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Critical Land Mapping of Protected Forest Areas in Sukamakmur District, Bogor Regency

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Abstract

Sukamakmur District is one of the areas in Bogor Regency where disasters often occur related to critical land conditions. This situation is often associated with changes in land cover as population growth continues. This research aims to identify and map critical land using a geographic information system (GIS) in Sukamakmur District. The method used is tumpeng stacking analysis with classification, scoring and weighting. There are 4 classes of critical land in Sukamakmur District, the largest percentage of low potentially critical land is 14,008 ha (82.32%). Then followed by slightly critical land with an area of 2,777.5 ha (16.32%), critical land with an area of 215.5 ha (1.27%), and very critical land with an area of only 16 ha (0.09%) of total area. This indicates that critical land for protected forests in Sukamakmur District is still relatively low.

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Abstrak

Kecamatan Sukamakmur adalah salah satu wilayah di Kabupaten Bogor yang sering terjadi bencana yang terkait dengan kondisi lahan kritis. Keadaan ini sering dihubungkan dengan perubahan tutupan lahan seiring terus berkembangnya pertumbuhan penduduk. Penelitian ini bertujuan untuk mengidentifikasi dan memetakan lahan kritis menggunakan sistem informasi geografis (SIG) di Kecamatan Sukamakmur. Metode yang digunakan yaitu analisis tumpang susun dengan pengkelasan, skoring, dan pembobotan. Terdapat 4 kelas lahan kritis di Kecamatan Sukamakmur, lahan potensial kritis rendah memiliki persentase terbesar yaitu seluas 14.008 ha (82,32%). Lalu diikuti lahan agak kritis dengan luas sebesar luas 2.777,5 ha (16,32%), lahan kritis seluas 215,5 ha (1,27%), dan lahan sangat kritis hanya memiliki luas 16 ha (0,09%) dari luas total. Hal ini menandakan bahwa lahan kritis terhadap hutan lindung di Kecamatan Sukamakmur masih tergolong rendah.

INTRODUCTION

The critical land phenomenon that occurs in land cover is a form of land degradation. Land experiences loss of soil function from physical, chemical and biological elements, especially in protected forest areas. Critical land refers to the exploitation of forests for production, and as part of the forest ecosystem, namely reducing the quality of land as a regulator of water resource storage and protection against landslides or floods (Indrihastuti et al., 2016). Critical land is a form of land that has been degraded (Sitorus et al., 2011). Critical land is land that is currently unproductive because its management does not pay attention to soil and water conservation requirements, so that the land experiences damage, loss or lack of function to a predetermined or expected limit (Rumenah et al., 2010).

Critical land is closely related to changes in land use as human activities develop, the need for land continues to erode land that is still in its original condition into land that is no longer productive or critical (Kubangun et al., 2016). Land experiences physical, chemical and biological damage which makes the land have no economic value. The level of criticality of land can be seen from the capacity of the land, the magnitude of the risk of threats or obstacles in the use of the land. According to Kubangun et al. (2014), critical land is often associated with land user intervention due to the physical condition of the land which cannot be controlled. As the population increases, the need for land as a place to live increases, land management increases so that the quality of the land decreases and the land that can be used for cultivation becomes increasingly limited. Lack of supervision and land management that is not in accordance with applicable regulations (such as failing to conserve land in some places or excessive land use) are factors causing land criticality (Prawira et al., 2005). According to Ramayanti et al (2015), vegetation density plays a major role in the criticality of land.

According to Kurnia et al. (2015), data on the rate of development of critical land in Indonesia from 1980-2007 has increased. The development of critical land from 1980 to 1994 showed a decline. However, from 1994 to 2003 the area of critical land increased sharply. Furthermore, Kurnia et al. (2015) explained that, at the beginning of the year in the 2000s, there were 23.25 million ha of critical land, 15.11 million ha of which were outside the forests, and 8.14 million ha within forest areas. critical land level in protected area functions outside forest areas.

Land use in Bogor Regency has increased. The study conducted by Mulya et al. (2022) that the development of built-up areas has expanded to peripheral areas. These changes were caused by the extent of agricultural factors, the growth of social facilities, and the growth of economic facilities (Sitorus & Mayasary, 2019). local government (Bogor Regency) should be alert to the land use changes that do not comply with the land use plan and also consistently apply the spatial planning (Cahya et al., 2018). Therefore, a study of critical land due to the impact of urban sprawl is very necessary as an illustration and policy in the future. Apart from that, Bogor Regency is an area where disasters frequently occur related to critical land conditions such as landslides (Naryanto et al., 2020). Bogor Regency is an area with medium and high landslide rates. The result of landslide susceptibility from the mid-region area of Bogor to the southern part was categorized as moderate to high landslide susceptibility zones (Silalahi et al., 2019). The Greater Bogor Area is highly prone to landslides, with a growing tendency in landslide events (Herdiansyah et al., 2024). This is related to the condition of the forest as a protector of the stability of downhill slopes.

The critical land mapping study in Sukamakmur District is useful in exploring natural resources by considering rehabilitation and soil conservation efforts. A common conservation practice is terraced land cultivation, which is used to avoid erosion and flooding (Eraku & Koem, 2018). Identification activities are usually carried out through terrestrial surveys and take a long time and access to areas is very difficult. Mapping critical land in Sukamakmur District can provide an overall picture of the thematic maps produced using Geographic Information Systems (GIS). This will make it easier to determine and analyze critical land spatially, thereby minimizing weaknesses in the process of making maps manually. GIS is an effective tool for collecting, recording, storing, analyzing, presenting and managing geographic and spatial data using interactive maps. Narendra et al. (2019) integrated GIS with the Analytical Hierarchy Process method and found that 32.7% of the East Lombok Regency area was included in the

critical area category where the area of critical land in the State Forest Area was smaller than in Other Utilization Areas. Simarmata et al. (2024) utilized GIS and Remote Sensing in the Bengawan Solo watershed and found that the critical land category dominates the area with an area of 45.94%, indicating potential risk in areas with moderate slopes. The steeper the area, the lower the criticality level. With the help of GIS applications, decision makers can edit spatial and geographic data in maps, analyze this data by making interactive searches, and visualize the conclusions of the process (Balaman, 2019). Based on the description above, this research aims to examine the distribution of critical land based on its level classification using a geographic information system in Sukamakmur District.

METHOD

Study Area

The study area was carried out in Sukamakmur District, Bogor Regency, West Java Province (Figure 1). Sukamakmur District is geographically located at 106°55'53.60"E - 107°5'51.72"E and 6°30'15.08"S - 6°40'6.45"S, with an area of 170.17 km^2 (Table 1) consisting of 10 villages (Cipta Karya PU, 2015). The lowest point of sub-district is in Jaura, Pabuaran Village which is on the border with Citeureup and Klapanunggal sub-districts. Meanwhile, the highest point is at the peak of Mount Tanggeuhan, Arca, Sukawangi Village, which borders Cianjur Regency. Sirnajaya Village, Sukamakmur is known as the largest coffee barn in Bogor Regency and is one of the largest suppliers of vegetables in Jabodetabekpunjur.

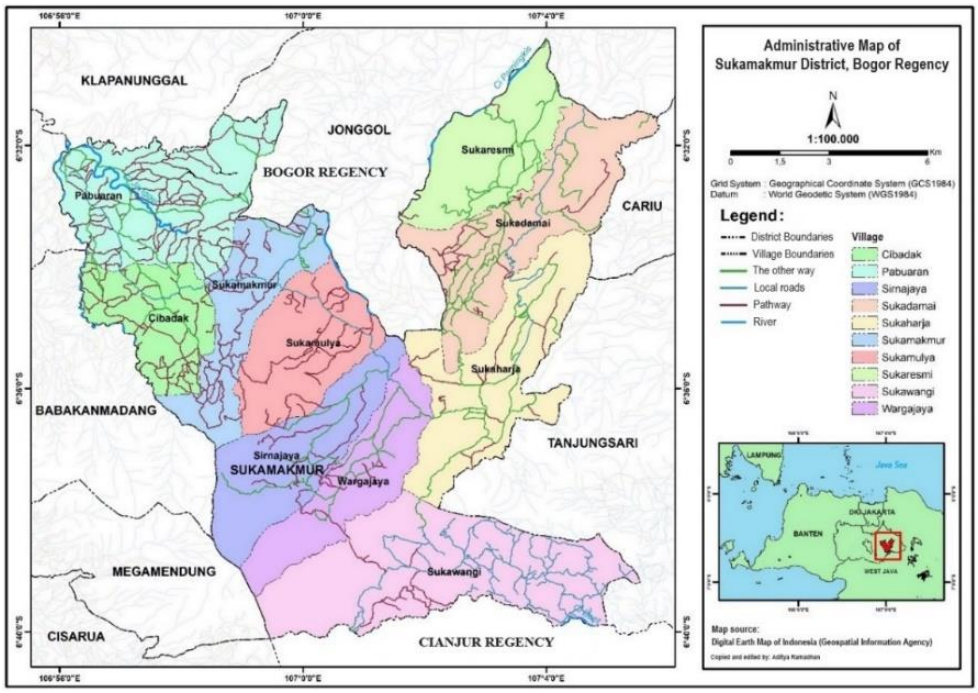

Figure 1. Administrative Map of Sukamakmur District, Bogor Regency

Table 1. Names of Villages in Sukamakmur District and Their Areas

No.	Village	Area (km^2)
1	Sukawangi	28,88
2	Sirnajaya	15,09
3	Wargajaya	12,79
4	Sukamulya	14,03
5	Cibadak	11,22
6	Sukaharja	20,51
7	Sukamakmur	12,99
8	Sukadamai	19,68
9	Pabuaran	21,33
10	Sukaresmi	13,65
	Total	**170,17**

Research Methods

This research uses an overlapping method between spatial layers of driving variables used to create a critical land level map. The method in this research uses descriptive research using scoring and weighting techniques using the overlay method. The unit of analysis used is the regional analysis unit. The feature used to analyze the critical land level is the intersect feature and is completely carried out in the AcrMap 10.3 software (Widyamanti, 2018; Ramadhan & Wibowo, 2022). ArcMap GIS is useful for combining spatial attributes for the variables used. The final result of this research is a map of critical land in Sukamakmur District.

Data

This research uses field data that has previously been taken by previous researchers, but this data can be accessed from publications or data releases from related agencies. The use of secondary data can provide further information on the phenomenon being studied apart from data obtained directly from the field (Omukuti et al., 2021). This research uses data in the form of land cover, slope, land management, and erosion levels to analyze the criticality level of a land (Table 2). Protected forest area data is also used to see the extent to which the level of critical land affects the protected area area.

Data Analysis

The critical land map is obtained using a simple calculation technique by adding up the score for each variable multiplied by the predetermined weight percentage and the results will be reviewed with the suitability of the critical land score (Table 3). The final result is a critical land level map reviewed for protected forest areas in Sukamakmur District. The results of the critical land determination map will be classified into five levels which can be seen in Table 4 to determine the status of critical land. The flow of this research can be seen in Figure 2 below.

Table 2. Data

No	Data	Type	Source
1.	Digital Map of Indonesia's Earth	Vector	Geospatial Information Agency (BIG)
2.	Slope	Vector	Geospatial Information Agency (BIG) https://www.indonesia-geospasial.com/
3.	Calculation of Erosion using USLE method in Sukamakmur District	Tabular	Wicaksono, 2019
4.	Land Coverage/Land Cover Sukamakmur District	Vector	Bappedalitbang Kabupaten Bogor https://geoportal.bogorkab.go.id/gallerybogor/
5.	Land Management	Vector	Wicaksono, 2019

Table 3. Critical Land Parameters in Protected Forest Areas

No.	Parameter	Class	Description	Score	Weight	Information
1	Slope	Flat	< 8%	5	20	It is the angle of inclination of the shape of the ground surface
		Slopping	8-15%	4		
		A little steep	15-25%	3		
		Steep	25-45%	2		
		Very steep	>45%	1		
2	Land cover	Very good	> 80 %	5	50	Percentage of vegetation canopy density
		Good	61 – 80 %	4		
		Moderate	41 – 60 %	3		
		Bad	21 – 40 %	2		
		Vary bad	< 20%	1		
3	Land Management	Good	Complate	5	10	Counseling, Security, Supervision
		Moderate	Incomplate	3		
		Bad	None	1		
4	Erosion	Low	0 & I	5	20	Using the USLE formula
		Moderate	II	4		
		Heavy	III	3		
		Very heavy	IV	2		

Source: BPDDASPS, 2013

Table 4. Critical Land Level Class from Total Score

Score Total			Critical Land Level
Protected Forest Area	Agricultural Cultivation Area	Protected Areas Outside Forest Areas	
120 – 180	115 – 200	110 – 200	Very critical
181 – 270	201 – 275	201 – 275	Critical
271 – 360	276 – 350	276 – 350	A bit critical
361 – 450	351 – 425	351 – 425	Potentially critical
451 - 500	426 - 500	426 – 500	Not critical

Source: BPDDASPS, 2013

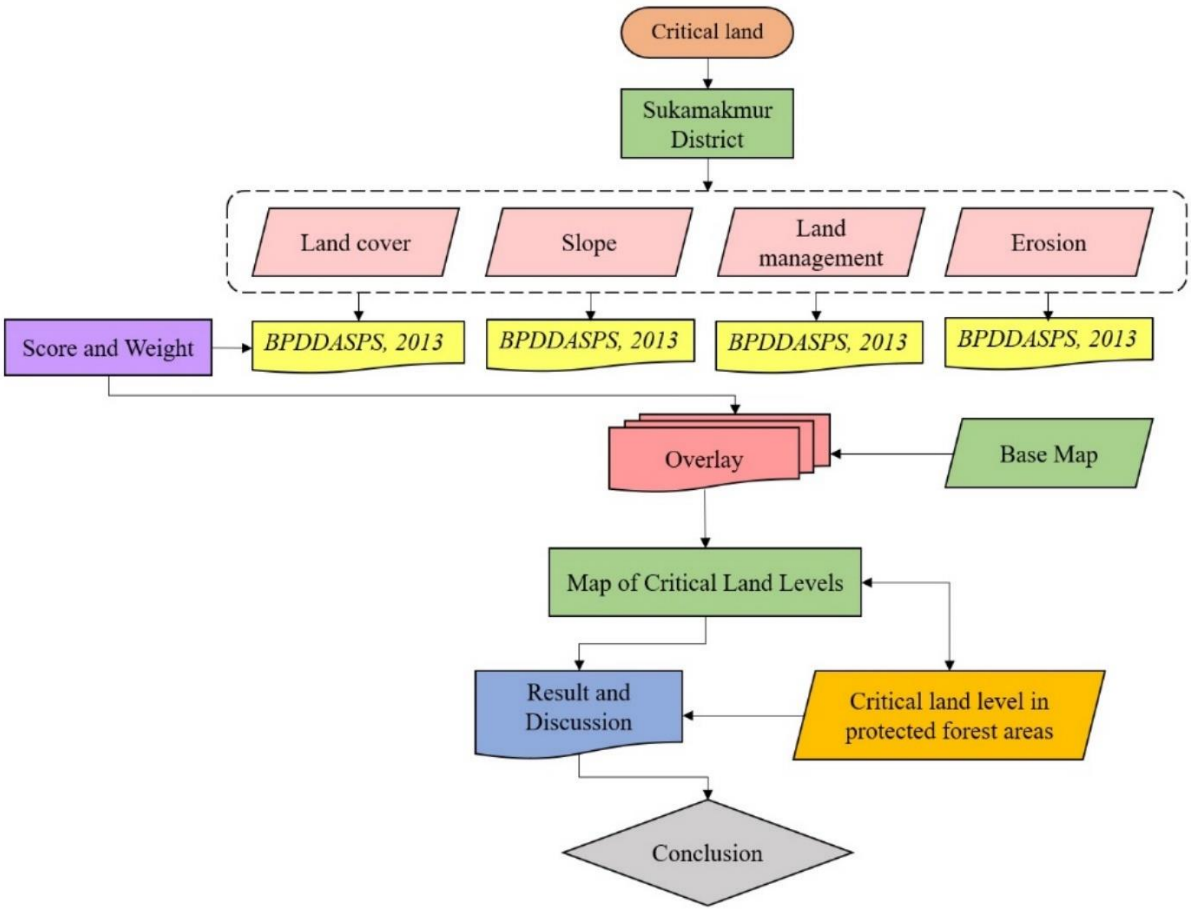

Figure 3. Critical Land Level Mapping Workflow

RESULT AND DISCUSSION

Map of Critical Land Variable

Sukamakmur District has five slope classes, namely flat surfaces covering an area of 1755.09 ha (10.31%), sloping surfaces covering an area of 4385.50 ha (25.77%), slightly steep surfaces covering an area of 5828.69 ha (34.25 %), the steep surface has an area of 3844.82 ha (22.59%), and the very steep surface has an area of 1203.31 ha (7.07%). All forms of slope are distributed throughout the region. Very steep slopes typically cluster towards the peak area which is located on the slopes of Mount Pangrango (Figure 4).

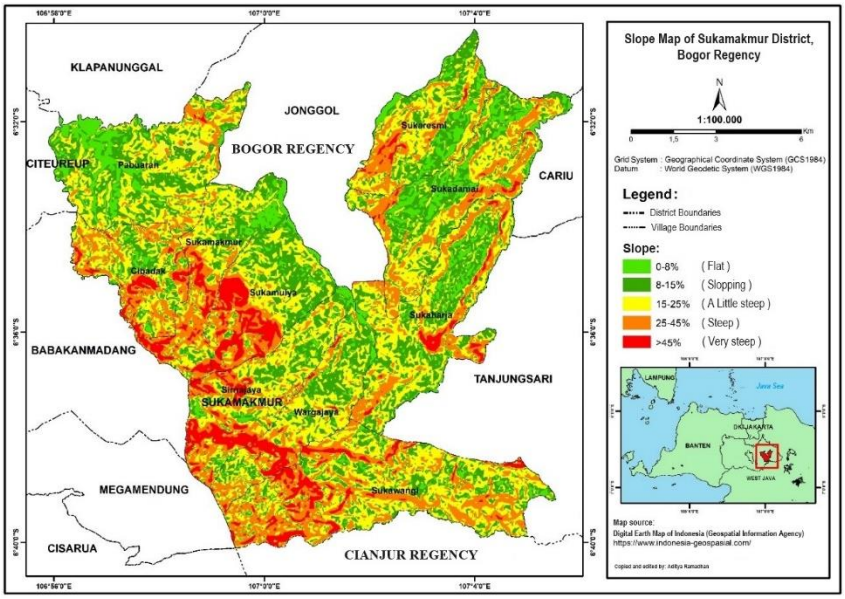

Figure 4. Slope map of Sukamakmur District, Bogor Regency

There are 6 types of land cover in Sukamakmur District, the largest land cover is in agricultural areas with an area of 13,418.81 ha (78.85%), followed by forest areas with an area of 3191.14 ha (18.75%), residential areas are visible does not dominate and is spread over an area of 307.84 ha (1.81%), there is also open land covering an area of 78.01 ha (0.46%), water bodies covering an area of 15.96 ha (0.09%), and land cover The smallest is the plantation area with an area of 5.64 ha (0.03%) (Figure 5).

After calculating the erosion hazard using the USLE method, the observation data is converted into spatial data so that a spatial study can be carried out from the erosion hazard map. The study area is dominated by light level class I erosion hazard covering an area of 14169.5 ha (83%), followed by a medium level class II area covering an area of 1517.8 ha (9%), class III severe level has an area of 174.8 ha (1%), and class IV erosion hazard with a very severe level covering an area of 1155.3 ha (7%). This indicates that land degradation has not occurred in parts of Sukamakmur District because it is dominated by light erosion. (Figure 6).

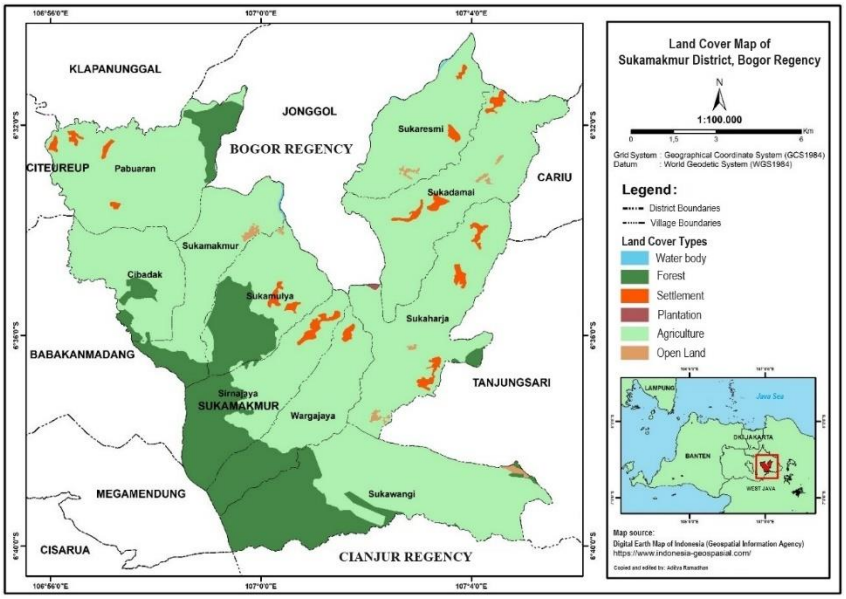

Figure 5. Map of Land Cover in Sukamakmur District, Bogor Regency

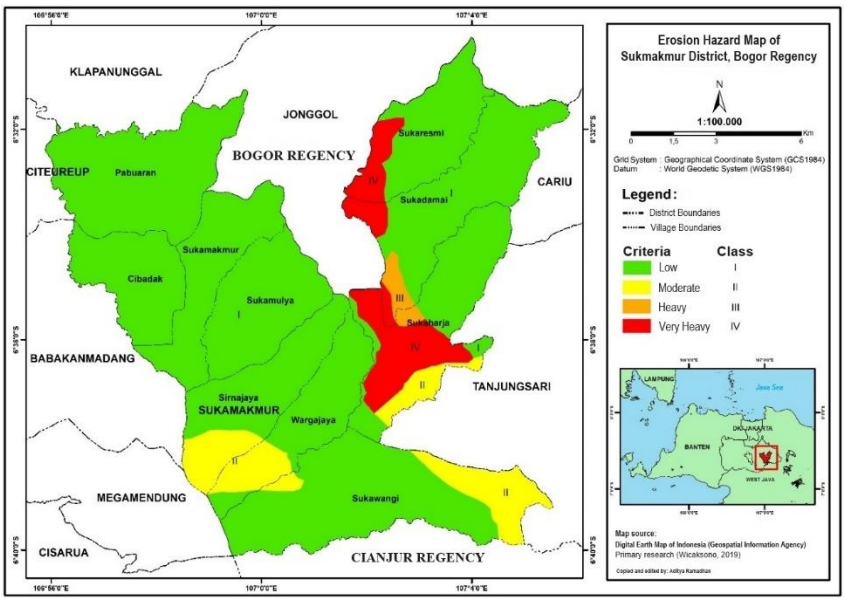

Figure 6. Map of Erosion Hazard in Sukamakmur District, Bogor Regency

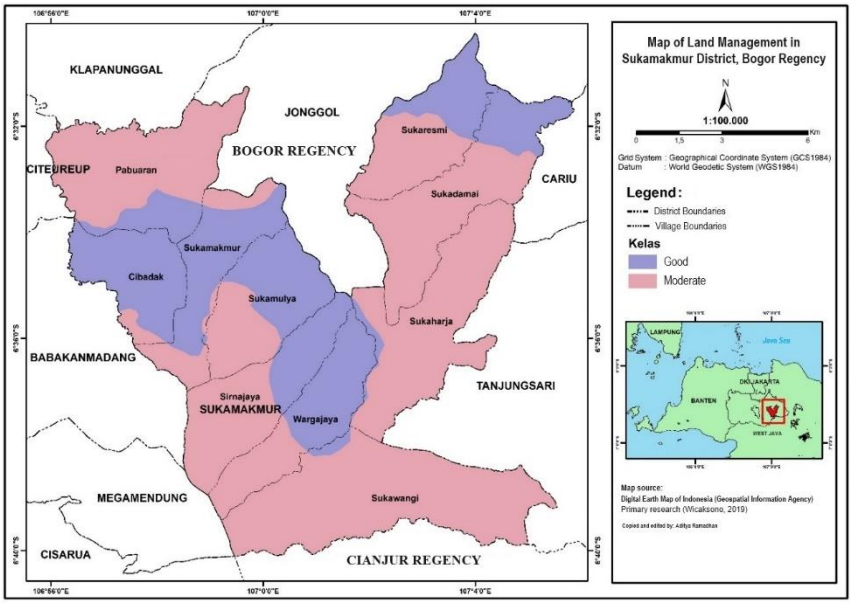

Figure 7. Map of Land Management in Sukamakmur District, Bogor Regency

Overall, the land in Sukamakmur District has been managed in the form of counseling and supervision following the application of technology in soil conservation in accordance with provisions. The area with good land management with a complete description is 5581.48 ha (32.8%), while the area with moderate management with an incomplete description is 11435.52 ha (67.2%) (Figure 7).

Critical Land Level of Protected Forests

Based on the results of the overlay analysis carried out using the Intersect feature in ArcGIS 10.3 software, the results of determining critical land for protected forests were obtained. It can be seen that low potentially critical land has the largest percentage (82.32%) or an area of 14,008 ha. For slightly critical land, it is in second place with a percentage of (16.32%) with an area of 2,777.5 ha. Furthermore, critical land has a percentage of (1.27%), namely an area of 215.5 ha. Lastly, very critical land only has a percentage (0.09%) of 16 ha of the total area of 17,017 ha. This indicates that critical land for protected forests in Sukamakmur District is still relatively small. The distribution of land criticality levels in Sukamakmur District can be seen in Figure 8.

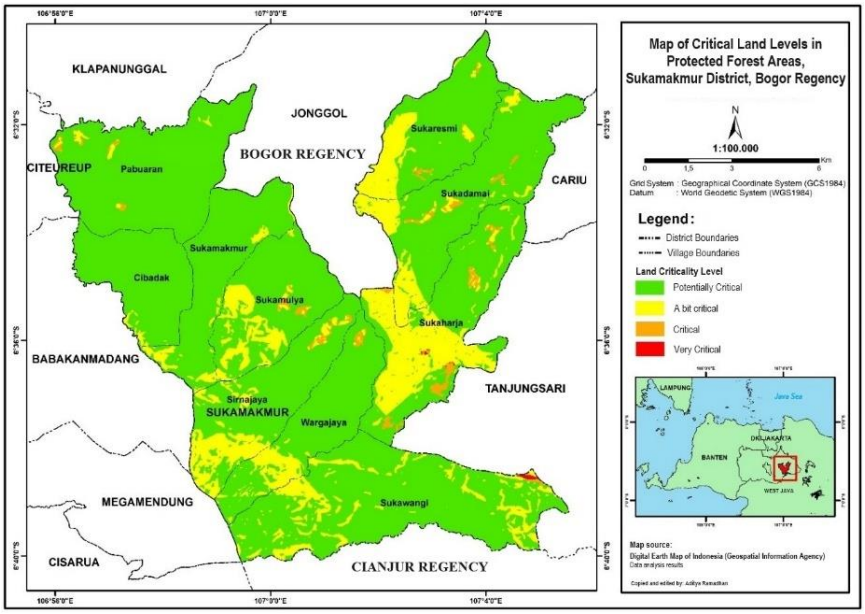

Figure 8. Critical Land Level Map of Protected Forest Areas in Sukamakmur District, Bogor Regency

In the scores and weightings used, the land cover variable has a larger percentage. According to Kusratmoko et al. (2020) land use is the main factor that determines the critical level of land, so changes in land use must be adjusted to the ability to control degraded land. According to Siswanto & Sule (2019) showed that there are no effect of slope steepness and landuse on organic matter, hydraulic conductivity and erodibility. The highest erodibility value was found on the forest with 8-15% slope. Fitriani et al. (2021) also showed that higher percentage of slopes the lower the criticality level of the land.

The use of scores and weights which are determined by scientific reports and relevant agencies are used in this research. However, this research did not consider other methods such as the Analytical Hierarchy Process (AHP) method. The AHP method is a popular and most representative statistical analysis temporally and in relation to the existing conditions of the study area by involving information from more expert experts (Taheri et al., 2020). In decision making from a spatial approach, this method can simplify the analysis of complex problems. Presents pair comparisons, and as an alternative for researchers so that the research results obtained can become more detailed.

Overlay is a technique in geographic information systems that actually applies to decision making methods based on multi-criteria. This technique is useful in combining determining parameters into decision making information. This technique is deemed appropriate for describing processing data into maps covering a wide area. The advantage is that each polygon of variables has a value down to the smallest unit, and each unit has an influence on what has been combined. In case studies of landslides, overlays can also be used to combine the history of previous landslide events as additional information in determining landslide-prone zones using arithmetic (Ramadhan & Kurniawan, 2021).

Behind the advantages mentioned above, the overlay method is limited to the classification used which cannot explain the extent of the mapped level of critical land. In research, especially in-depth critical land classification studies, critical land should be described in terms of the types of critical land, and the severity of the land. critical. The overlay method focuses on combining critical land trigger variables with a spatial approach and using spatial data. However, in decision making, this method is the simplest for intense and wide-scale problems (Pal et al., 2020). Apart from that, this method prioritizes GIS technology in data processing and analysis.

CONCLUSION

Based on the results of the discussion from the study, it can be seen that more than 80% of the land in Sukamakmur District has low critical potential status. For land with a moderately critical level (16.32%), in-depth conservation efforts can be carried out so that it does not develop into critical or very critical land. Strong

management is also needed in terms of counseling and supervision so that the area of critical land does not increase significantly. Therefore, critical land, especially protected forests, is a phenomenon that has a negative impact on the lives of humans living in that area.

Critical land is an illustration of land and forest degradation. This causes disruption to land functions as a form of reduction in the function of water catchment conservation, protection from flooding, as well as production functions for food security and the social economy of the community. Disasters can arise from the escalation of critical land that continues to occur due to the inability of the land to function as a protection. Therefore, critical land conservation efforts are a long-term form of resilience and disaster mitigation, considering that this area frequently experiences hydrometeorological disasters.

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