Study of land potential based on soil characteristics using interpolation and scoring methods for non agricultural uses: a case study in Wonosalam, Jombang District, East Java

Siswanto[1] and Purnomo Edi Sasongko[1]

[1]Program Study of Agrotechnology , Faculty of Agriculture,UPN "Veteran" Jawa Timur
*Corrensponding author. Email: siswanto.agro@upnjatim.ac.id

Received: September 5th, 2023 / Accepted: March 20th, 2024

ABSTRACT

The state asset land managed by UPN "Veteran" East Java is located in the Wonosalam District based on land certificate data issued by the Jombang BPN covering 13.5 hectares. Currently, more than 50% of the land has not been used optimally to support learning, research, and community service. The problems that arise in utilizing land assets to support learning, research, and community service are 1) the legal boundaries of land ownership are not yet clear, 2) there is no land use master plan to support the learning process, 3) there is no potential data that can be used. prepare use and development plans. Against the background of the problems above, this research aims to map the potential of state land assets by "spatial interpolation, scoring and weight overlay" of land characteristics. Interpolation is a way of calculating the area of several representative measurement points while scoring and "Weight Overlay" is a facility provided by ArcMap GIS that combines input spatial data with weighting (weight factor) and scoring. Land unit maps are obtained from overlaying relief, geology, slope, and land use maps. Interpolation, Scoring, and Weight Overlay of the nine land characteristics yielded a potential land asset for buildings, good category 16.61% (44,130.38 m^2); moderate 25.66% (67,382.75 m^2) and bad 7.523% (19,784.88 m^2). Playing field potential, good category 54.73% (71,865.05 m^2) and medium 45.27% (59,432.62 m^2). Potential for road infrastructure development in the good category was 32.38% (42513.74 m^2); Moderate 42.68% (56035.24 m^2) and Bad 24.94% (32748.69 m^2), and all of these potentials are in Slightly Flat topography (Slope, 0-3%) to hilly (Slope, 15-25%).

Keywords: *land map units (LMU), land potential, scoring, soil characteristics, spatial interpolation.*

INTRODUCTION

UPN "Veteran" East Java is one of the PTNs that is given the authority to manage the finances of public service agencies (PTN PK BLU), to improve educational services to make the lives of society and the nation more intelligent. The flexibility of PTN PK BLU's financial management is based on productivity and the application of sound business practices. Government Regulations Number 74 of 2017 and Number 6 of 2006 which have been amended by PP Number 38 of 2008, only apply to financial management.

Based on data in the land certificate issued by the Jombang Regency Land Agency (BPN), the state asset land managed by UPN "Veteran" East Java in Wonosalam District is 13.5 hectares, located at an altitude of between 246 to 295 m above sea level. Currently, more than 50% of this land has not been utilized optimally to support learning, research, and community service activities, even though its use has the potential to be maximized.

Land evaluation is an approach or way of assessing land systematically and classifying it based on properties that are potential and inhibiting in its use (Arsyad, 1989). Evaluation of land capability is an evaluation of land potential for a wide variety of uses and does not discuss specific designations or management actions, therefore it is a more general evaluation compared to land suitability evaluation.

Geographic information systems are computer-based systems used to design, compile, store, manipulate, process, display, and analyze spatial information (Khusnawati & Kusuma, 2020). Input data can be in the form of a combination of raster and vector spatial data. Available geoprocessing facilities will make it easier to integrate spatial data. The results of quantitative measurements in the field and in the laboratory are mapped and weighted for overlapping (weight overlay). The input values must be integer form, and if there are floating-point values they must first be converted to an integer raster before they can be used in a weighted overlay. Each value class in the input raster is given a new value based on the evaluation scale (Maroeto et al. 2022).

The overlapping process begins by combining topographic maps, slope maps, and rock maps to obtain soil map units (SPT). The land unit map is superimposed on the current land use/land cover map to obtain a land unit/SST map (Purwadi & Siswanto, 2021).

Spatial interpolation is an approach to predict unknown values around known values. Based on this understanding, interpolation can be used to determine or predict a value at a location without having to use actual data but using existing data as a sample. Interpolation by taking into account the distance from the sample point in reverse is known as inverse distance weighted/IDW (Lestari et al. 2018).

DOI: https://doi.org/10.21107/agrovigor.v17i1.2255

Agrovigor: Jurnal Agroekoteknologi
http://journal.trunojoyo.ac.id/agrovigor
ISSN: 1979-5777 (*Print*), 2477-0353 (*Online*)

Scoring is the process of giving weights or values to map polygons that represent certain phenomena in a series of spatial analyses. The value or score given to a map polygon represents the level of closeness, interconnectedness, or severity of a particular impact on a phenomenon spatially. Determining land potential is carried out by giving weights/scoring to each land parameter as used by Adininggar et al. (2016).

MATERIAL AND METHOD

The stages in carrying out this research generally begin with a preliminary study followed by data collection, interpolation, scoring and weighting, data processing and analysis, and conclusions from the research results.

Preliminary Study

A preliminary study was carried out to collect secondary data in the form of climate data for the research area obtained from NASA/POWER CERES/MERRA2 Native Resolution Monthly Data at an altitude of 239.05 m at an average coverage area of 0.5 x 0.625 degrees covering the districts of Mjowarno, Mojoagung, Bareng, Wonosalam Jatirejo, Pujon, Kasembon, and Kandangan. Annual rainfall data for the last 5 years was averaged using the Thiessen polygon method. Topographic maps and slope maps were derived from East Java DEM-SRTM data at a resolution of 30 m. The grouping of regional and slope shapes is based on Marsoedi et al. (1997) in Sukarman, Ritung, Anda, Suryani (2017), the Rock Map was obtained from the Geological Map of East Java at a scale of 1: 250,000 published by the Geospatial Information Agency.

Merging with the overlapping of rock, topography, and slope maps yields a soil map unit (LMU), which is then overlaid with the current land use/land cover to obtain a land unit map (LMU). The results of overlaying the research area in land units plus contour, river, and road layers are used as shown in Figure 1.

Soil sampling was carried out for each land unit using the Purposed Random Sample method with the number of sampling points proportionally based on the area of the land map unit (LMU).

Soil Characteristics

Data on soil characteristics were obtained by direct field measurements and laboratory analysis which included the following parameters: Flood, Drainage, Solum Thickness, Permeability, Texture, Rock, Slope, and Erosion Hazard.

Interpolation

The land potential map is obtained from the interpolation of land characteristic measurement data at all observation points. Interpolation is done using the Inverse Distance Weighted (IDW) method which is calculated by the equation (Lioyd, 2010):

$$Z_0 = \sum_{i=1}^{N} \omega_i Z_i$$

Z_i = Estimated ith value
ω_i = Weight reversed to i from the previous point
i = Index to i s/d N

The value of ω_i is calculated by the equation:

$$\omega_i = \frac{h_i^{-p}}{\sum_{j=0}^{n} h_j^{-p}}$$

h_i = Distance between data points to j.
P = Adjustable rank
$\Sigma(h_i)^{-p}$ = The sum of the reciprocals of the p power of the distance between points.

h_i is calculated by the equation:

$$h_i = \sqrt{(x - x_i)^2 + (y - y_i)^2}$$

(x, y) = Interpolation point coordinates
(x_i, y_i) = Coordinates of each point distribution

Scoring and Weighting

Scoring is carried out on each physical soil parameter after grouping it based on the provisions set out in the soil survey and mapping guide. The value given to each parameter with the lowest scoring is given to inhibiting factors and the highest to supporting factors. Meanwhile, weight percentages are given to land characteristic parameters based on the size of the influence on land potential (Adininggar, Suprayogi, and Wijaya, 2016). The scoring and weighting of the land characteristics given are shown in the following Table 1.

Data Processing and Analysis

Data processing is carried out by overlaying maps resulting from interpolation, scoring and weighting. Determination of land potential for agriculture and non-agriculture is obtained from the sum of weighted land characteristic parameter scores. Potential use is determined by calculating the width of the total score interval (Satria, 2012), namely:

$$\text{Interval Width (I)} = \frac{Intervals\ (R)}{Number\ of\ Intervals\ (N)}$$

Interval classes for potential agricultural land, buildings, playgrounds, and roads are presented in the following Table 2.

In a chart of data processing and analysis, is presented in Figure 2. below, and a description of the process is shown in the methodology above.

The land potential map for buildings in Figure 3 which is the result of overlapping several land characteristics shows a good potential of = 44,130.38 m^2, medium = 67,382.75 m^{2,} and bad = 19,784.88 m^2 of a total land asset of 131,297.67 m^2. These three potentials are supported by factors without flood hazard, fast surface drainage, shallow soil solum, very light erosion hazard and a lot of coarse material. Meanwhile, the percentage of potential use of buildings is shown in Figure 4 below.

RESULTS AND DISCUSSION

Map of Building Development Potential Based on Land Characteristics

Graph figure 4 shows that state land assets which are under the control of UPN "Veteran" East Java located in the Wonosalam sub-district, Jombang District when developed to support learning and community service facilities in the form of a physical laboratory building or structure, have a good potential of = 33.61%, moderate = 51.32% and poor = 15.07%. The building or physical structure can be erected on land that has a flat topography (Slope, 0-3%) covering an area of 10,397.93 m^2, undulating (Slope, 3-8%) = 76,966.16 m^2, rolling (Slope, 8-15 %) = 31,237.55 m^2 and hummocky (Slope, 15-25%) = 12,696.03 m^2.

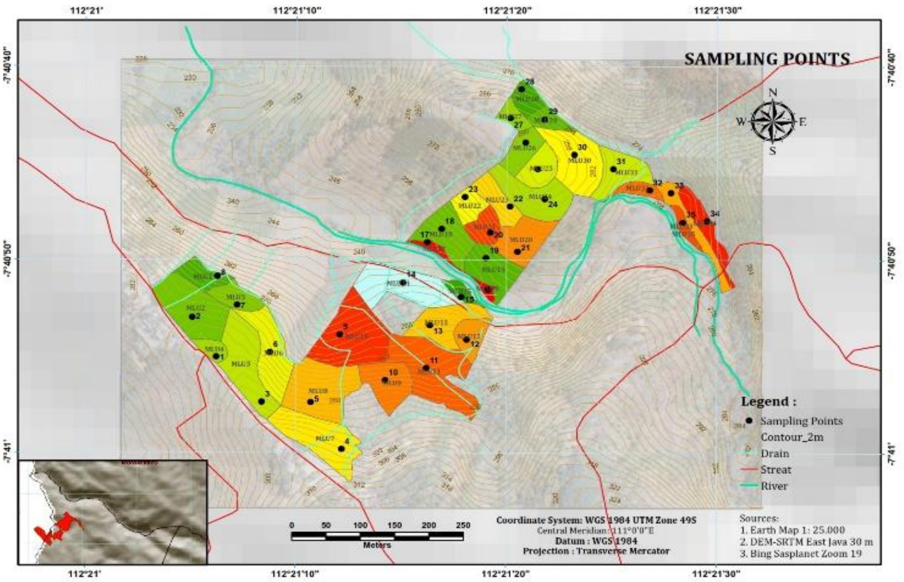

Figure 1. Soil sampling points

Table 1. Potential modifications for non-agriculture

No	Parameter	Class	Value	Score	Weight
1	Flood Sukarman et al.. 2017	Without	Never	5	20%
		Infrequently	Once every 6 -10 years	4	
		Sometimes	Once every 2-5 Years	3	
		Frequently	Once in 1 year	2	
		Very Frequently	> Once in 1 year	1	
2	Drainage Arsyad (1989) with modification)	Very Slow	Slope 0 - 3%	1	15%
		Slow	Slope > 3 - 8%	2	
		A bit slow	Slope > 8 - 15%	3	
		Moderate	Slope > 15 - 30%	4	
		Fast/Very Fast	Slope > 30 - 45%	5	
3	Permeability Arsyad (1989) with modification)	Slow/Very Slow	0,125 – 0,5	1	10%
		A bit slow	0,5 – 2,0	2	
		Moderate	2,0 – 6,35	3	
		Rather fast	8,35 – 12,7	4	
		Fast/Very Fast	12,7 – 25,4	5	
4	Solum (cm) Arsyad (1989) with modification)	Very Deep	> 90	1	10%
		Deep	> 75 - 90	2	
		Moderate	> 50 - 75	3	
		Shallow	> 20 - 50	4	
		Very Shallow	< 20	5	
5	Texture Sukarman et al. (2017)	Fine (h)	SC, C, SiC	1	15%
		Rather Fine (ah)	CL, SCL, SiCL	2	
		Moderate (s)	VfSL,L, SiL, Si	3	
		A bit Rough (ak)	SL	4	
		Rough (k)	S, LS	5	
6	Slope (%) Sukarman et al. (2017)	A bit flat	3 - 8	5	10%
		Sloping	> 8 - 15	4	
		Slightly Steep	> 15 - 25	3	
		Steep	> 25 - 40	2	
		Very Steep	> 40 - 60	1	
7	Coarse Material (%) Ritung et al. (2011)	Without	0	1	15%
		A little	1 - 15	2	
		Moderate	15 - 35	3	
		Many	35 - 60	4	
		So Many	> 60	5	
8	Erosion Hazard Ritung et al. (2011)	Very Light	< 0.15	5	5%
		Light	0.15 - 0.9	4	
		Moderate	> 0.9 - 1.8	3	
		Heavy	> 1.8 - 4.8	2	
		Very Heavy	> 4.8	1	

(Source: USDA, 1983 in Mega et al., 2010)

Table 2. Land Potential Criteria Based on Interval Class
Land Potential Total Score

Criteria	Building	Playground	Road
Good	≥ 3,35	≥ 3,35	> 3,25
Moderate	3,35 - 2,75	3,35 - 2,35	≥ 3,25 - 2,75
Bad	< 2,75	< 235	□ 2,75

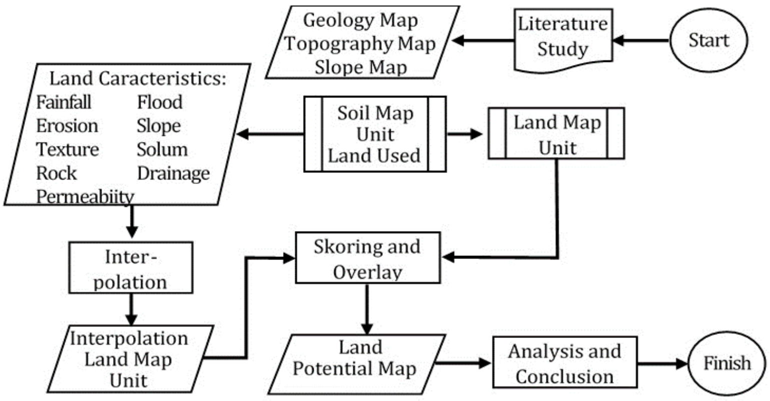

Figure 2. Research flow chart

Map of potential playing fields based on land characteristics

The land potential map for playing fields in Figure 5, which is the result of overlapping several land characteristics, shows good potential of = 71,865.05 m^2, and medium area of = 59,432.62 m^2 from total land assets of 131,297.67 m^2. This potential lead is supported by the factors of no risk of flooding, fast surface drainage, shallow soil solum, very light erosion risk, and a large amount of coarse material. The percentage of each category of potential land use for playing fields is shown in Figure 6 below.

The graph in Figure 6 shows that state land assets under the management of UPN "Veteran" East Java located in the Wonosalam sub-district, Jombang district which have not been used to support learning, research and community service facilities based on land characteristics have the potential to develop a playing field with a good category amount = 54.73%, and medium = 45.27%. Play facilities can be developed to support physical and mental training activities, and outbound state defense. The playing field can be developed on land that has a flat topography (Slope, 0-3%) covering an area of 18,094.27 m^2, undulating (Slope, 3-8%) = 67,001.48 m^2, Rolling (Slope, 8-15%) = 31,163 .29 m^2 and hummocky (Slope, 15-25%) = 15,038.63 m^2.

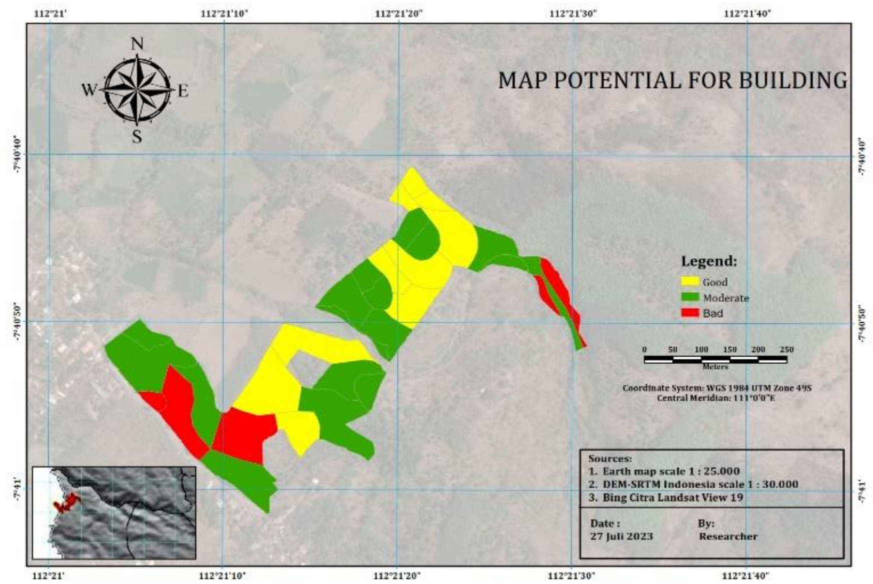

Figure 3. Land potential map for buildings

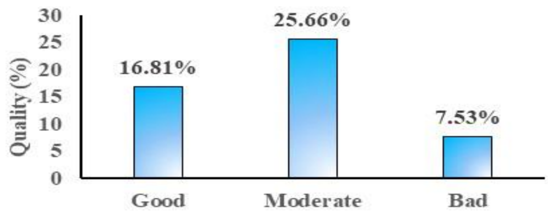

Figure 4. Graph of land potential for buildings

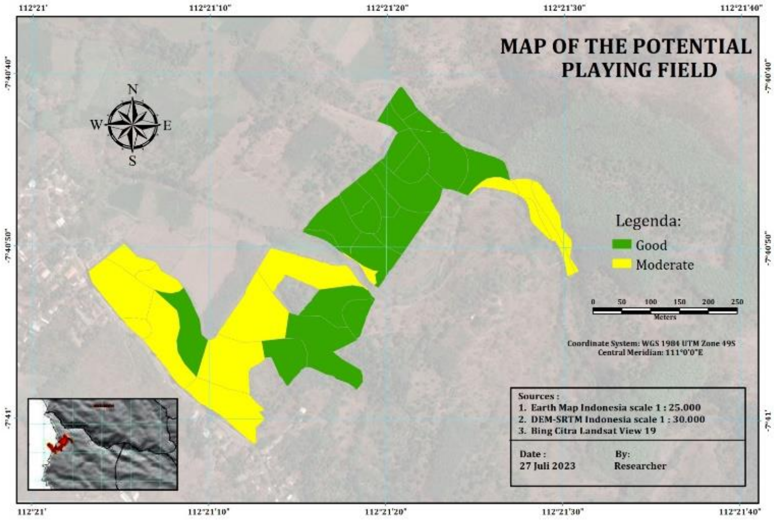

Figure 5. Potential playing field map

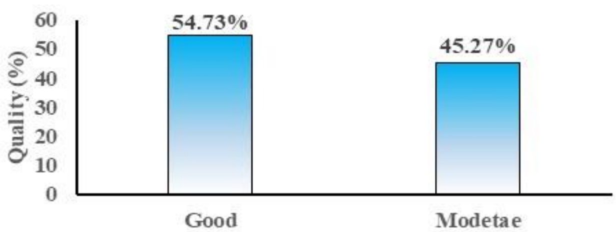

Figure 6. Graph of land potential for playing fields

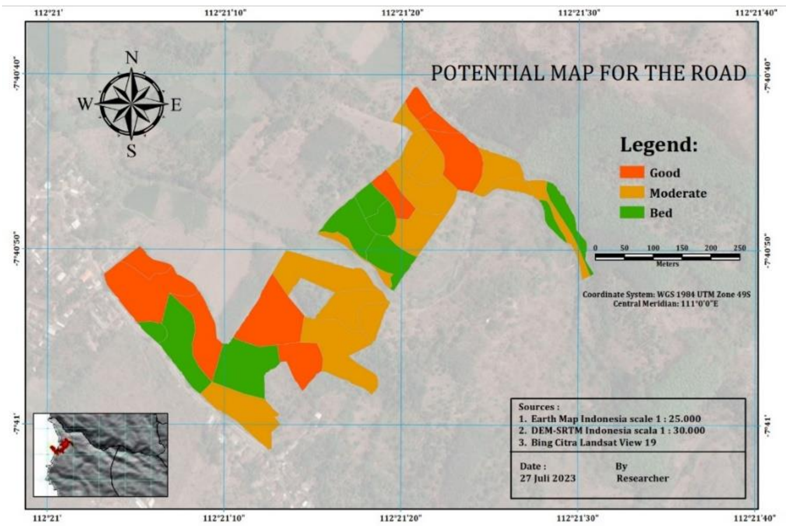

Figure 7. Map of land potential for road facility

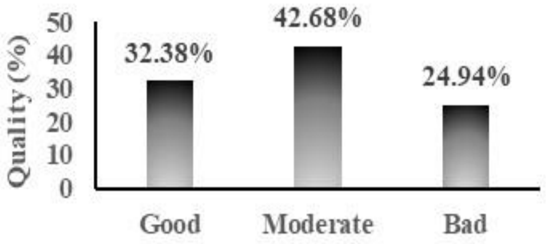

Figure 8. Graph of potential land for roads

Map of potential land for roads based on land characteristics

Figure 7 shows the results of the overlapping interpolation of land characteristics that affect the potential of road facilities. The results of overlaying for road infrastructure facilities obtained good potential = 42513.74 m2, medium = 56035.24 m2 and bad = 32748.69 m2 from an asset land area of 131,297.67 m2, which is supported by factors without the threat of flooding, slightly fine texture, moderate surface drainage. -rather quickly, and the danger of erosion is very slight. The percentage of potential land for roads in each land condition is shown in the following figure:

Based on Figure 4 above, it can be seen that the state asset land under the management authority of the East Java "Veteran" UPN located in Wonosalam, Jombang to support educational and community service facilities related to road facilities has good potential, amounting to 32.38%, medium potential 42 .68% and a bad potential of 24.94% which is on a rather flat topography (Slope, 0-3%) area = 18077.75 m^2, undulating (Slope, 3-8%) = 69286.20 m^2, rolling (Slope, 8-15%) = 31237.68 m^2 and hummocky (Slope, 15-25%) = 12696.04 m^2.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the research and the descriptions in the previous sections it can be concluded that IDW interpolation can be used to calculate the area from one point measuring land characteristics (in situ) in a land map unit. The scoring and Weight Overlay method is used to quantitatively categorize the results of measuring qualitative land characteristics based on the magnitude of the influence on land potential. Scoring and Weight Overlay of 9 (nine) land characteristics produces potential land assets for building construction, good category 16.61% (44,130.38 m^2); moderate 25.66% (67,382.75 m^2) and bad 7.523% (19,784.88 m^2). Playing field potential, good category 54.73% (71,865.05 m^2) and medium 45.27% (59,432.62 m^2). Potential for roads, good category 32.38% (42513.74 m^2); medium 42.68% (56035.24 m^2); and bad 24.94% (32748.69 m^2) of the total land area of 131297.67 m^2. The four potential land assets are in a Slightly Flat topography (Slope, 0-3%) to hilly (Slope, 15-25%).

REFERENCES

Arsyad, S. (2009). *Konservasi tanah dan air*. Pt Penerbit Ipb Press.

Adininggar, F. W., Suprayogi, A., & Wijaya, A. P. (2016). Pembuatan peta potensi lahan berdasarkan kondisi fisik lahan menggunakan metode weighted overlay. *Jurnal Geodesi Undip*, *5*(2), 136-146. DOI: https://doi.org/10.14710/jgundip.2016.11530

Aydın, A., Dengiz, O., & Ormancı, İ. F. (2022). Land evaluation for sustainable land management with multi-criteria decision making and linear combination technique; A case study in Samsun-Kavak District.

Khusnawati, N. A., & Kusuma, A. P. (2020). Sistem informasi geografis pemetaan potensi wilayah peternakan menggunakan weighted overlay. *Jurnal Mnemonic*, *3*(2), 21-29. DOI: https://doi.org/10.36040/mnemonic.v3i2.2788

Lloyd, C. (2010). *Spatial data analysis: an introduction for GIS users*. Oxford University Press, USA.

Lestari, M., Mira, M., Prasetyo, S. Y. J., & Fibriani, C. (2021). Analisis daerah rawan banjir pada daerah aliran sungai tuntang menggunakan skoring dan inverse distance weighted. *Indonesian Journal of Computing and Modeling*, *4*(1), 1-9. DOI: https://doi.org/10.24246/icm.v4i1.4615

Maroeto, A. F., Santoso, W., & Siswanto, R. P. (2022). Assessment of land suitability evaluation for plantation crops using AHP-GIS Integration in the Wonosalam Forest Area, East Java. *Universal Journal of Agricultural Research*, *10*(5), 569-586. DOI: https://doi.org/10.13189/ujar.2022.100512

Mega, I. M., Dibia, I. N., Ratna, I. G. P., & Kusmiyarti, T. B. (2010). Klasifikasi Tanah dan Kesesuaian Lahan. Fakultas Pertanian, Universitas Udayana, Denpasar. page. 137-141

Satria, M., & Rahayu, S. (2013). Evaluasi kesesuaian lahan permukiman di kota Semarang Bagian Selatan. *Teknik PWK (Perencanaan Wilayah Kota)*, *2*(1), 160-167.

Purwadi, P., & Siswanto, S. (2021). Identifikasi dan pemetaan tingkat lahan kritis wilayah dataran menengah Kabupaten Probolinggo menggunakan teknik sistem informasi geografi (SIG). *Agrovigor: Jurnal Agroekoteknologi*, *14*(1), 13-29. DOI: https://doi.org/10.21107/agrovigor.v14i1.8711

Sukarman, Ritung S., Anda M., Suryani E., (2017). *Pedoman Pengamatan Tanah Di Lapangan. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian*. Badan Penelitian dan Pengembangan Pertanian. ISBN 978-602-344-163-1