, soil CEC, pH H_2O, C-Organic, N-Total, salinity, and slopes obtained at BPTP NTB, BMKG West Lombok, and relevant agencies that provide the necessary data.

2.2.1. Classification of Land Suitability Class

Assessment of the suitability of land for agriculture is very important information for agricultural development and future planning [4]. Land suitability class is a further division of the Order and describes the degree of suitability of an Order. The grade in the class is indicated by a number (sequence number) written behind the Order symbol. The serial number indicates the decreasing grade level in an Order. The recommended number of classes is three classes in Order S, namely: S1, S2, S3, and two classes in Order N, namely: N1 and N2. Class S1 means highly suitable where the land does not have a significant or significant limiting factor for sustainable use, or the limiting factor is minor and will not significantly affect land productivity. An S2 class is moderately suitable where the land has a limiting factor, affecting its productivity and requiring additional input. The farmers themselves can usually overcome these barriers. S3 class has the meaning of marginally suitable where the land has a heavy limiting factor, which will significantly affect its productivity, and require more additional inputs than land classified as S2. Class N means the land is not suitable because it has a weighty limiting factor and/or is difficult to overcome.

2.2.2. Determination of climate suitability

The level of climate suitability is based on secondary data on the average temperature and rainfall in the last few years from the Moyo Hilir District. The climate data obtained are then presented in tabular form for the study of Geographic Information Systems. Each variable will be categorized according to its suitability class by referring to the criteria for the land suitability class of the plant concerned.

2.2.3. Determination of land suitability

Determination of land suitability is determined based on soil analysis data obtained from villages in Moyo Hilir District. The data results are then presented in tabular form for the study of Geographic Information Systems. Land data will be categorized according to its suitability class by referring to the criteria for the land suitability class of the plant concerned.

2.2.4. Making a land suitability map

This study will examine three types of vegetables for land suitability: chili and tomatoes. The data collection and processing results will be presented in the form of a land suitability map based on the criteria for land suitability. Data processing and map-making are done using geographic information system (GIS) software.

2.2.5. Data analysis

The data obtained from the results of this research will be made in the form of maps and tables. Each variable will be categorized as a land suitability class concerning the land classification system developed by FAO. The land-use requirements for red chili (*Capsicum annuum*) and tomatoes (*Solanum lycopersicon esculentum* Mill) are based on research by [5].

3. RESULTS AND DISCUSSION

3.1. Temperature

Climate in this case precipitation and temperature are important determinants in determining land suitability classes [6]. There are four criteria for the suitability of

Table 1. Distribution of land suitability class scores

Class	Score
Highly suitable (S1)	4
Moderately suitable (S2)	3
Marginally suitable (S3)	2
Not suitable (N)	1

tomato and chili plants for the temperature limiting factor, which can be seen in Table 1.

Based on Table 2, it can be determined the land suitability class for each plant from the temperature data that has been obtained from the BMKG NTB Province, which can be seen in Table 3.

Table 2. Land suitability criteria for tomato and chili plants temperature limiting factor

Class	Tomato (°C)	Chili (°C)
Highly suitable (S1)	18– 26	24– 28
Moderately suitable (S2)	26– 30 and 16 – 18	>28–30 and 21- <24
Marginally suitable (S3)	30–35 and 13 - 16	>30-32 and 18 - <21
Not suitable (N)	> 35 and < 13	> 32 and < 18

Source: Wahyunto et al. [5]

Table 3. Temperature in Moyo Hilir District

Village	Height (masl)	Temp. (°C)	Chili		Tomato	
			Score	Class	Score	Class
Serading	32	26.1	4	S1	3	S2
Kakiang	24	26.2	4	S1	3	S2
Moyo	26	26.1	4	S1	3	S2
Poto	20	26.2	4	S1	3	S2
Berare	17	26.2	4	S1	3	S2
Ngeru	31	26.1	4	S1	3	S2
Olat Rawa	13	26.2	4	S1	3	S2
Batu Bangka	37	26.1	4	S1	3	S2
Moyo Mekar	31	26.1	4	S1	3	S2
Labuan Ijuk	17	26.2	4	S1	3	S2

Source: Google Earth.

3.2. Rainfall

Table 4. Criteria for land suitability for tomato and chili plants, limiting factors for rainfall

Class	Tomato	Chili
Highly suitable (S1)	400-700	1200-2000
Moderately suitable (S2)	700-800 and 300-400	1000-<1200 and >2000-2500
Marginally suitable (S3)	200-300 and >800	800-<1000 and >2500-3000
Not suitable (N)	<200	<800 and >3000

Source: Wahyunto et al. [5]

Table 5. Rainfall in Moyo Hilir District in the last 5 years

Year	Rainfall	Chili		Tomato	
		Class	Score	Class	Score
2016	1761	S1	4	S3	2
2017	1362	S1	4	S3	2
2018	738	N	1	S2	3
2019	1075	S2	3	S3	2
2020	971	S3	2	S3	2
Average	1181.4	S2	3	S3	2

Source: BMKG West Lombok, 2016-2020

The limiting factors for rainfall in chili and tomato plants have four suitability criteria which are presented in Table 4.

To determine the suitability of rainfall on chili and tomato plants, then compare the rainfall data obtained with the criteria for the suitability of chili and tomato plants, so that rainfall conditions are obtained in Moyo Hilir District (Table 5).

3.3. Soil texture

Soil texture influences the moisture availability for plants, and coarse texture tends to be less able to store soil moisture Meena et al. [7] and low nutrient capacity [8]. Soil texture will determine suitable commodities to be developed in an area.

After the soil texture data was obtained, a comparison was made with the land suitability criteria for chili and tomato plants. The suitability data are grouped by class. The classes are: highly suitable (S1) with a score of 4, moderately suitable (S2) with a score of 3, marginally suitable (S3) with a score of 2, and not suitable (N) with a score of 1 (Table 6).

Table 6. Soil texture in Moyo Hilir District

Area (ha)	Soil Texture	Tomato		Chili	
		Class	Score	Class	Score
11917.79	fine	S2	4	S2	3
4573.05	slightly rough	S3	2	S3	2
1434.87	slightly smooth	S1	4	S1	4
2256.61	slightly smooth – smooth	S1	4	S1	4

Source: Dodokan Moyosari Watershed and Protected Forest Management Center

3.4. CEC (Cation Exchange Capacity)

Soil CEC describes soil cations such as Ca, Mg, and Na and can be exchanged and absorbed by plant roots [9]. After the soil CEC data was obtained, the soil CEC data was matched with the criteria for land suitability for tomato and chili plants. In tomato plants, for the land suitability class, which is highly suitable (S1), the required CEC value is >16; then, moderately suitable (S2), the needed CEC value is 5-16, and according to marginally suitable (S3), the required CEC value is <5. In chili plants, for land suitability class which is highly suitable (S1), the needed CEC value is >16, then moderately suitable (S2), the required CEC value is 5-16, and marginally suitable (S3), the needed CEC value is <5 (Table 7).

Table 7. Soil CEC in Moyo Hilir District

Villages	Soil CEC	Tomato		Chili	
		Class	Score	Class	Score
Batu Bangka	34.42	S1	4	S1	4
Berare	25.60	S1	4	S1	4
Kakiang	18.43	S1	4	S1	4
Labuan Ijuk	6.52	S2	3	S2	3
Moyo	36.61	S1	4	S1	4
Moyo Mekar	39.70	S1	4	S1	4
Ngeru	16.00	S2	3	S2	3
Olat Rawa	17.93	S1	4	S1	4
Poto	31.97	S1	4	S1	4
Serading	21.41	S1	4	S1	4

Source: Soil Chemistry Laboratory Unram

3.5. Soil pH

Soil pH regulates the availability of plant nutrients. Soil and plant productivity is related to the pH value of the soil. The optimal range of soil pH for most agricultural crops is between 5.5 and 7.5 [10]. Laboratory tests were carried out on soil samples obtained from villages in Moyo Hilir District using an H_2O solution. After the soil pH data was obtained, the soil pH data matched the land suitability criteria for tomato and chili plants (Table 8).

Table 8. Criteria for land suitability for tomato, chili, pH (H_2O) limiting factors t

Class	Tomato	Chili
Highly suitable (S1)	6.0 - 7.5	6.0 - 7.5
Moderately suitable (S2)	5.5 – 6.0 dan 7.5 -8.0	5.5 – 6.0 dan 7.5 -8.0

Source: [5]

Table 9. pH (H_2O) in Moyo Hilir District

Villages	pH (H_2O)	Tomato		Chili	
		Class	Score	Class	Score
Batu Bangka	7.4	S1	4	S1	4
Berare	6.9	S1	4	S1	4
Kakiang	7.6	S2	3	S2	3
Labuan Ijuk	6.4	S1	4	S1	4
Moyo	6.9	S1	4	S1	4
Moyo Mekar	7.9	S2	3	S2	3
Ngeru	7.6	S2	3	S2	3
Olat Rawa	7.0	S1	4	S1	4
Poto	6.7	S1	4	S1	4
Serading	6.7	S1	4	S1	4

Source: Soil Chemistry Laboratory UNRAM

After matching each plant's land suitability criteria, the suitability class of tomato and chili plants was obtained based on the pH (H_2O) limiting factor (Table 9).

3.6. C-Organic

Soil functions and the formation of their physical, chemical, and biological properties are closely related to the content of C-organic, which improves soil structure and reduces erosion, which leads to improved water quality in groundwater and surface water. C-organic inputs and losses depend on the environment, including geomorphological processes, climatic conditions, ground cover, and vegetation [11].

Table 10. Organic C in Moyo Hilir District.

Villages	C-organic (%)	Tomato		Chili	
		Class	Score	Class	Score
Batu Bangka	1.34	S1	4	S2	3
Berare	2.49	S1	4	S1	4
Kakiang	1.52	S1	4	S2	3
Labuan Ijuk	0.61	S3	2	S3	2
Moyo	2.01	S1	4	S1	4
Moyo Mekar	0.74	S3	2	S3	2
Ngeru	1.33	S1	4	S2	3

After the C-organic soil was obtained, the C-organic data matched the criteria for land suitability for tomato and chili plants. For tomato plants, the class is highly suitable (S1) with a score of 4, C-organic must be >1,2, for the class is moderately suitable (S2) with a score of 3, C-organic must be in the range of 0.8-1.2, for marginally suitable class (S3) with a score of 2, C-organic should be <0.8. For chili plants, the class is highly suitable (S1) with a score of 4, C-organic must be > 2.0, for the class is moderately suitable (S2) with a score of 3, C-organic

must be in the range of 0.8-2.0, for marginally suitable class (S3) with a score of 2, C-organic should be <0.8 (Table 10).

3.7. N-Total

According to [12], nitrogen deficiency reduces plant leaves' transpiration, stomata conductance, and chlorophyll content.. The data obtained from numbers is then matched with the total N classification table (Table 11).

Table 11. Classification of Total N

Value	Class
<0.1	Very low
0.1-0.2	Low
0.21-0.5	Medium

Source: [13]

Table 12. N-Total in Moyo Hilir District.

Villages	N-total	Class-N total	Tomato		Chili	
			Class	Score	Class	Score
Batu Bangka	0.14	Low	S2	3	S2	3
Berare	0.14	Low	S2	3	S2	3
Kakiang	0.15	Low	S2	3	S2	3
Labuan Ijuk	0.07	Very Low	S3	2	S3	2
Moyo	0.20	Low	S2	3	S2	3
Moyo Mekar	0.07	Very Low	S3	2	S3	2
Ngeru	0.13	Low	S2	3	S2	3
Olat Rawa	0.12	Low	S2	3	S2	3
Poto	0.25	Medium	S1	4	S1	4
Serading	0.14	Low	S2	3	S2	3

Source: Soil Chemistry Laboratory UNRAM

The N-total classification was obtained and then manually matched the soil nitrogen data with the land suitability criteria for tomato and chili plants. Furthermore, the suitability data were grouped based on the highly suitable class (S1), moderately suitable (S2), and marginally suitable (S3) so that it can be displayed in the form of a nitrogen suitability limiting map for tomato and chili plants (Table 12).

3.8. Salinity

Saline conditions in cultivated land can affect plant growth and yield. The problem of salinity occurs when the soil has a high enough dissolved salt content so that it can inhibit plant growth [14].

Based on the land suitability criteria for tomato plants, the suitability class is highly suitable (S1), with a salinity score of 4 should be < 5. For a moderately suitable class (S2) with a score of 3, salinity is required ranging from 5-8. For the marginally suitable class (S3) with a score of 2, the required salinity is 8-10, and for the not suitable class (N), the required salinity is >10. Based on the criteria for land suitability for chili plants, the suitability class is highly suitable (S1) with a score of 4 salinity should be < 3 for a moderately suitable class (S2) with a score of 3 salinity required ranging from 3-5 for marginally suitable class (S3) with a score of 3 2 salinity is needed 5-7. For not suitable class (N), the required salinity is >7 (Table 13).

Table 13. Salinity in Moyo Hilir District.

Villages	Salinity	Tomato		Chili	
		Class	Score	Class	Score
Batu Bangka	0.112	S1	4	S1	4
Berare	0.155	S1	4	S1	4
Kakiang	0.604	S1	4	S1	4
Labuan Ijuk	0.027	S1	4	S1	4
Moyo	0.023	S1	4	S1	4
Moyo Mekar	0.055	S1	4	S1	4
Ngeru	0.206	S1	4	S1	4
Olat Rawa	0.156	S1	4	S1	4
Poto	0.127	S1	4	S1	4
Serading	0.050	S1	4	S1	4

Source: Soil Chemistry Laboratory UNRAM

3.9. Slope

Topography affects the magnitude of the acceleration of runoff, erosion and sediment loads in nearby fluvial networks and their ecosystems. The biggest effect of topography is the loss of the topsoil. The longer the slope, the greater the yield of sediment and erosion [15]. Slope data was obtained from the Indonesia Geospatial Portal in the form of DEM (Digital Elevation Model) data and then processed using GIS into a slope map.

Land suitability criteria for tomato plants for highly suitable class (S1) < 3 for moderately suitable class (S2) 3-8 for marginally suitable class (S3) 8-15 and not suitable class (N) > 15. The land suitability criteria for chili plants are similar to those for tomato plants (Table 14).

Table 14. Slopes in Moyo Hilir District

Area (ha)	Slope	Tomato		Chili	
		Class	Score	Class	Score
2957.31	<3 %	S1	4	S1	4
6537.20	3-8 %	S2	3	S2	3
4254.31	8-15 %	S3	2	S3	2
6591.18	>15%	N	1	N	1

3.10. Drainage

Drainage is needed on agricultural land to control excess water in the land, control salinity, control erosion, and control floods. Thus indirectly, drainage plays an important role in contributing to food security. Control of excess water is necessary because excess water can inhibit plant growth and limit the use of agricultural machinery.

Table 15. Land capacity unit (LCU) for drainage.

Elevation Map	Value	Tilt map (%)	Value	Rainfall Map	Value	LCU Drainage	Value
<500	5	0-2	5	2500 - 3000 mm	2	High (12-14)	3
		2-5	4	3000 - 3500 mm	3	Moderate (6-11)	2
500-1500	4	5-15	3	3500 - 4000 mm	4		
1500-2500	3	15-40	2	4000 - 4500 mm	5	Less (3-5)	1
		>40	1				

Source: Public Works Ministerial Decree No. 20 of 2007

Table 16. Drainage in Moyo Hilir District

Area (ha)	Drainage	Tomato		Chili	
		Class	Score	Class	Score
17719.19	Moderate	S1	4	S1	4
2621.07	High	S2	3	S2	4

The provisions for the unit value of land capability for drainage are presented in table 15, while the drainage data for Moyo Hilir District is presented in Table 16.

3.11. Overlays land suitability

Overlay map combines various limiting parameters, namely rainfall map, temperature map (temperature), soil texture map, pH (H_2O) map, salinity map, soil CEC map, soil C-organic map, N-total map, slope map, and drainage maps.

For giving the level of value, the classification is divided into four categories, namely S1 has a score of 4, S2 has a score of 3, S3 has a score of 2, and N only has a score of 1. Then the analysis of the results of the sum of scores is carried out by calculating the range. Range 31 – 40 is included in the S1 class category, 21 – 30 is included in the S2 class category, 11 – 20 is included in the S3 class category, and the range 1 – 10 is included in the N class category. This range can simplify the data processing process after being overlaid or combined (Table 17).

Table 17. Overlay of superior vegetable commodities

Tomato			Chili		
Overlay	Class	Area (ha)	Overlay	Class	Area (ha)
29	S2	45.5	29	S2	45.5
30	S2	767.5	30	S2	772.7
31	S1	741.5	31	S1	1252.5
32	S1	1245.5	32	S1	1514.1
33	S1	1476.1	33	S1	5016.8
34	S1	5949.4	34	S1	4114.1
35	S1	3925.5	35	S1	5419.8
36	S1	4896.3	36	S1	1159.3
37	S1	840.4	37	S1	595.3
38	S1	240.1	38	S1	237.8

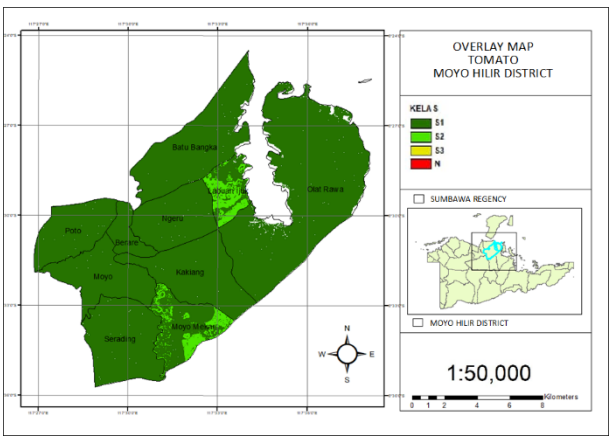

Figure 1 Overlay map of tomato land suitability conditions in Moyo Hilir District.

Based on Figure 1, the map overlay of land suitability conditions for tomato plants in Moyo Hilir District after being combined has two colors: fir green and quetzal green. Fir green indicates a highly suitable land suitability class (S1), and quetzal green indicates a moderately suitable class (S2). For tomato plants, the S1 class covers an area of 19315.52 ha and the S2 813.03 ha in the Moyo Hilir District. In tomato plants, the highest

score was 39 with an area of 0.3 ha, and the lowest was 29 with 45.5 ha.

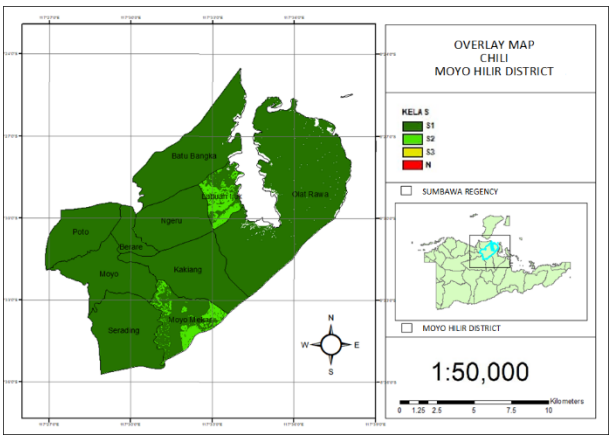

Figure 2 Overlay map of chili land suitability conditions in Moyo Hilir District.

Based on Figure 2, the overlay map of the land suitability of chili plants in Moyo Hilir District, the map layout shows the colors, namely fir green, and quetzal green. The fir green color marks highly suitable (S1) if planted in Moyo Hilir District with an area of 19310.26 ha, and the quetzal green indicates that the area is moderately suitable for planting with an area of 818.29 ha. In Moyo Hilir District, chili plants have the highest score of 39, with an area of 0.3 ha. In contrast, the lowest score is 29, with an area of 45.5 ha.

CONCLUSION

Tomato plants have a highly suitable land suitability class (S1) with an area of 19315.52 ha and moderately suitable (S2) with 813.03 ha in Moyo Hilir District. Chili plants have a highly suitable land suitability class (S1) with an area of 19310.26 ha and moderately suitable (S2) with 818.29 ha in Moyo Hilir District.

AUTHORS' CONTRIBUTIONS

Conceptualization: J.S., and S.E.S.; Methodology: J.S., I.A.W., and S.E.S.; validation, J.S., I.A.W.; formal analysis: J.S., I.A.W., and S.E.S.; writing-original draft preparation: I.A.W., and S.E.S.; writing-review and editing: J.S., and I.A.W.

ACKNOWLEDGMENTS

The authors would like to thank the support for data and laboratory facilities from BPTP NTB, BMKG West Lombok, and the Agricultural Faculty University of Mataram.

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