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MAPPING OF FOREST AND LAND FIRE VULNERABILITY LEVELS IN KABUPATEN TANAH LAUT, PROVINSI KALIMANTAN SELATAN

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Abstract: This study aims to assess the level of vulnerability to forest and land fires in Kabupaten Tanah Laut and provide recommendations for preventing these fires, particularly in high-risk areas. This study uses a mix of quantitative and qualitative methods. The quantitative method maps the vulnerability to forest and land fires spatially, while qualitative methods with descriptive analysis provide recommendations for preventing forest and land fires in Kabupaten Tanah Laut. The study's results indicate that Kabupaten Tanah Laut has the highest level of vulnerability to forest and land fires, covering an area of 217,211.08 hectares, or 56.51% of the total area. Input recommendations for preventing forest and land fires are carried out by involving various steps, one of which is conducting a depth interview with the Manggala Agni service and the sub-district head in Kabupaten Tanah Laut regarding the Patrol SOP carried out to prevent forest and land fires.

Keywords: Kabupaten Tanah Laut, Forest and Land Fires, Vulnerability, Mapping

INTRODUCTION

Indonesia is a country with the greatest vulnerability to natural disasters (Mujayanah and Fadilah, 2019). F orest and land fires, commonly known as karhutla, are the most frequent disasters in this country. Karhutla seems to occur every year in various regions in Indonesia, with varying degrees of severity. The increasing level of karhutla in Indonesia has the potential to cause additional problems in the environmental, social, and economic fields both domestically and in neighboring countries (Widayati & Effendi, 2021).

Karhutla is an event that ignites forests and land, causing significant damage. The Indonesian forest fires of 1997–1998 burned an area of 11.7 million hectares. Kalimantan saw the largest fire, burning 8.13 million hectares in total, followed by Sumatra, Papua, Sulawesi, and Jawa, each with 2.07 million, 1 million, 400 thousand, and 100 thousand hectares (Sri Suryani, 2012). The National Disaster Management Agency (BNPB) data reveals that Kalimantan Selatan, with 2,341 karhutla disaster incidents in the last five years, ranks 4th out of 38 most affected regions.

Kalimantan Selatan experienced a similar disaster in 2023 at 13 locations with an affected area of 31,095.95 hectares. Information (Kumalawati, R., Dianita, A., and Elisabeth, E., 2019) Kabupaten Tanah Laut has a very high vulnerability to forest and land fires considering that there are 11 sub-districts in Kabupaten Tanah Laut (Suci, 2022).

The forest fire incident that occurred in 2022 reached the highest level of severity in Kabupaten Barito Kuala, with an affected area of 212 hectares, and in Kabupaten Tanah Laut, an area of 18 hectares. The following year, from January to December, the area affected by the Kabupaten Tanah

Laut forest fire expanded to 31,095.95 hectares. Utilizing remote detection technology is considered important in prevention efforts to find signs of disaster (Clark and Boblle, 2007).

According to Pualilin et al. (2019), strategies to prevent forest and land fires include determining the level of disaster vulnerability. Variables such as certain fuel conditions, climate, and human activities can significantly influence the increase of similar cases. Planning for disaster-prone areas should allow for the use of new technologies in remote detection and geographic data frameworks (Rianawati, 2016).

Table 1. The Area of Forest and Land Fires in Kalimantan Selatan in 2022 to 2023

No	Regency	Area of Burned Land (hectares)	
		2022	**2023**
1	Balangan	5.00	1,040.33
2	Banjar	34.00	49,529.82
3	Barito Kuala	212.00	22,027.55
4	Hulu Sungai Selatan	0	33,031.51
5	Hulu Sungai Tengah	0	3,390.38
6	Hulu Sungai Utara	0	10,710.36
7	Kota Banjarbaru	0	5,893.69
8	Kota Banjarmasin	0	103.46
9	Kotabaru	156.00	2,421.95
10	Tabalong	0	705.79
11	Tanah Bumbu	0	3,611.66
12	**Tanah Laut**	**18.00**	**31,095.95**
13	Tapin	3.00	26,832.15
	Total	428.00	190,394.60

Source :https://sipongi.menlhk.go.id/

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According to Pualilin et al. (2019), strategies to prevent forest and land fires include determining the level of disaster vulnerability. Variables such as certain fuel conditions, climate, and human activities can significantly influence the increase of similar cases. Planning for disaster-prone areas should allow for the use of new technologies in remote detection and geographic data frameworks (Rianawati, 2016). According to PPI Directorate General Regulation No. 6 P. 2021, the Ministry of Environment and Forestry determines the weight value of each forest and land fire vulnerability estimate by recalculating the total research for each typology. We then determine this weight value through a verification analysis using real forest and land fire areas that occurred from 2015 to 2020 (KLHK, 2021).

Table 2. Classification of Forest Fire Prone Typology

Province	Typology	Province	Topology
Aceh	1	Banten	3
Gorontalo	1	Bangka Belitung	3
Maluku	1	Jambi	3
Maluku Utara	1	Bengkulu	3
Nusa Tenggara Barat	1	Jawa Barat	3

Province	Typology	Province	Topology
Nusa Tenggara Timur	1	Jawa Tengah	3
Sulawesi Utara	1	Kalimantan Barat	3
Sulawesi Barat	1	Kalimantan Tengah	3
Sulawesi Tengah	1	Kalimantan Timur	3
Sulawesi Tenggara	1	Kalimantan Utara	3
Jakarta	2	Papua	3
DIY Yogyakarta	2	Papua Barat	3
Bali	2	Sumatra Utara	3
Jawa Timur	2	Sumatra Barat	3
Kalimantan Selatan	**2**	Sumatra Selatan	3
Lampung	2	Sulawesi Selatan	3
Kepulauan Riau	2	Riau	4

Source: PPI Directorate General Regulation No. 6 P., 2021 (KLHK, 2021)

Using a cluster analysis approach, we identified four forest and land fire vulnerability typologies: typology 1, typology 2, typology 3, and typology 4. This typology grouping enhances the homogeneity of the study area, leading to more accurate estimation of forest and land fire vulnerability and more efficient management of forest and land fires. Kalimantan Selatan is included in typology 2, and the variables and weights used for mapping forest and land fire vulnerability in typology 2 are as follows:

Table 3. Parameters and weights in typology 2

No	Variables	Weight (%)
1	Land Cover	40(%)
2	Rainfall	20(%)
3	Elevation	15(%)
4	Forest Area	25 (%)

Source: PPI Directorate General Regulation No. 6 P.2021 (KLHK, 2021)

Innovations in geographic data frameworks and remote detection can handle forest and land fire disasters. The development of geographic data frameworks and remote detection, which provide geographic data to the community to help reduce damage, especially in forest and land fire disasters, has made handling forest and land fire disasters more efficient and accurate (Yayan, Purwanto, and Nugraha, 2019). Planning for areas prone to forest and land fires should utilize geographic data framework innovations and check areas that may experience problems (Pualilin, Y., Tjoneng, A., and Abdullah, A., 2019)

We expect this mapping to provide a clear picture and assist in making effective policies to deal with forest and land fire disasters. Given the aforementioned background, it is crucial to conduct research on mapping the level of vulnerability to forest and land fires in Kabupaten Tanah Laut, Provinsi Kalimantan Selatan. The purpose of this study is to identify the location of hotspots in Kabupaten Tanah Laut and determine areas with low, medium, high, and very high levels of vulnerability. Additionally, this study seeks to offer suggestions for implementing prevention strategies at various levels of vulnerability.

LITERATURE REVIEW

Setiawan (2018), ICA (International Cartographic Affiliation), states that a map is a visual representation or depiction of the dynamic appearance of the outermost layer of the earth and celestial objects, usually represented on a small level or plane. According to (Setiawan, D., et al., 2018), a map communicates a small image of the world's surface on two layers of paper or media. Maps present data about the world's surface (for example: distribution of vegetation, waterways, roads, settlements, geology, and so on). An image depicts this data. Maps are an essential idea and the essence of geological science (Angriani, P., Adyatma, S., Rahman, MA, and Saputra, NS, 2020).

Forest and land fires are natural disasters that often occur in Indonesia, especially during the dry season. These fires cause enormous environmental damage, economic losses, and social problems. In the 1980s, Indonesia gained global attention due to recurrent forest and land fires. The forest and land fire disaster continued to hit Indonesia in 1997–1998, reaching 10 million hectares of affected areas. In 2015, forest and land fires occurred again, sweeping an area of 2 million hectares, causing losses of around 221 trillion rupiah (Tacconi, 2003 in Tohir, and Pramatana, 2020).

Both Sumatra and Kalimantan are regions rich in peat. Eastern Sumatra's coast is home to peat, which then extends to the south and west of Kalimantan. Despite the mounds' ability to store a significant amount of water, their surfaces can quickly dry out, making them vulnerable to fire during the dry season. Land clearing for agricultural and plantation purposes, along with the absence of sustainable peatland planning, is the primary cause of land fires in Indonesia.

According to Arisanty, D., Haris, MA, and Kumalawati, R., (2017) various factors, both natural and man-made, often lead to the failure of handling forest and land fires. The condition of the fuel, with its low water content, makes it susceptible to forest and land fires. Another factor that complicates fire management is the challenge of obtaining fuel. It is hoped that an understanding of these components will help improve the way to handle and prevent forest and land fires.

Forest and land fires in Indonesia often occur due to human carelessness or large-scale land clearing carried out by plantation organizations and forest rangers who violate the law, such as village and plantation organizations, forest ranger services, and others, some of which occur naturally (Qodriyatun, 2014). According to Mubarak, Z., Kumalawati, R., and Adyatama, S, (2021) peatland and forest fires can be caused by various factors during the dry season, such as natural events, activities of plantation organizations, and unintentional human negligence. For example, daily activities such as burning cigarette areas or deliberately clearing land can cause fires. Some of the causes of detrimental forest and land fires include environmental conditions, types of land cover, soil properties, financial factors, and approaches to increasing human collaboration with land and forests.

Vulnerability is a geographical, hydrological, climatological, social, cultural, political, economic, and technological condition or characteristic that reduces the ability to prevent, mitigate, achieve readiness, and respond to certain hazards (Law No. 24 of 2007). The level of vulnerability is a measure that indicates how likely or small a region or area is to experience a disaster. Vulnerability to forest and land fires is the result of a combination of various factors that influence the occurrence of forest and land fires and fire behavior, such as fuel, weather, topography, and fire sources. The term "disaster prone" refers to specific conditions or characteristics in an area at a specific time, encompassing various geological, biological, climatological, geographical, hydrological, economic, cultural, technological, and political elements. This condition can reduce the ability to avoid, mitigate, prepare for, and respond to the adverse effects of certain hazards (Law of the Republic of Indonesia No. 24 of 2007 concerning Disaster Management, Article 14).

Table 4. Assessment of land and forest vulnerability parameters weighting

No	Parameter	Weight (%)
1	Land Cover	40 (%)
2	Rainfall	20 (%)
3	Elevation	15 (%)
4	Forest Area	25 (%)

Source: KLHK, 2021

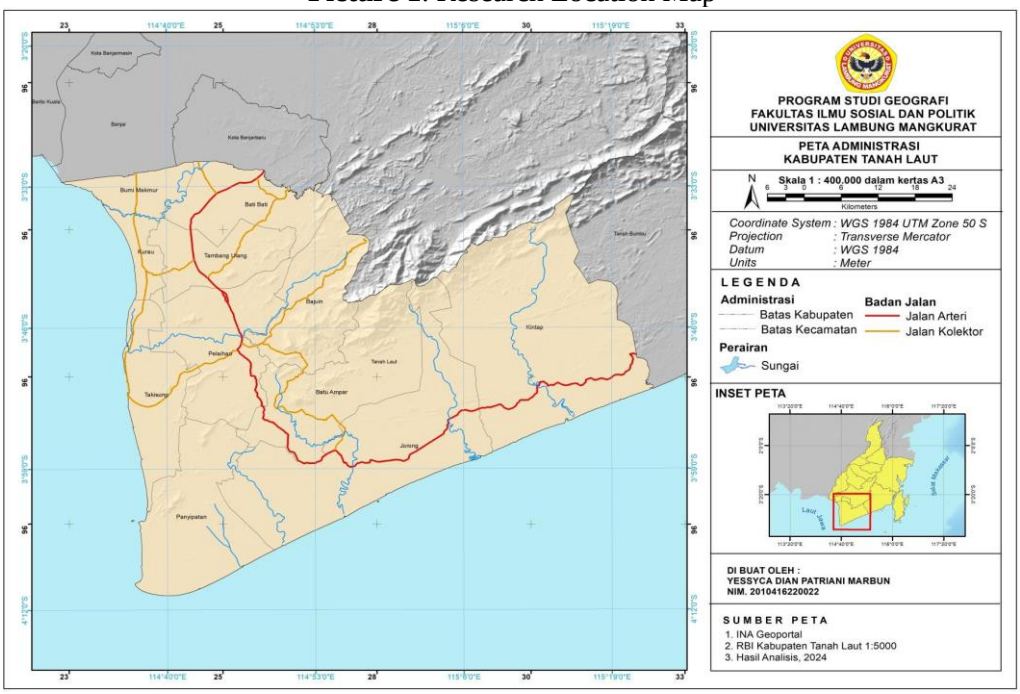
Forest and Land Fire Hazard Maps must have basic and thematic features, according to thematic map cartographic standards (KLHK, 2021). The preparation of a forest and land fire hazard map involves the preparation of parameters, variables, and weight values for each variable. The variables in question are values that describe

population characteristics, such as the mean value of the frequency or area of forest and land fire incidents and their diversity or standard deviations, which are referred to as parameters on this hazard map. The mean value and standard deviation of forest and land fire incidents or areas can be used as a benchmark for the size of forest and land fire uncertainty (KLHK, 2021).

RESEARCH METHODS

This research focuses on the analysis of two methods, known as mixed methods. (Rachman, A., et al., 2024) define mixed methods as a research method that simultaneously combines two research methods, namely quantitative and qualitative, in a research activity to obtain valid, comprehensive, objective, and reliable data. The location of this research was conducted in Kabupaten Tanah Laut, Provinsi Kalimantan Selatan. Kabupaten Tanah Laut has an area of 384,349.49 ha. Physiographically, Tanah Laut is located between 114º30'20" to 115º23'31" East Longitude and 3º30'33" to 4º11'38" South Latitude and consists of 11 (eleven) districts, namely Takisung, Panyipatan, Kintap, Bumi Makmur, Bati-Bati, Bajuin, Batu Ampar, Jorong, Kurau, and Tambang Ulang.

Picture 1. Research Location Map



Source: Data Processing, 2024

The entire burned area from the Karhutla mapping in Kabupaten Tanah Laut, as observed from the hotspots from 2019 to 2023, served as the sample for this study. (Sugiono, 2018). The complete burned region identified in the Karhutla mapping of Kabupaten Tanah Laut, based on hotspots from 2019 to 2023, constituted the sample for this study. The Prediction of Worldwide Energy Resources (Nasa Power) supplied the rainfall map for 2014–2024, the Provinsi Kalimantan Selatan Forestry Service delivered the forest area map for 2021, the South Kalimantan Provincial Forestry Service provided the land cover map for 2022, and the DEM data furnished the elevation map.

The research participants employed purposive sampling approaches in this qualitative methodology. Purposive sampling is a data collection method that selects certain samples according to the research objective. This evaluation is conducted to ensure that the selection of the informant is precise, encompassing a clear comprehension of the inquiries posed and their intended meaning, thereby facilitating research aligned with the subject under investigation by the author (Sugiyono, 2019).

Researchers employ purposive sampling to pick samples based on certain criteria; the informants in this study are pivotal and possess pertinent expertise regarding the execution of forest and land fire protection actions in the region. The participants in this study included the Head of DAOPS Manggala Agni Kalimantan VI/Tanah Laut, the Commanders of Squads 1, 2, 3, and 4 of DAOPS Manggala Agni Kalimantan VI/Tanah Laut, as well as the Heads of the following districts: Kecamatan Bati Bati, Kecamatan Batu Ampar, Kecamatan Bumi Makmur, Kecamatan Jorong, Kecamatan Panyipatan, Kecamatan Pelaihari, Kecamatan Tambang Ulang, and Kecamatan Tankisung. This study used an in-depth interview tool, also known as a depth interview.

This interview instrument did not undergo validity and rehabilitation tests, as the study employs semi-structured interviews that are conducted with greater flexibility (Sugiyono, 2017). This interview guide employs two tactics: mapping strategies and strategies for information dissemination, socialization and counseling, education or training, and early warning (Natalia et al., 2021) Kooten strategies, specifically organizational, programmatic, resource-based, and institutional strategies (Achyar, 2023). This study utilizes quantitative analytic methods like scoring, weighting, and overlay. Each assessment variable is appraised according to the degree of influence the research variable exerts on Karhutla. Higher risk correlates with increased value. Assessing the nature of fire risk enables us to categorize the degree of fire susceptibility. This study utilizes qualitative analysis through a SWOT framework to develop recommendations for the prevention of forest and land fires. The principal reference is the Regulation of the Director General of Climate Change Control No. P.12/Ppi/Set/Kum.1/12/2020, which delineates the Standard Operating Procedures (SOP) for the management of forest and land fires.

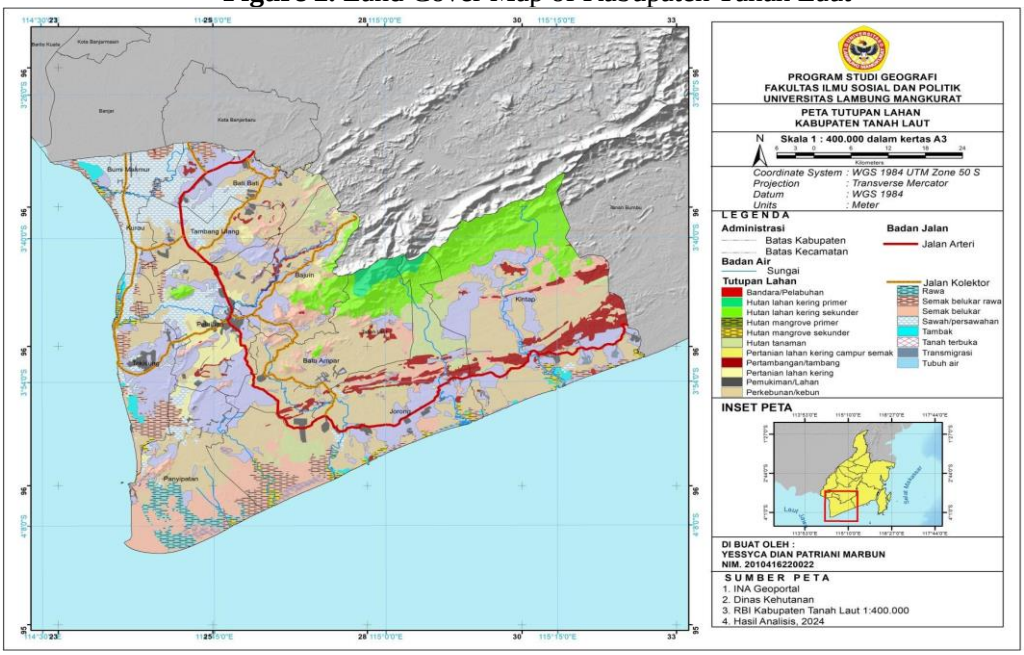
RESULTS AND DISCUSSION

This study employs four variables to assess the sensitivity to forest and land fires in Kabupaten Tanah Laut: land cover, precipitation, elevation, and forest area. The study on delineating regions susceptible to forest and land fires in Kabupaten Tanah Laut produced the following findings based on these variables.

1. Land Cover

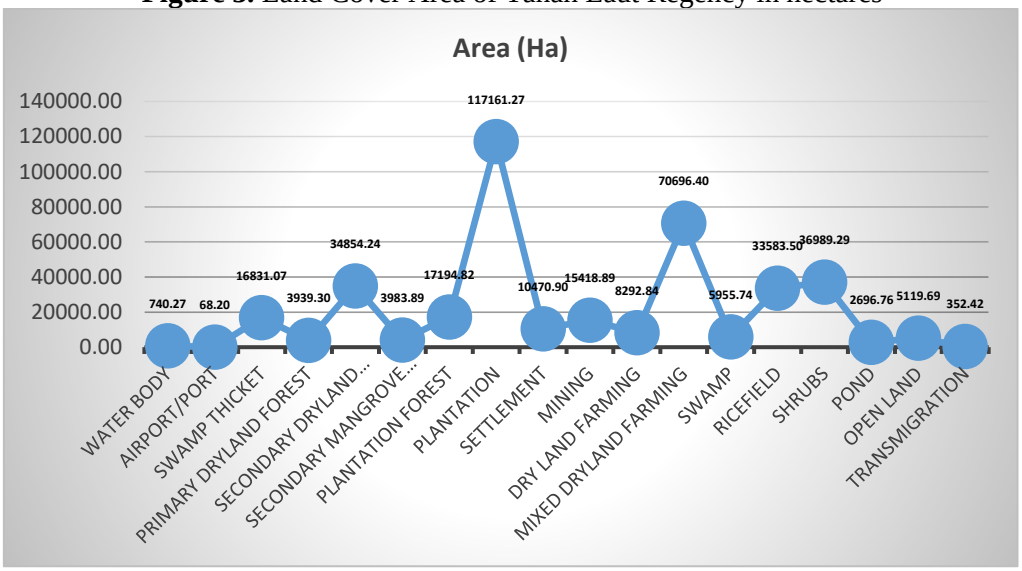
Forest and land fire vulnerability maps utilize a score and weight system for land cover. The following image displays the land cover map:

Figure 2. Land Cover Map of Kabupaten Tanah Laut



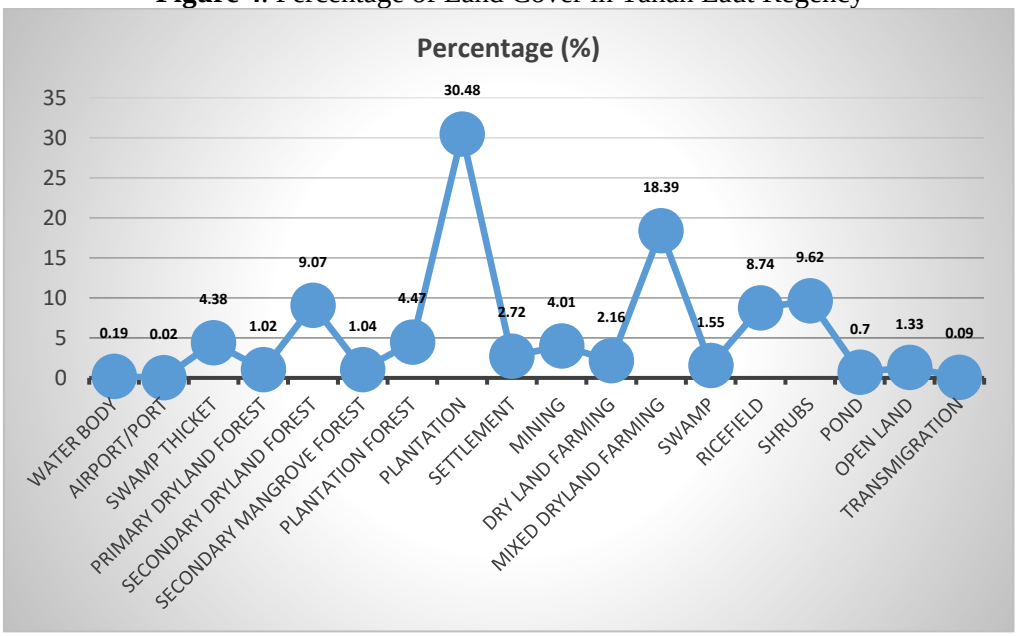
Source: Data Processing, 2024

Figure 3. Land Cover Area of Tanah Laut Regency in hectares



Data Processing, 2024

Figure 4. Percentage of Land Cover in Tanah Laut Regency



Data Processing, 2024

Land cover is a visualization of vegetation, natural elements, and culture found on the earth's surface. Land cover is a biophysical cover on the earth's surface that can be observed and is the result of human regulation, activity, and treatment of certain land cover to carry out production activities, maintenance, or changes in the area (Gifari et al., 2023). The dynamic nature of this land cover necessitates its annual update. When compiling or updating the latest land cover map, use remote sensing imagery to identify the lands that have received special business permits. Significantly changed areas can benefit from updating spatial land cover data. Despite its indicative nature, the delineation of these areas remains valid (KLHK, 2021).

Land cover has a score and weight that are used in making a map of forest and land fire vulnerability in Kabupaten Tanah Laut; the score, weight, and area of land cover in Kabupaten Tanah Laut can be seen as follows (table 5).

Table 5. Scores, Weights and Area of Land Cover in Kabupaten Tanah Laut

Land Cover	Area (Ha)	Score	Weight
Primary dryland forest, Primary mangrove forest, Open land, Water bodies, Fishponds, Airports/Ports	12564.21	1	
Settlement, Secondary mangrove forest, Transmigration, Mining	30226.10	2	
Secondary dryland forest, Plantation forest,	52049.05	3	40%
Shrubs, dry land farming, dry land farming mixed with shrubs	115978.53	4	
Plantation/gardens, Swamp scrub, Rice fields, Swamp	173531.59	5	

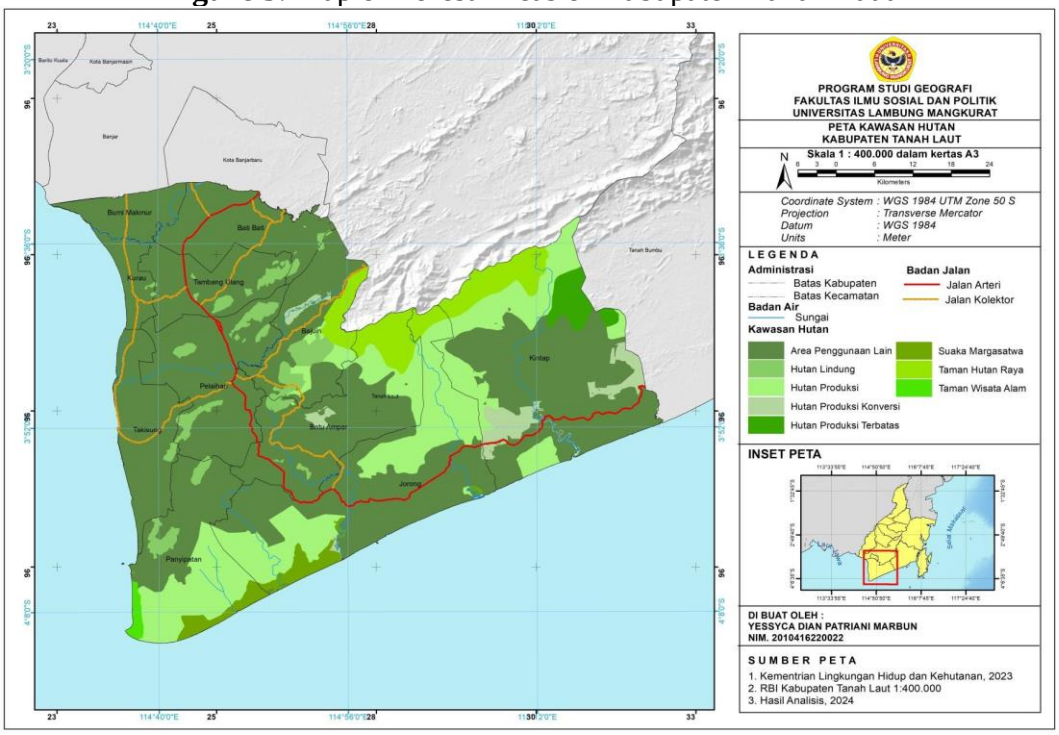
Data source: data processing, 2024

2. Forest Area

The forest regions of a region are integral to the respective province, district, or city, hence provincial and district/city spatial planning strategies will substantially influence the forest's sustainability. As stated by Erni Mulyanie (2016), nature conservation forest areas possess distinct attributes aimed at protecting life support systems, conserving biodiversity of flora and fauna, and fostering the sustainable utilization of natural biological resources and their ecosystems.

Conversely, hunting parks are wooded regions explicitly allocated for hunting tourism activities. The government has designated specific regions as permanent forests for preservation. The Ministry of Environment supplied the data for the forest area maps in this study in 2021. The subsequent figure illustrates the Forest Area Map of Kabupaten Tanah Laut.

Figure 5. Map of Forest Areas of Kabupaten Tanah Laut



Source: Data Processing, 2024.

Forest Areas in Kabupaten Tanah Laut are divided into several classifications. The following is the area of Forest Areas in Kabupaten Tanah Laut:

Table 6. Area of Forest Area in Kabupaten Tanah Laut

Types of Forest Areas	Area (Ha)	(%)
Other Areas of Use	259153.23	67.43
Protected forest	13688.39	3.56
Production Forest	70155.16	18.25
Conversion Production Forest	8788.74	2.29
Limited Production Forest	5235.57	1.36
WIldlife reserve	6853.35	1.78
Forest Park	19102.18	4.97
Nature Tourism Park	1372.87	0.36
Total	**384349.49**	**100.00**

Source: MenKLHK, 2023

Based on the above table, the forest area that dominates the land in Kabupaten Tanah Laut is the Other Use Area. The other use areas in Kabupaten Tanah Laut have an area of 259,153.23 hectares, or 67.43% of the area. Each sub-district contains a variety of other use areas. This suggests that Kabupaten Tanah Laut prioritizes other use areas, with the Nature Tourism Park occupying the smallest area at 1372.87 hectares, or 0.36% of the total area. Maps of forest and land fire vulnerability use scores and weights specific to forest areas. The following table displays the area, score, and weight of forest areas.

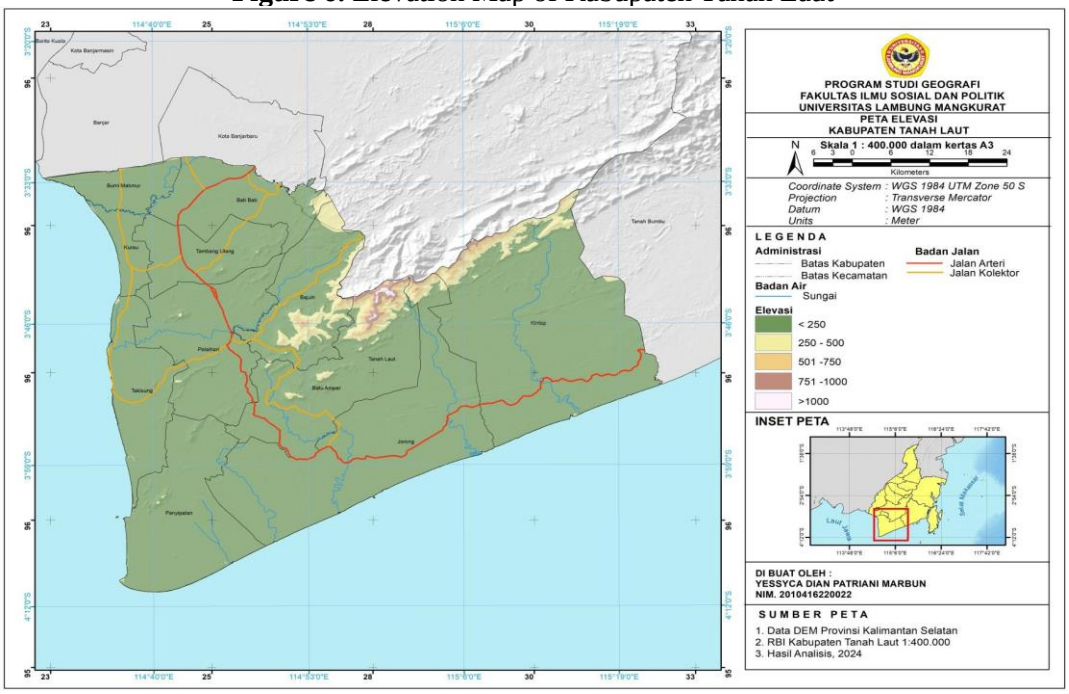
Table 7. Score and weight and area of forest area in Kabupaten Tanah Laut

Forest Area	Area (Ha)	Score	Weight
National Parks	0	1	25%
Grand Forest Park, Nature Tourism Park, Limited Production Forest, Nature Reserve Area	25710.61	2	
Wildlife reserve	6853.35	3	
Production Forest, Protected Forest	83843.55	4	
Other Use Areas, Conversion Production Forest	267941.97	5	

Data source: data processing, 2024

3. Elevation

Figure 6. Elevation Map of Kabupaten Tanah Laut



Source: Data Processing, 202

An elevation surface layer is a composite layer that represents the surface of the land or other specific surface. The elevation surface layer establishes elevation values throughout the entire map area or displayed landscape. One or more elevation source layers compose an elevation surface layer, which contributes elevation values to the display. People also commonly use elevation to describe the vertical distance of an object or point from a reference level, typically the ground or sea surface. Forest and land fire vulnerability maps use an elevation (place height) score and weight.

The following image displays the elevation map pay attention to Figure 5. Based on the processed DEM data, the elevation or height of places in Kabupaten Tanah Laut is divided into several classifications according to KLHK, 2021. Based on the table above, the height of a place in Kabupaten Tanah Laut is defined as an area with an altitude of less than 250 meters above sea level. The altitude <250 in Kabupaten Tanah Laut has an area of 362267.5 hectares, or 94.25% of the area. The following are the elevations or heights of places in Kabupaten Tanah Laut:

Table 8. Elevation Area in Kabupaten Tanah Laut

No	Elevation	Area (Ha)	Percentage (%)
1	<250	362267.5	94.25
2	250-500	15103.2	3.93
3	501-750	4444.57	1.16
4	751-1000	2157.83	0.56
5	>1000	376.35	0.10
	Total	384349.49	100.00

Source: Data processing, 2024

Based on the table above, the height of a place in Kabupaten Tanah Laut is defined as an area with an altitude of less than 250 meters above sea level. The altitude <250 in Kabupaten Tanah Laut has an area of 362267.5hectares, or 94.25% of the area. Areas with lowlands <250 meters above sea level are spread across each sub-district with varying areas, and the altitude with the smallest area in Kabupaten Tanah Laut is the altitude with an altitude > 1000 meters above sea level, which is in several sub-districts and only has 376.36 hectares or 0.10% of the area. Forest and land fire vulnerability maps use elevation's score and weight. The following table displays the area, score, and elevation weight.

Table 5. Score and weight and area of elevation in kabupaten Tanah Laut

Elevation	Area (Ha)	Score	Weight
0 - <250 masl	362267.54	5	25%
250 - <500 masl	9477.16	4	
500 - <750 masl	4444.57	3	
750 - <1000 masl	2157.83	2	
>1000 masl	376.35	1	

Data source: KLHK, 2021

4. Average Rainfall

Average rainfall is defined as the amount of water that falls on the ground surface in a certain period measured above the horizontal surface in millimeters (Firdaniza et al., 2016). In the interim, rainfall intensity is defined as the volume or height of rainfall per unit of time. The intensity of rainfall is contingent upon the frequency of occurrence and the duration of the rainfall (Febriani., et al., 2019). Indonesia boasts diverse rainfall due to the presence of areas with varying altitudes.

A rainfall of 1 mm is equivalent to the accumulation of water with a height of 1 mm in a 1 m2 flat area. In this case, the water is accumulated at a height of 1 mm or 1 liter (Triatmodjo, 2008).

The average rainfall in Kabupaten Tanah Laut was determined by utilizing monthly rainfall data from NASA POWER (Prediction of Worldwide Energy Resources) over a 10-year period from 2014 to 2023. Twelve observation points were employed in this calculation.

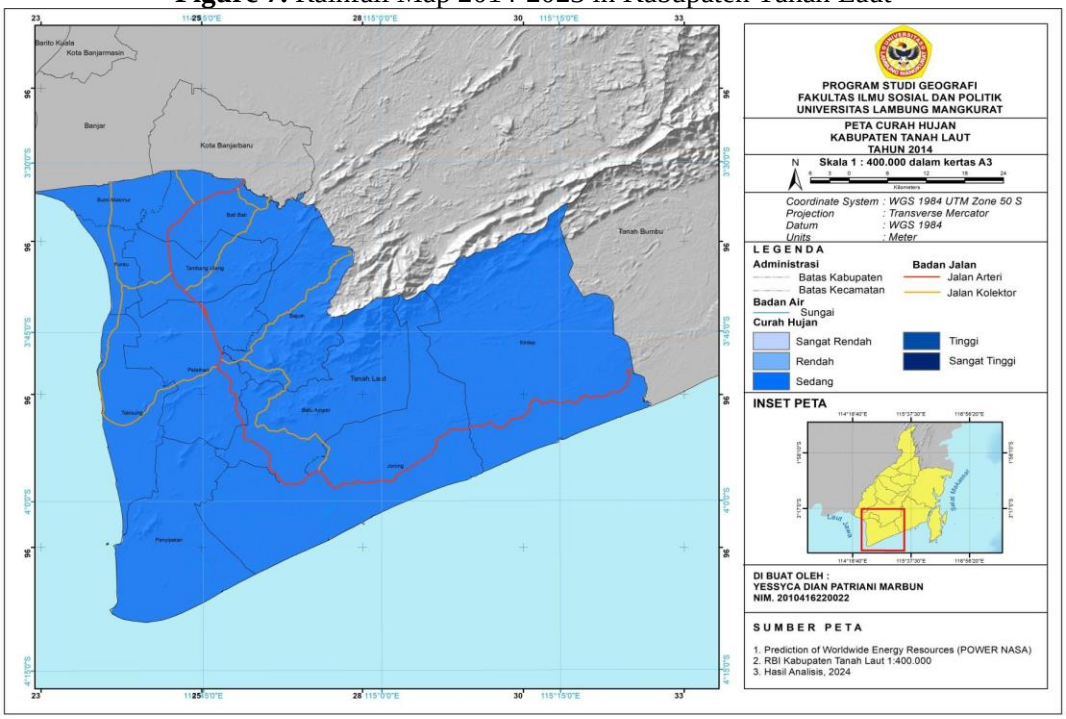
Table 6. Observation Coordinate Points

Observation Point	Latitude (Y)	Longitude (X)
P1	-3.25	114.25
P2	-3.25	114.75
P3	-3.25	115.25
P4	-3.25	115.75
P5	-3.75	114.25
P6	-3.75	114.75
P7	-3.75	115.25
P8	-3.75	115.75
P9	-4.25	114.25
P10	-4.25	114.75
P11	-4.25	115.25
P12	-4.25	115.75

Source: Nasa Power

The average annual rainfall intensity in Kabupaten Tanah Laut for the period 2014-2023 is 2637. Every year, Kabupaten Tanah Laut experiences 2637 mm of rainfall during each rainy season. High monthly rainfall intensity occurs when the rainy season comes, which is generally from October to March. Over a period of 10 years, in Kabupaten Tanah Laut, the highest rainfall intensity is in March with an average rainfall intensity of 342 mm/month. In March 2020, the rainfall intensity was the highest among other years, with a value of 8265 mm. The dry season experiences the lowest rainfall intensity, peaking in August and September. August is a dry month, and there is little rain with an average intensity value of 97 mm. In June, it rains with a medium rainfall intensity of 250 mm. The following image displays the rainfall map from 2014 to 2023

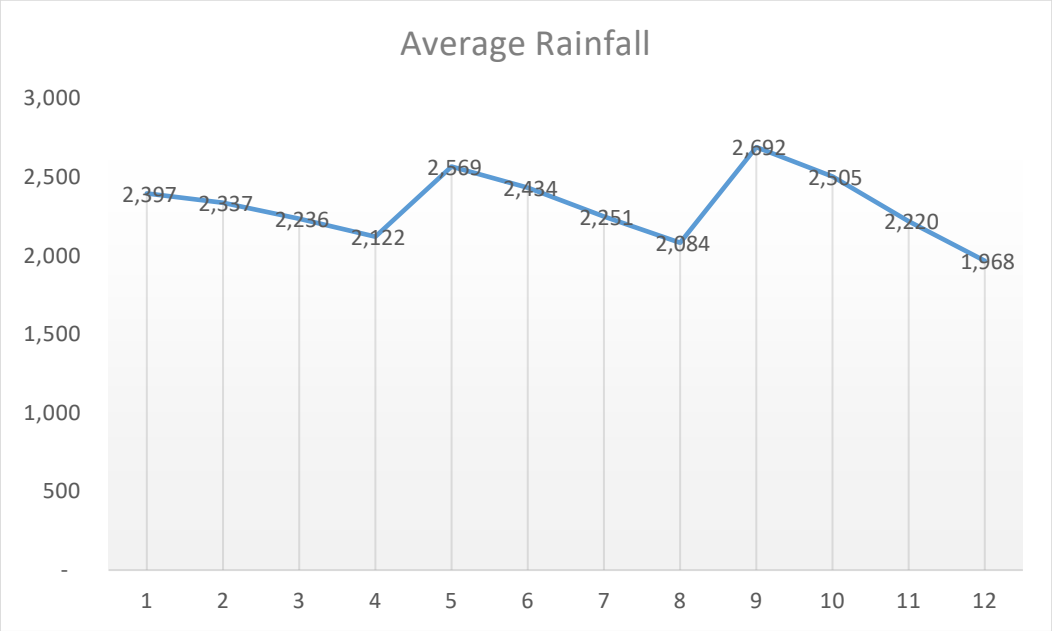
Figure 7. Rainfall Map 2014-2023 in Kabupaten Tanah Laut



Source: Data Processing, 2024

Every year the intensity of rainfall in a region will change as a result of climate change and global warming. This certainly impacts the amount of rain that falls each month. The following is a rainfall intensity graph in Kabupaten Tanah Laut in the last 10 years. Based on the average rainfall trend graph above, in the past 10 years, Kabupaten Tanah Laut has had fluctuating rainfall intensity from year to year. The lowest rainfall intensity occurred in 2019 with a rainfall of 1965.42 mm/year. However, at 3476.74 mm/year, 2020 was the wettest year in the past decade. When compared to previous years, 2020 showed a remarkable improvement. From 3289.94 mm/year to 2032.76 mm/year, the rainfall intensity decreased significantly in 2023. Varieties of rainfall intensity are observed in Kabupaten Tanah Laut on a monthly basis. Presented below are the rainfall intensities for each month throughout the last decade.

Figure 8. Average Rainfall Graph 2014-2023



Source: Data Processing, 2024

Forest and land fire vulnerability maps use a score and weight for rainfall. The following table displays the rainfall score and weight:

Table 7. Rainfall Score and Weight

No	Rainfall	Score
1	1000 - <1500 mm/yr	5
2	1500 - <2000 mm/yr	4
3	2000 - <2500 mm/yr	3
4	2500 - <3000 mm/yr	2
5	>3000 mm/yr	1

Source: MenKLHK, 2023

The weighted overlay method, as described by (Adininggar et al., 2016) s a spatial analysis that employs the overlay technique to analyze multiple maps related to factors that influence vulnerability assessment. This method utilizes raster data with pixels as the smallest unit, enabling scoring and weighting for each pixel with a unique value. By overlaying multiple raster data, a common measurement scale can be used, and each weight can be adjusted according to its specific needs (Aisy & Hermon, 2024).

The process of mapping the level of vulnerability to forest and land fires involves several parameters, including land cover, forest area, elevation, and rainfall. To unify these parameters, a weighted overlay is used, which involves overlaying several maps as parameters that influence the mapping analysis used (Tarkono et al., 2021).

The scoring method is the assignment of scores to the interval class for each parameter used; the scoring is based on the level of influence on the mapping results (Muzaki et al., 2022). his method will divide the results into four classes: very high, high, medium, and low. The following table displays the interval values for each class:

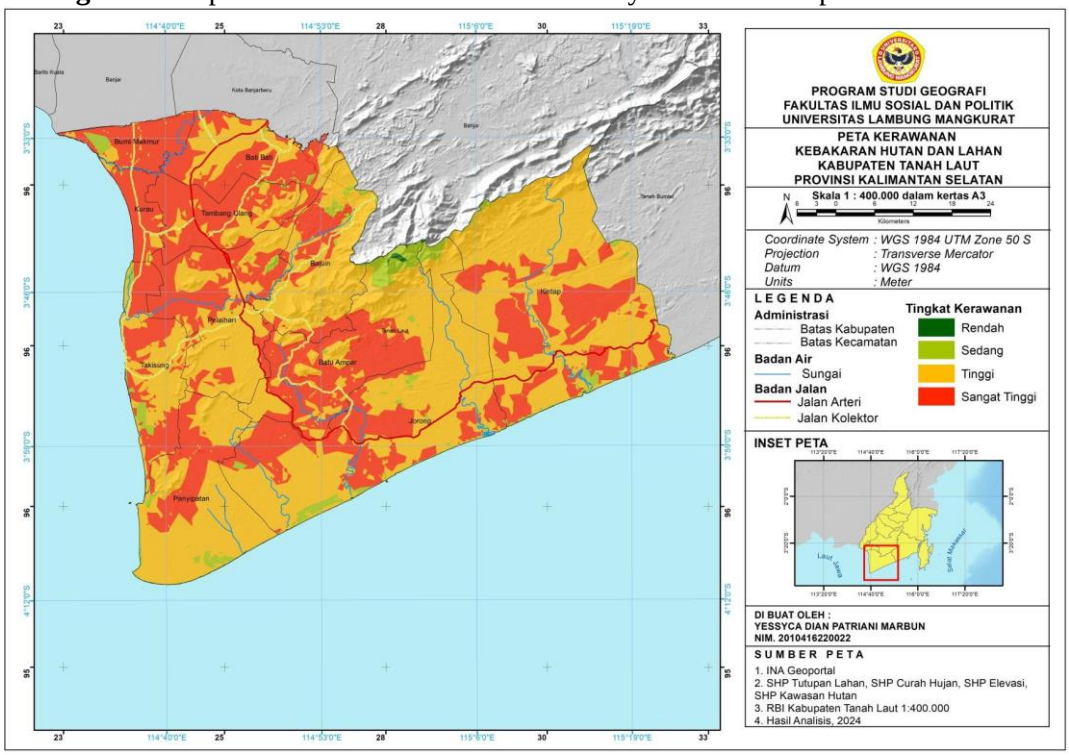
Table 8. Interval value of each vulnerability class

Vulnerability Interval Value (K)	Vulnerability Level
1 - < 2	Low
2 - < 3	Currently
3 - < 4	Tall
4 – 5	Very high

Source: Data processing, 2024.

The result of overlaying 4 variables, namely rainfall, land cover, forest area, and elevation, then obtained a map of forest and land fire vulnerability in Kabupaten Tanah Laut. The following image displays the map of forest and land fire vulnerability levels.

Figure 8. Map of forest and land fire vulnerability levels in Kabupaten Tanah Laut



Source: Data Processing, 2024

Kabupaten Tanah Laut tends to fall into the high and very high vulnerability levels. The largest area of the high vulnerability level is 217,211.08 Ha, or 56.51% of Kabupaten Tanah Laut's total area. The area of the very high vulnerability level is 151,255.98 Ha, or 39.35% of Kabupaten Tanah Laut's total area. The smallest area is the low vulnerability level, which covers 305.82 Ha, or 0.08% of Kabupaten Tanah Laut, while the moderate vulnerability level covers 15,576.61 Ha, or 4.05% of Kabupaten Tanah Laut. The following table displays the percentage of each level of forest and land fire vulnerability in Kabupaten Tanah Laut.

Table 9. Area of each level of forest and land fire vulnerability

No	Vulnerability Level	Area (Ha)	Percentage (%)
1	low	305.82	0.08
2	currently	15576.61	4.05
3	tall	217211.08	56.51
4	very high	151255.98	39.35
	Amount	**384349.49**	**100.00**

Source: Data processing, 2024

Each sub-district in Kabupaten Tanah Laut has its own level of vulnerability to forest and land fires.

Table 10. Area of Forest and Land Fire Vulnerability Level in Sub-districts in Kabupaten Tanah Laut

Subdistrict	Vulnerability Level				Area (Ha)
	Low	Currently	Tall	Very high	
Bajuin	0	1162,86	20196,75	7127,09	28486,7
Bati Bati	0	330,26	10518,67	12592,14	23441,07
Batu Ampar	299,43	3074,01	17753,86	20799,81	41927,11
Bumi Makmur	0	804,81	818,2	8852,23	10475,24
Jorong	6,38	3750,51	45347,58	20712,8	69817,27
Kintap	0	2852,51	57509,84	25374,05	85736,4
Kurau	0	89,32	826,09	5960,92	6876,332

Subdistrict	Vulnerability Level				Area (Ha)
	Low	Currently	Tall	Very high	
Panyipatan	0	1509,6	28013,16	9399,39	38922,15
Pelaihari	0	395,85	20598,72	15435,82	36430,39
Tankisung	0	1496,55	10225,15	10665,53	22387,23
Tambang Ulang	0	110,34	5403,06	14336,19	19849,6

Source: Data processing, 2024

There are 11 sub-districts in Kabupaten Tanah Laut, namely Bumi Makmur, Bati Bati, Kurau, Tambang Ulang, Takisung, Bajuin, Batu Ampar, Panyipatan, Jorong, and Kintap. Each sub-district exhibits varying levels of vulnerability to forest and land fires. The following table displays the level of vulnerability to forest and land fires in each sub-district

The table above explains that the largest subdistrict with the lowest level of vulnerability is Kecamatan Batu Ampar, with an area of 299.43 ha. The sub-district with the most extensive moderate vulnerability is Kecamatan Jorong, with an area of 3074.01 Ha, and the highest level of vulnerability is in Kecamatan Kintap, with an area of 57509.84 Ha. The very high level of forest and land fire vulnerability is in Kecamatan Kintap, with an area of 25374.05 Ha.

5. Recommendations for Forest and Land Fire Prevention in Kabupaten Tanah Laut

The presence of SWOT facilitates the evaluation of suggestions to improve the efficacy of the Standard Operating Procedure (SOP) for Forest and Land Fire Control Activities. This Standard Operating Procedure was established. The Standard Operating Procedure for Forest and Land Fire Control provides a framework for pertinent stakeholders to execute the necessary processes and protocols for managing forest and land fires. These measures encompass preventive, mitigation, post-management, human resource administration, and infrastructure oversight.

SWOT is a valuable instrument for comprehending the internal strengths and vulnerabilities, as well as the external opportunities and threats that an organization or team may encounter. The primary reference is the Regulation of the Director General of Climate Change Control No. P.12 / PPI / Set / Kum.1 / 12 /2020, which specifies the Standard Operating Procedure (SOP) for the management of forest and land fires. This regulation provides exhaustive guidelines to ensure the effective and efficient execution of operations to prevent, mitigate, and restore forest and land areas, from the preparation stage to the post-fire phase.

Conducting an in-depth SWOT analysis is necessary to make more precise decisions. SWOT analysis allows us to identify the internal strengths and weaknesses of the organization, as well as external opportunities and threats that can affect fire prevention efforts. Thus, the strategies developed will be more relevant to current conditions and able to minimize the risk of major fires and their negative impacts on the environment and society. The SWOT matrix provides a detailed description of opportunities and threats in the context of mapping the level of vulnerability to forest and land fires. It also provides recommendations for preventive measures and the management of forest and land fires, following the Standard Operating Procedure (SOP) for Forest and Land Fire Control Activities, which is implemented by the Ministry of Environment and Forestry, Directorate General of Climate Change Control.

SWOT Matrix The SWOT matrix allows us to identify our positions in four distinct squares, which we can then analyze directly to inform our decision-making process. The following image displays the SWOT diagram

Picture 9. SWOT diagram

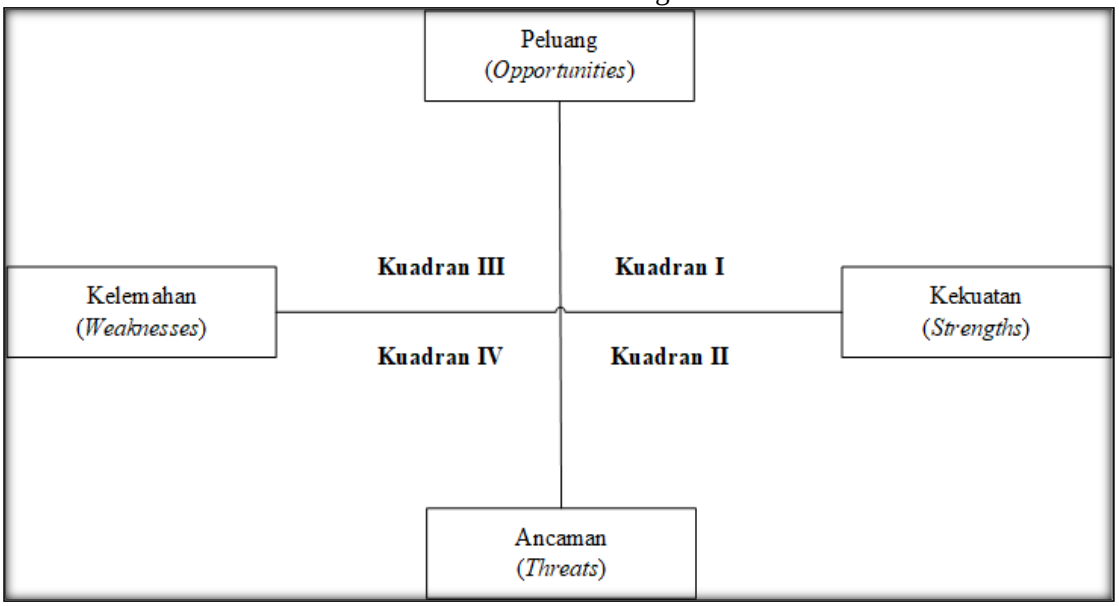


Table 11. SWOT Matrix

	Power (SO)	**Weakness (WO)**
Opportunity (ST)	This quadrant emphasizes the utilization of the internal strengths of the implementing team, such as good technical skills, qualified resources, and systematic SOPs, to take advantage of external opportunities such as technological support, availability of satellite data for mapping, and involvement of the community or related associations. development of a more sophisticated geographic information system (GIS) for mapping fire-prone areas, education of internal teams and the community, and tightening of regulations by the government in efforts to prevent forest and land fires.	This quadrant identifies opportunities that can be leveraged to address internal weaknesses, such as lack of resources or expertise in digital and automated mapping. Strategies may include partnerships with research institutions or universities for capacity building, or for mapping and early detection technologies.
Threat (WT)	This quadrant focuses on using power to address external threats, such as information about climate change and human activities that increase the risk of forest and land fires. Strategies may include increasing cross-sectoral and international cooperation to share best practices, increasing law enforcement against perpetrators of forest and land fires, and adapting advanced firefighting technologies.	This quadrant is in a position to face the dual challenge of internal weaknesses and significant external threats. Strategies here may require emergency actions, such as the adoption of strong cross-sectoral policies for forest and land fire control, building community-level preparedness and rapid response, and allocating specific resources to areas most at risk.

Source: Primary data processing, 2024

The findings from the depth interview conducted between researchers, the Manggala Agni Service, and the community, represented by the sub-district head in Kabupaten Tanah Laut, will serve as the basis for a SWOT analysis. The SWOT analysis produced multiple recommendations for the prevention of forest and land fires in this study.

Strengths Recommendations

a. Monitoring and controlling forest and land fires requires high technical expertise, good cooperation between various parties, and careful planning.
b. Field personnel need to have a thorough understanding of fire behavior and extinguishing techniques.
c. The government, communities, and non-governmental organizations (NGOs) should coordinate effectively, particularly through groups like fire-aware communities (MPA).
d. Having a clear organizational structure is the key to success in preventing and controlling forest and land fires.
e. Taking advantage of external opportunities such as technological support, availability of satellite data for mapping, and involvement of the community or related associations.
f. It performs maintenance on the provided facilities, making sure that, in addition to renewal, it also looks after the facilities that Manggala Agni owns.

Weaknesses Recommendations

a. Difficult geographical conditions and a lack of coordination between the sub-district government and the Manggala Agni service hindered the extinguishment efforts.
b. Low public awareness of the dangers of forest and land fires and a lack of outreach regarding fire prevention measures exacerbate the situation.
c. Weak law enforcement and lack of focus on education in standard operating procedures (SOPs) indicate weaknesses in long-term prevention aspects.
d. Improving coordination between various parties, including communities, companies, and the government, as well as regular performance evaluations are also key in efforts to reduce the risk of forest and land fires.
e. It is necessary to conduct outreach to the community and surrounding companies regarding the dangers of forest and land fires and the applicable sanctions.

Opportunities Recommendations

a. The existing Standard Operating Procedures (SOP) open up numerous opportunities in efforts to prevent and control forest and land fires (karhutla).
b. The development of technology such as drones and satellites, as well as the use of more sophisticated data processing applications, enables early detection and monitoring of forest and land fires more effectively.
c. Ongoing training for officers and education for the community are also key to increasing awareness and ability to prevent fires.
d. Governments and international organizations can provide financial support for the purchase of equipment and the development of capacity.
e. Manggala Agni should enhance its training in technology application and foster stronger collaboration with local governments and research institutions.
f. International partnerships can also be an additional resource for the development of mapping and early detection technologies.

Threats Recommendations

a. Reducing the potential for threats by creating policies to burden perpetrators of illegal land clearing and logging,
b. Tightening the law by monitoring the imposition of sanctions on perpetrators who are proven to have carried out land burning, then providing strict sanctions so that it is hoped that it can be an example that perpetrators of forest and land fires will be subject to severe sanctions.

c. Embracing the community in this case, MPA, by providing compensation for services rendered in this case will strengthen the relationship between Manggala Agni and MPA.
d. The government should involve private companies in improving the supervision and security of land and forest protection, given the significant potential for forest and land fires.
e. Together, we safeguard the ecosystem of flora and fauna, enabling prompt management and repair of any impacted areas.

CONCLUSION

The research conclusions, which are derived from the research results and analysis, are as follows. Each sub-district in Kabupaten Tanah Laut has a different level of vulnerability to forest and land fires. Table 4.82 reveals that the high category dominates the level of vulnerability to forest and land fires in Kabupaten Tanah Laut. The area with a high level of vulnerability reaches 217,211.08 hectares, followed by the very high category with an area of 151,255.98 hectares. The moderate category has a much smaller area, namely 15,576.61 hectares. Meanwhile, the low category is only found in Kecamatan Batu Ampar and Jorong with a total area of 305.82 hectares. These results indicate that most areas in Kabupaten Tanah Laut have a fairly high risk of forest and land fires.

The analysis provides recommendations for forest and land fire prevention. The analysis of forest and land fire prevention highlights the importance of community participation in prevention efforts. Intensive socialization and involving the community in patrol and extinguishing activities can increase awareness and collective responsibility in protecting the environment. Strict law enforcement, which imposes severe sanctions on land burning perpetrators, is also crucial. To prevent forest and land fires, law enforcement officers and the community must continuously improve their supervision and close cooperation.

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