THE UTILIZATION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS FOR ANALYSIS OF LAND SUITABILITY FOR THE GROWING OF CIPLUKAN *(PHYSALIS ANGULATA L.)*

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Abstract. Remote sensing data and geographic information systems are widely used for land suitability analysis for crops such as coffee and corn. This study aims to analyze and map suitable land for the plant known locally as ciplukan (*Physalis angulata L.*). As the cultivation of this plant is expected to be developed by the Institute of Technology of Sumatra, analysis of this type is needed. The parameters used in this study were slope, land use, rainfall and soil type. Information extraction from remote sensing data was carried out via visual interpretation of aerial photography used to create land-cover maps. Shuttle RADAR Topographic Mission (SRTM) data was converted from digital surface model (DSM) to digital terrain model (DTM) to provide elevation information. Land suitability analysis was performed using a scoring method and overlay analysis. The results obtained from the analysis identified several classes of land suitability for *Physalis angulata L.*, categorized as suitable, less suitable, and not suitable. The less suitable class, scored at 9 to 11, comprised a total area of 180.96 ha, while the suitable area, scored at 12, comprised a total area of 49.1 ha.

Keywords*: remote sensing aerial photos, GIS, Physalis angulata L., land suitability*

1 INTRODUCTION

Ciplukan (*Physalis angulata L.*) generally grows wild and mixed with herbs and other shrubs in gardens, dry fields, roadsides, forest edges and areas of forest exposed to the sun. It usually thrives in lowland areas. Ciplukan fruit contains chemical compounds such as citric acid and fissain, malic acid, alkaloids, tannins, cryptoxanthines, vitamin C and sugar. Research into the beneficial properties of ciplukan identifies it as an analgesic and diuretic, and suggests that it can help to neutralize toxins, relieve coughing, and assist in the activation of glandular function (Slifka, et all, 2000). These properties exist because the seeds of ciplukan plants contain 12-25% protein, 15-40% fatty oil the main component of palmitic acid and stearic acid. Ciplukan leaves can help inhibit the growth and development of cancer cells in breast cancer (Bastos et al., 2008). Ciplukan fruit is also often eaten directly to treat epilepsy, difficulty urinating and jaundice (Sediarso, Hadi, & Nurul, 2013).

The condition of the topsoil strongly influences the fertility of ciplukan plants. Suitable conditions for growth are fertile,

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loose, waterlogged, and near-neutral pH soils. Ciplukan plants can live in soil that is rather dense and poorly maintained and in low-lying areas with elevation ranging from 1–1,550 m above sea level (Rahim, Supli, Damiri, Chairil, & Husin, 2019).

Remote sensing data and geographic information systems are widely used in land suitability mapping for a variety of different types of crops, including coffee, corn, rice and many others. The parameters used in determining the suitability map for *Physalis angulata L.* in this study were elevation, rainfall, land use, and soil type. Land use information can be extracted using very-high-resolution aerial imagery (Pratama, Sophia, & Kharistya, 2015; Sediarso et al., 2013). Geographic information systems (GIS) are useful support for analysis, evaluation, and presentation, both tabular and spatial, and have the ability to provide an overview, description and estimate of factual conditions (Paryono, 1994).

Based on these factors, the purpose of this study was to map suitable land for ciplukan planting at the Institute of Technology of Sumatera (ITERA) using remote sensing and geographical information systems. The specific objectives of this research were to: 1) determine the classes of land suitability; 2) determine characteristics of appropriate land for the development of ciplukan planting; and 3) identify optimal location based on the suitability classes obtained.

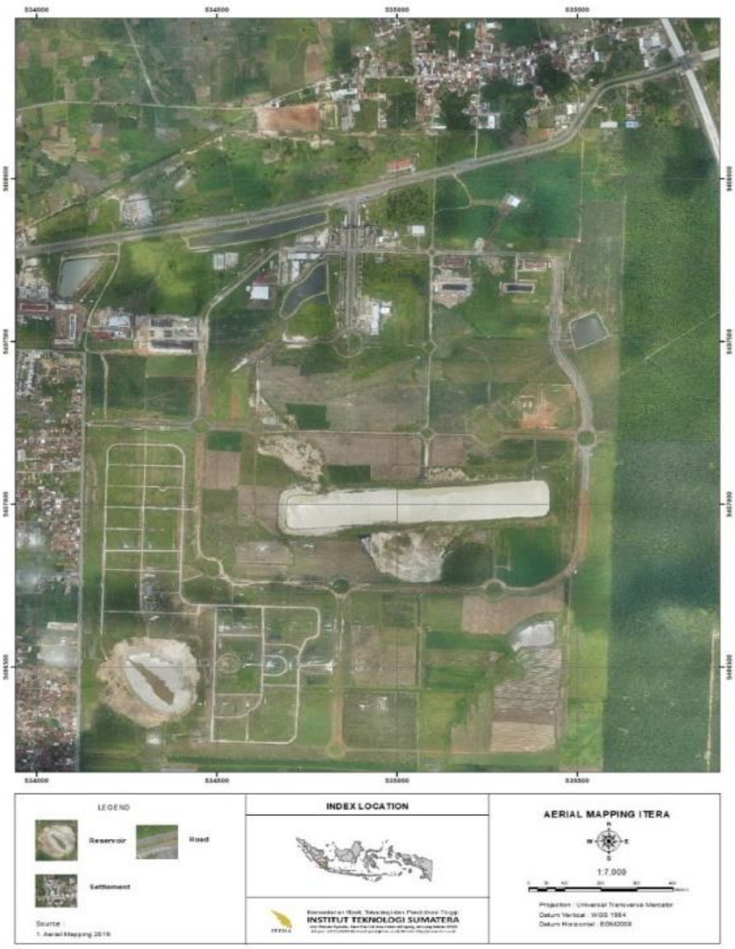

Figure 2-1: Research sites.

2 STUDY AREA

The research was conducted at the Institut Teknologi Sumatera (ITERA) botanical garden which has an area of 275 ha and is located in Sabah Balau village, Agung Jati subdistrict, South Lampung regency. The ITERA territorial limits are as follows:

- North: Way Yam village, Jati Subdistrict Court
- East: Kota Baru, Jati Subdistrict Court
- South: District of Sukarme, Bandar Lampung
- West: District of Sukabumi, Bandar Lampung

The detailed layout of the research area is shown in Figure 2-1. According to the initial plan, 40% of the campus area will be used for facilities and infrastructure, while the rest will be used as green open space.

3 MATERIALS AND METHODOLOGY

Land suitability analysis for ciplukan (*Physalis angulata L.*) was carried out through several stages: data collection, data processing, field survey and data analysis. Location studies commenced by determining the location for the development of medicinal *Physalis angulata L.* planting, because not every department on campus was used as a botanical garden. The study was conducted using qualitative and quantitative analysis. The implementation phase of the project then followed the following steps (Djaenudin, et al., 2011):

1. Data collection and data processing

The necessary data, comprising slope information, land-use/land-cover type, rainfall data, and soil type, were collected. Rainfall data was collected from a rain gauge stations for the previous 12 months. Slope information was derived from elevation data. The original DSM was converted into DTM using Submit Software Evolution before deriving slope information. The DSM itself was obtained from aerial imagery acquired in 2017. Soil-type information was obtained from the South Lampung soil map at 1:50.000 scale. A field survey was then conducted to validate the aforementioned map. Visual interpretation of the 2017 aerial photography was used to produce the land-use/land-cover information.

2. Field survey

The field survey was conducted to observe parameters such as soil type, land use and slope. The soil types were confirmed using soil profile information obtained from soil auger/soil probe samples.

3. Data analysis

Suitability maps were determined using overlay analysis for the previously mentioned parameters: slope, land use, rainfall rate and soil type.

Weighted linear combination was used as the scoring system to represent the degree of closeness or connectedness, or the severity of a certain impact on a spatial phenomenon (Drobne & Anka, 2009).

The classification range was determined based on the value range of the output parameters (*Xmin* to *Xmax*), for the desired number of classes.

$$Xmin = \sum_{i=1}^{n} Xmin\_i \qquad (2\text{-}1)$$

Each parameter data was classified based on the suitability level for ciplukan. The levels used in this study ranged from 1 to 3, where 1 equals 'not suitable', 2 equals 'less suitable', and 3 equals 'suitable'.

Physical land suitability analysis was carried out by matching land quality to land units with all the requirements for the plants to grow successfully. The matching process was applicable at legal minimum, i.e. the land suitability class was determined according to the heaviest limiting factor (Isaac et. al., 2012). Soil characteristics were obtained from the combination of slope information at 1:50.000 scale, land cover at 1:10.000 scale, rainfall at 1:50.000 scale and soil type at 1:50.000 scale.

A benchmarking method is one way to evaluate land suitability by matching and comparing the land quality and characteristics with the land suitability criteria. These matching methods are commonly performed through tabular techniques. The quality and characteristics were obtained from the field inventories. For more details, the research stages are shown in Figure 3-1.

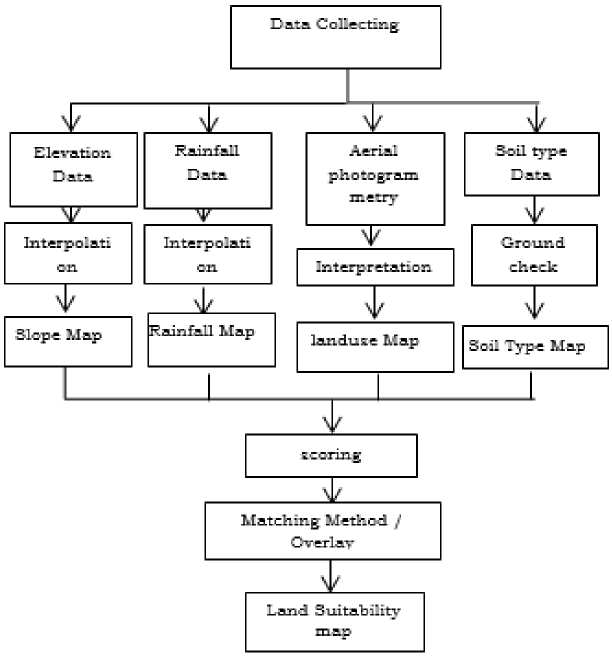

Figure 3-1: Research stages

Table 3-1: Data used in this study

Data type	Acquisition date	Data source	Purpose
Aerial photograph Scale 1:10,000	February 10 2018	From Aerial Photography Institute of Technology, Sumatra	Land use classification
Elevation data Scale 1:50,000	2017	SRTM data	Slope map
Rainfall data Scale 1:50,000	2017	UPT MKG ITERA	Rainfall map
Types of soil Scale 1:50.000	2017	Bappeda, South Lampung	Soil-type Map
Sample data validation	June 2018	Field survey	Field-verification test

4. *Data analysis*

Based on the data collected, the types of data needed in the analysis of land suitability for ciplukan crops (*Physalis angulata L.*) are presented in Table 3-1.

5. *Land suitability analysis*

Actual land suitability is described as the current status of land without any prior land improvement. Potential land suitability is described as land suitability after specific treatment is performed to improve its condition. Hardjowigeno and Widiatmaka (2007) and Bachri, Sulaiman, Rofik, Hidayat, and Mulyani (2016) suggest comparing the properties of land using the terms 'land use' and 'land quality', and the characteristics of the land. Land quality is the traits of land that can be measured directly (complex land attributed) and that have a real influence on suitability for a particular use, while land characteristics include factors that can be measured or estimated in magnitude, such as slope, rainfall, soil texture and so on.

In order for ciplukan (*Physalis angulata L.*) to grow, the following parameters need to be fulfilled:

- Rainfall: 1,750–2,000mm/year
- Soil type: dominated by kanhapludults composition
- Relatively flat terrain with slope ranges from 0–3%

Determination of classes and sub-classes for land suitability units (SKL) uses the land evaluation framework of the FAO (1976). The suitability hierarchy is differentiated according to its level: namely, order, class, sub-class and units.

A. Order

The state of global land suitability: land status is only classified into suitable (S) and not suitable (N).

B. Grades: Circumstance suitability at the level of orders. The suitable (S) class was then classified into three more detailed suitability levels, namely, S1, S2 and S3. S1 refers to highly suitable land, S2 refers to moderately suitable land, and S3 refers to less suitable land. Meanwhile, land belonging to the N class was not differentiated into more detailed classes. The following are definitions of each class (Pratama et al., 2015):

a) S1 (highly suitable):
The land does not have any limiting factors that can significantly affect the sustainable use of the land or reduce land productivity.

b) S2 (moderately suitable):
The land has a limiting factor that will affect productivity, thus requiring additional inputs (treatments).

c) S3 (less suitable):
Land with severe limiting factors that will affect productivity. More additional treatments are required than the S2 class. To overcome the barriers to using S3 land, government or private parties would need to assist farmers.

d) Class N (not suitable):
Land that is deemed not suitable (N) has very severe limiting factors and/or factors that are difficult to overcome.

4 RESULTS AND DISCUSSION

Slope map

The slope maps derived from DTM data were classified into three classes. Table 4-1 shows detailed information regarding the reclassified slope classes as well as total coverage and scores. A gentle slope of 0–3% was the dominant slope, covering 239.89 ha. Figure 4-1 shows the detail slope maps generated for our study area. Since ciplukan plants prefer flat areas, the 0–3% slope class scored the highest.

Table 4-1: Scoring of slopes.

Slope level	Area (ha)	Score
0–3%	239.89	3
4–6%	11.632	2
> 6%	24.72	1
Total	276.24	-

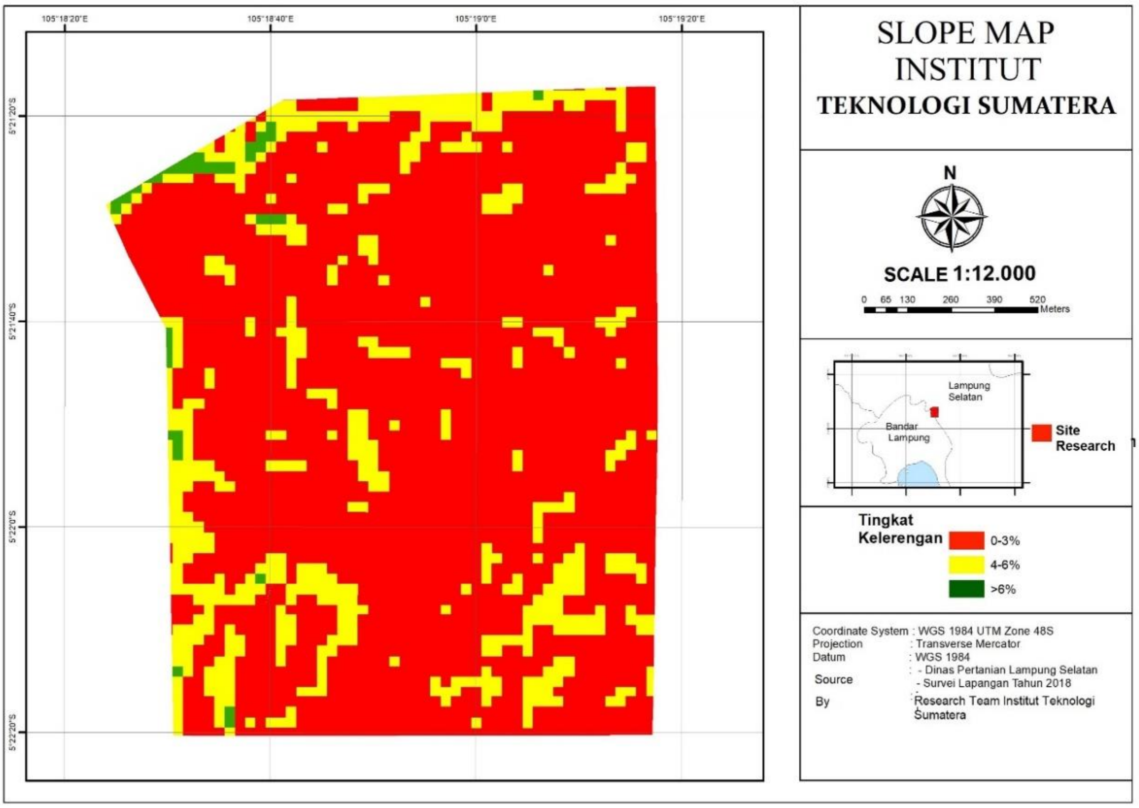

Figure 4-1**:** Slope map

Table 4-2: Attribute land cover/land use, ITERA.

No.	Type of land cover/land use	Area (ha)
1	Dormitory 1	0.12
2	Dormitory 2	0.09
3	Dormitory 3	0.12
4	Reservoir A	0.74
5	Reservoir B	0.91
6	Reservoir C	0.71
7	Reservoir D	0.59
8	Reservoir E	6.12
9	Reservoir F	0.85
10	Building A	0.07
11	Building B	0.08
12	Buildings C and D	0.25
13	Building E	0.27
14	Main gate	0.12
15	Bridge	0.01
16	Bridge	0.01
17	Bridge	0.01

18	Bridge	0.01
19	Canteen	0.08
20	Wooden house	0.12
21	Fish pond	0.09
22	Gallery	0.02
23	Mosque	0.06
24	Mosque	0.03
25	Trench	0.45
26	Trench	0.18
27	Trench	0.07
28	Trench	0.04
29	Trench	0.07
30	Trench	0.01
31	Power plants	0.02
32	Swamp	0.8
33	Swamp	0.9
34	Swamp	1.05
35	Swamp	1.11
36	Swamp	1.65
37	Swamp	0.25
38	Swamp	0.74
39	Swamp	0.94
40	Swamp	0.22
41	Swamp	0.22
42	Swamp	2.22
43	Building	0.08
Total		22.36

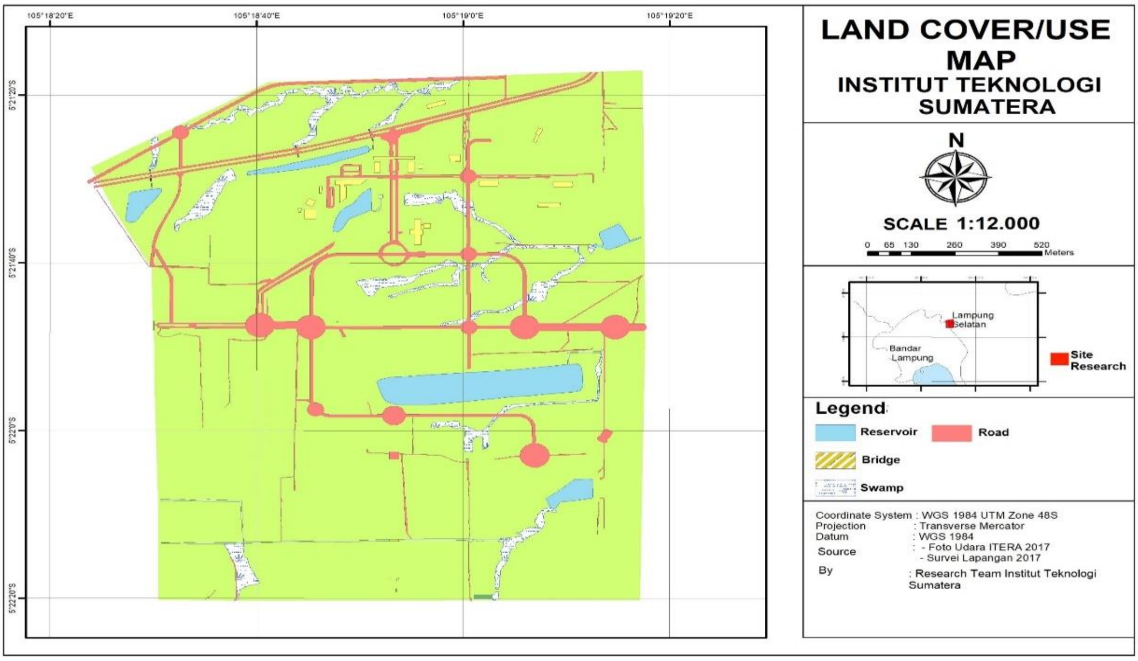

Figure 4-2: Land-cover

Land-use/land-cover map

Based on visual interpretation, it was identified that the land use/land cover in our study area consisted of reservoirs, ponds, roads, bridges, buildings, swamps and ditches (Sihombing, Rauf, Rahmawaty, & Akoeb, 2017). Figure 4-2 shows the land-use/land-cover map.

Soil-type map

Soil types in ITERA were obtained from existing soil maps and then validated through a field check to obtain soil-type information.

Analysis of soil types in the study area revealed three soil compositions. The spatial distribution of these soil types is shown in Figure 4-3.

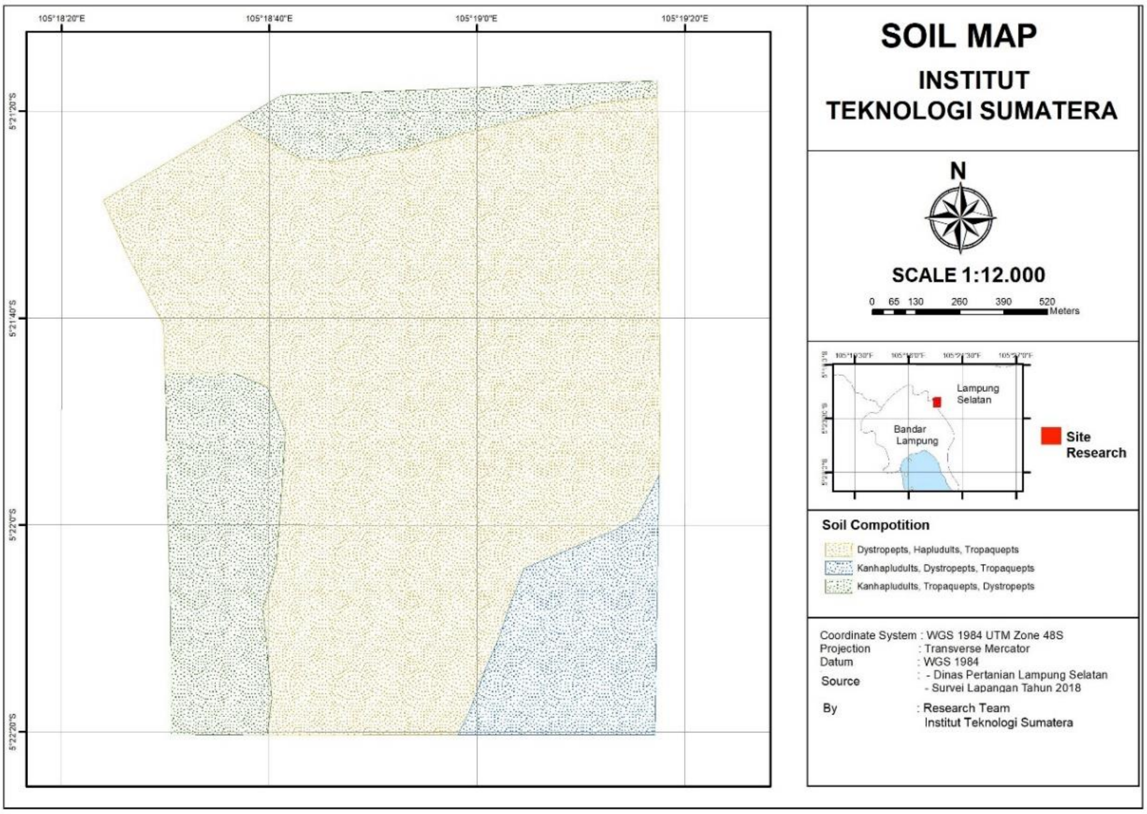

Figure 4-3: Soil-type map.

Figure 4-4: Kanhapludults, dystropepts and tropaquepts soil types

Dystropepts, hapludults, tropaquepts

The dominant soil composition found in the study area is dystropepts. Dystropepts is alluvial soil or soil formed by deposition . Such soil is clay or sandy clay in nature, having a hard consistency when dry and being firm when moist. It is much contained phosphate and soluble in 2% citric acid, contains 5% CO_2 and lime flour and has a solid structure that in its dry state can be broken down into fragments. Several types of soil samples were taken in the study area, as shown in Figure 4-4.

Based on the composition of the soil map, the results were obtained with the dominant composition in sample was kanhapludults and tropaquepts. Pelembahan in the basin and could be found tropaquepts soil type which was a cross-section of medium and fine soil texture. Organic matter content was also low. Tropaquepts composition including the type of soil inceptisol. More details of soil composition were presented in Figure 4-5.

Land suitability for ciplukan planting (*Physalis angulata L.*)The land suitability analysis was conducted in order to determine the potential value of land for purposes such as determining a suitable area to grow ciplukan (*Physalis angulata L.*). Figure 4-6 shows suitable land for ciplukan planting.

The corresponding area found in the scoring areas of each map (rainfall, slope, soil type and land-cover maps) that have been overlaid, and the value of scoring shown in Table 4.3, which represents a total score of 12 (from a maximum value of 3 for each of the four parameters of rainfall, slope, soil type and land-cover).

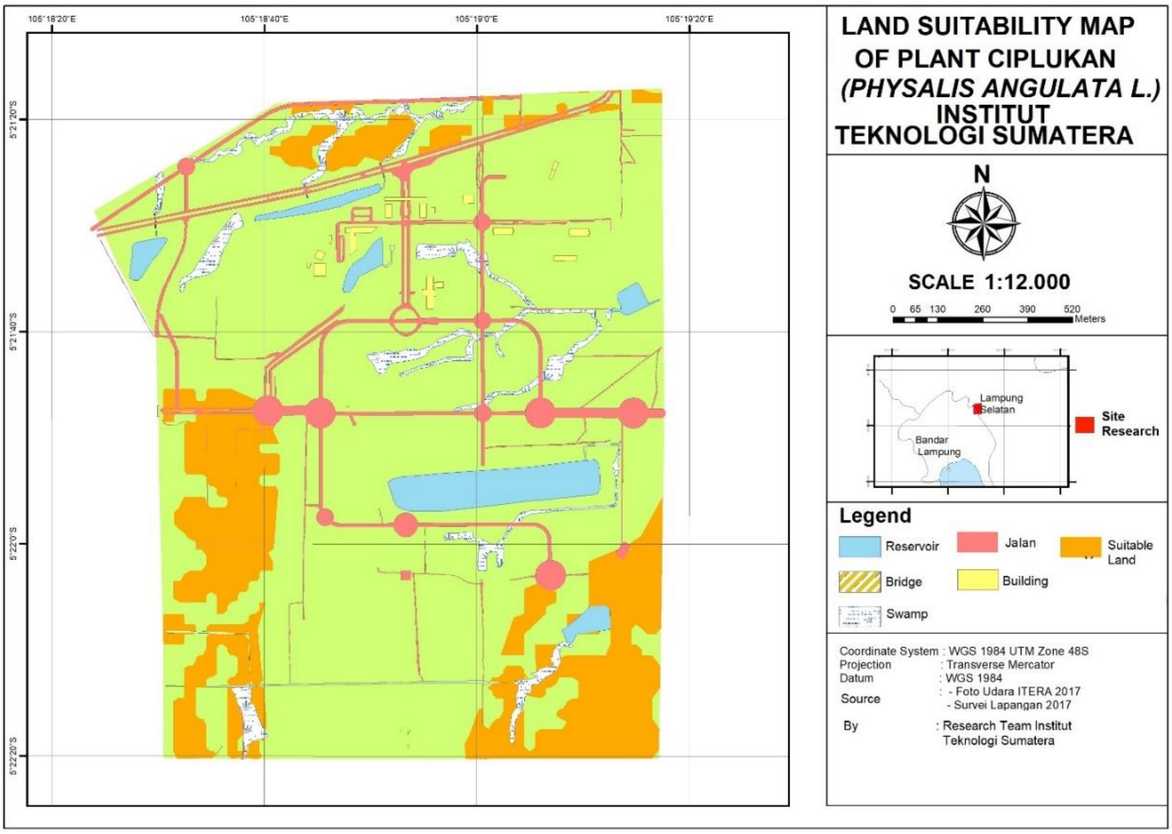

Figure 4-5: Map of land suitability for ciplukan (*Physalis angulata L.*)

Table 4-3: Scoring of land suitability.

Score	Classification	Area (ha)
12	Highly suitable	49.11
9–11	Less suitable	180.96
6–8	Not suitable	52.19

As can be seen, highly suitable land for ciplukan planting in our area of study covers 49.11 ha, while there is 52.19 ha of land that is not suitable for ciplukan.

Based on Table 4-3, that 52.19 ha score 6 to 8 and so are not suitable for ciplukan planting, 180.96 ha score 9 to 11 and so are less suitable for planting, while 49.11 ha are highly suitable for this type of cultivation.

Thus, based on parameters for data processing which include rainfall, soil type, altitude and slope, and combined with land use data, maps of land suitability for ciplukan (*Physalis angulata L.)* can be produced.

The weighting was based on the highest values of suitability parameters for growing ciplukan crops. Land use in ITERA is influenced by the quality and characteristics of the land. ITERA land use consists of buildings, roads, ponds, marshes, bridges, vegetation and ditches. Regions that have a high level of fitness for ciplukan cultivation are in the vegetation area and have the highest score of 3, while the lowest value is found for buildings, roads, ponds, marshes, bridges and culverts.

5 CONCLUSION

Based on the analysis of land suitability for ciplukan crops (*Physalis angulata L.)* it was concluded that the slope grade of ITERA includes slopes of 0–3% covering 239.89 ha, 4–6% covering 11.63 ha and more than 6% covering an area of 24.72 ha. The intensity of the average rainfall in the ITERA region is 1,750–2,000 mm/year, and soil analysis shows that kanhapludults soil type (T1, T3, T4) is the most suitable for plants of this type.

The suitability of our study area was divided into three classes. The highly suitable class has a total area of 49.11 ha, the less suitable has a total area of 180.95 ha, and the not suitable class has a total area of 52.19 ha.

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