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Spatial analysis of drought-prone locations using geographic information systems in Hulu Sungai Utara Regency

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ABSTRACT

Hulu Sungai Utara Regency is one of the regions in South Kalimantan Province that has a high potential for drought disasters due to the influence of climate variability, the relatively flat physical condition of the region, and limited spatial information regarding drought-prone areas. The absence of accurate vulnerability maps has resulted in mitigation efforts not being optimal. This study aims to map the level of drought vulnerability in Hulu Sungai Utara Regency and identify the main factors that influence it. The method used is a Geographic Information System (GIS)-based spatial analysis with a weighted overlay technique using the Analytical Hierarchy Process (AHP) method. The parameters analyzed include slope gradient, land elevation, rainfall, soil type, land cover, river density, vegetation index (NDVI), wetness index (NDWI), and land surface temperature (LST). The results show that most areas of Hulu Sungai Utara Regency are categorized as moderately drought-prone with a percentage of 95.361%, while the non-vulnerable category only covers 4.639% of the area, and no highly vulnerable areas were found. The most influential factor on drought vulnerability is rainfall, followed by NDWI and NDVI. It is hoped that the resulting vulnerability map can be the basis for mitigation planning and sustainable water resource management.

INTRODUCTION

Indonesia is strategically located in the tropical region between the Asian and Australian continents and between the Pacific and Indian Oceans. Its location around the equator, flanked by two continents and two oceans, makes Indonesia vulnerable to climate variability. Indonesia's climate is strongly influenced by natural phenomena such as the El Niño-Southern Oscillation (ENSO) (Mas'oed et al., 2024). The El Niño and Dipole Mode (+) phenomena cause decreased rainfall in several regions in Indonesia. Rainfall in Indonesia is influenced by several large-scale climate phenomena, including the Madden-Julian Oscillation, the El Niño-Southern Oscillation (ENSO), and the Indian Ocean Dipole. These climate modes influence rainfall variability across Indonesia, with stronger ENSO influences generally observed in eastern Indonesia compared to western regions (Ariska et al., 2023).

Drought is a natural hazard that often occurs during dry periods in regions with limited water availability. It develops slowly over time and is commonly described as a slow-onset disaster that continues until sufficient rainfall restores water availability (Contreras et al., 2020). Drought is a serious problem in Indonesia, as it can lead to forest and land fires. The potential for drought hazards occurs in various regions in Indonesia, including South Kalimantan. Hulu Sungai Utara Regency is one of the regencies in South Kalimantan province with drought potential, covering an area of 89,270 hectares, which is categorized as moderate. Although categorized as moderate, the potential for forest and land fires is categorized as high, covering an area of 80,613 hectares. Drought hazard is assessed based on meteorological factors and the soil's ability to retain water (Direktorat Pemetaan dan Evaluasi Risiko Bencana, 2021).

Hulu Sungai Utara Regency still lacks information on the distribution of drought-prone areas. This lack of information contributes to the impediment to drought resolution. Identifying drought-prone areas is crucial to preventing broader impacts. Therefore, it is necessary to identify drought-prone areas using several influencing parameters, such as rainfall, hydrogeological conditions, and land use. Therefore, Hulu Sungai Utara Regency needs to map drought-prone areas through spatial analysis using Geographic Information Systems. Geographic Information Systems (GIS) are the most advanced technology for data acquisition, verification, compilation, storage, updating, management, retrieval, processing, analysis, and presentation of geographically referenced spatial data (Ahmed, 2021). Geographic Information Systems (GIS) enable detailed spatial mapping and analysis of areas vulnerable to drought. By integrating environmental variables such as climate data, land use, and topographic conditions, GIS can help identify regions that should be prioritized in drought mitigation and management strategies (Senamaw et al., 2021).

A database in a geographic information system consists of a collection of interconnected data that includes spatial data and attribute data. Spatial data represents the location of objects on the Earth's surface and is usually expressed in a geographic coordinate system, such as latitude and longitude. This data is used in GIS to store, manage, and analyze geographic information, while attribute data provides descriptive information about the objects represented on the map (Khot & Srivas, 2018). Spatial data in a geographic information system is generally represented using three fundamental vector types: points, lines, and polygons. These spatial features are organized into map layers and linked to attribute tables that contain descriptive information such as statistical, numeric, or textual data about each feature (Ongley et al., 2015). This study aims to determine the distribution map of potential drought hazards and their mitigation in Hulu Sungai Utara Regency.

METHODS

This research was conducted in Hulu Sungai Utara Regency, South Kalimantan Province. Astronomically, Hulu Sungai Utara Regency is located at 02°17’31” North Latitude and 02°33’31” North Latitude, and between 114°50’58” East Longitude and 115°24’13” East Longitude. Hulu Sungai Utara Regency has a land area of approximately 892.70 km². Based on its elevation, this area has an altitude of approximately 7.44 meters above sea level. As of the end of 2020, Hulu Sungai Utara Regency consisted of 10 sub-districts within its administrative area. Primary data in this study were obtained through surveys, interviews, or direct observation. Questionnaires were conducted with experts in the government and academic fields. Primary data were then analyzed using the Analytical Hierarchy Process (AHP) method. The secondary data required in this study are rainfall data for Hulu Sungai Utara Regency from 2012 to 2023, as well as administrative data, land use, river data, and soil type data used, which are data from Hulu Sungai Utara Regency in 2022. Data validation uses data from the InaRISK-Portal of the National Disaster Management Agency (BNPB). Secondary data is then processed using a Geographic Information System (GIS).

RESULTS AND DISCUSSION

Administrative Boundaries

Administrative boundary data for Hulu Sungai Utara Regency is a crucial component in spatial analysis, particularly in studies of drought vulnerability. Administrative boundaries provide a clear spatial framework for defining governmental units such as districts or municipalities, which facilitates the integration of social, economic, and environmental datasets. In vulnerability analysis, this information is essential for identifying affected areas, grouping risk levels based on administrative units, and supporting effective disaster mitigation planning (Daud et al., 2024).

Table 1. Area of North Hulu Sungai Regency

District	Number of Villages/Sub-districts	Area (Km^2)
Amuntai Selatan	30	159,96
Amuntai Tengah	29	86,33
Amuntai Utara	26	38,55
Babirik	23	73,11
Banjang	20	111,62
Danau Panggang	16	150,32
Haur Gading	18	38,70
Paminggir	7	200,50
Sungai Pandan	33	62,26
Sungai Tabukan	17	18,83

Source: BPBD (2022)

Based on Table 1, Hulu Sungai Utara Regency consists of 10 sub-districts with a total of 219 villages. Based on area, Paminggir District is the largest, accounting for approximately 21.33% of the total area of the regency. Sungai Tabukan District has the smallest area, at 2%.

Slope Gradient

Slope refers to the difference in elevation across a landform's relief. Land slope reflects regional characteristics that need to be considered when determining land use direction. The slope class, classification, and slope score are important factors in this analysis (Luhukay et al., 2019). Land slope is also a crucial factor in analyzing the potential for drought. This is because the slope level affects how much rainwater can infiltrate the soil. When rainfall intensity is higher than the soil infiltration rate, rainwater flows over the surface as runoff. On steeper land, surface flow tends to move faster, so water has less time to infiltrate the soil (Soewandita, 2018). The slope analysis used DEM data with scores for slope parameters as shown in Table 2.

Table 2. Slope scoring classification for drought analysis

Slope Gradient	Slope Classification	Scoring Value
0 – 8 %	Flat	1
8 – 15 %	Gently Sloping	2
15 – 25 %	Moderately Steep	3
25 – 45 %	Steep	4
>45 %	Very Steep	5

Source: Wardani dkk. (2022)

Table 2 shows that the slope classification generally divides terrain into five categories: 0–8% (flat), 8–15% (gentle), 15–25% (slightly steep), 25–45% (steep), and more than 45% (very steep), which are widely applied in GIS-based land suitability and environmental vulnerability assessments (Rusdi et al., 2015). Paminggir District had the highest percentage in this category at 20.755%, followed by South Amuntai (15.252%), Danau Panggang (14.396%), Banjang (11.063%), and Babirik (8.040%). Meanwhile, Central Amuntai, Sungai Pandan, and North Amuntai each showed percentages of score 5 at 7.987%, 5.446%, and 2.907%, respectively. The district with the lowest score of 5 was Sungai Tabukan (2.318%). In the score category 4 (>25–45), the highest value was found in South Amuntai (1.036%), while the other districts had relatively small values, generally below 1%. Similarly, scores in categories 3, 2, and 1 showed very small proportions across all districts, with most values below 0.3%. The results of the analysis and slope gradient map in Hulu Sungai Utara Regency are shown in Figure 1.

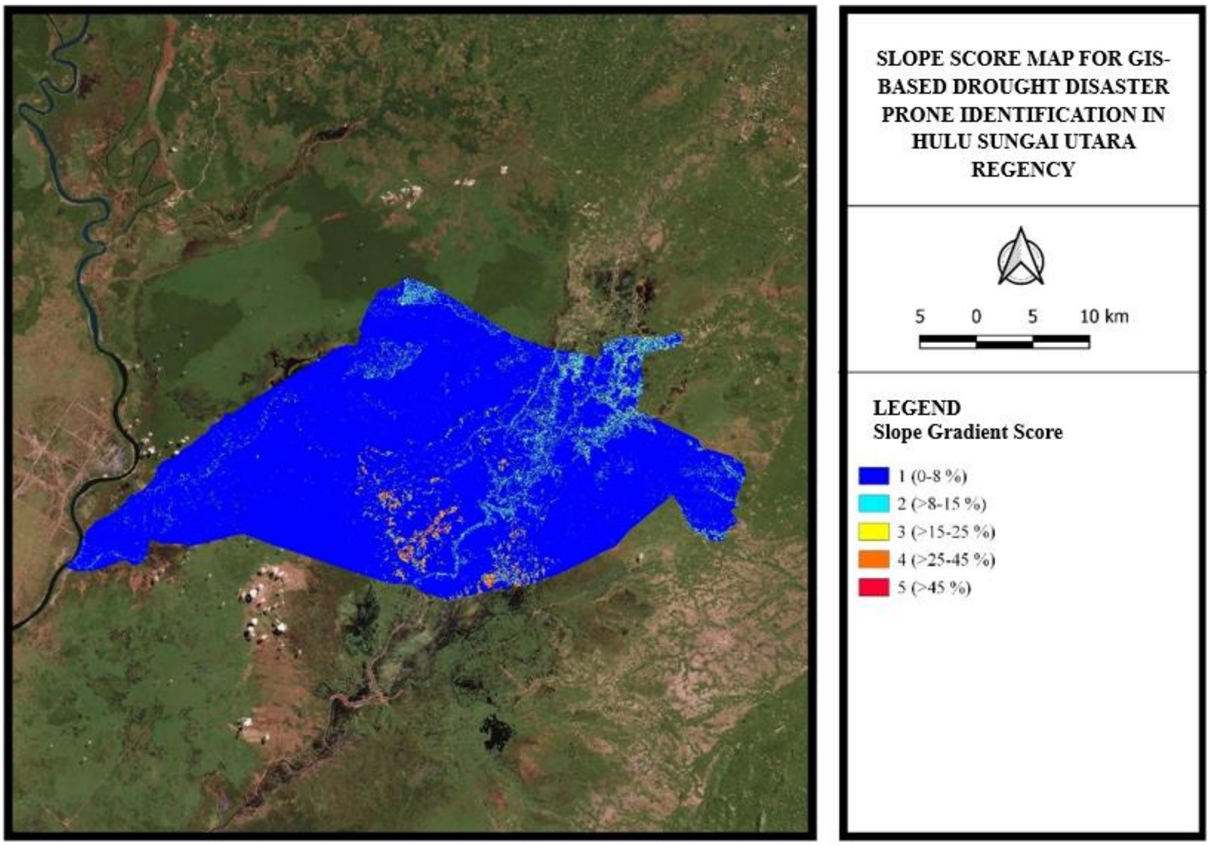

Figure 1. Results of slope gradient coring map analysis

Land Height

Elevation refers to the height of a location on the Earth's surface above sea level, which influences climate conditions, vegetation, and human activity in an area (Maurya & Manisha, 2024). Elevation plays a significant role in determining the vulnerability of an area to drought because variations in altitude influence climatic conditions and water availability across landscapes (Dissanayake et al., 2024). Differences in elevation affect the depth of the groundwater table, infiltration capacity, and the potential for water storage in the soil. Areas with higher elevations generally have deeper groundwater tables, making access to water reserves difficult during the dry season, increasing the risk of drought. Meanwhile, areas with lower elevations generally have greater potential access to groundwater but can still experience drought if recharge and water resource management are not optimal (Kang & Byun, 2024). Differences in elevation not only affect water distribution but also directly impact groundwater availability and soil moisture levels, which overall strengthens the role of elevation in drought risk analysis (Sarkar et al., 2024). Elevation is an important physiographic factor that influences drought vulnerability and is often used as a parameter in geospatial-based drought analysis models (Swain et al., 2022). The values in Table 3 are used as input for the elevation scoring parameters.

Table 3. Land elevation scoring classification for drought analysis

Elevation (m)	Value
0 - 10	1
>10 - 50	2
>50 - 100	3
>100 - 200	4
>200	5

Source: Sarkar et al. (2024)

Paminggir District recorded the highest percentage of score 1 at 21.667%, followed by South Amuntai (16.223%), Banjang (13.661%), and Danau Panggang (10.937%). Most other districts also showed quite significant values on this score, such as Central Amuntai (8.720%), Babirik (7.188%), and Sungai Pandan (7.084%). The score category 2 appeared in small numbers in almost all districts, with the highest values found in South Amuntai (0.684%) and North Amuntai (0.598%). Meanwhile, score 3 only appeared minimally in three districts, namely Babirik (0.002%), Sungai Pandan (0.002%), and Danau Panggang (0.001%). There was no data on the score categories 4 and 5 in all districts. In general, the distribution of scores across all regions tends to be concentrated in the low value category, with very few regions having scores above category 2. The results of the analysis and land elevation map are shown in Figure 2.

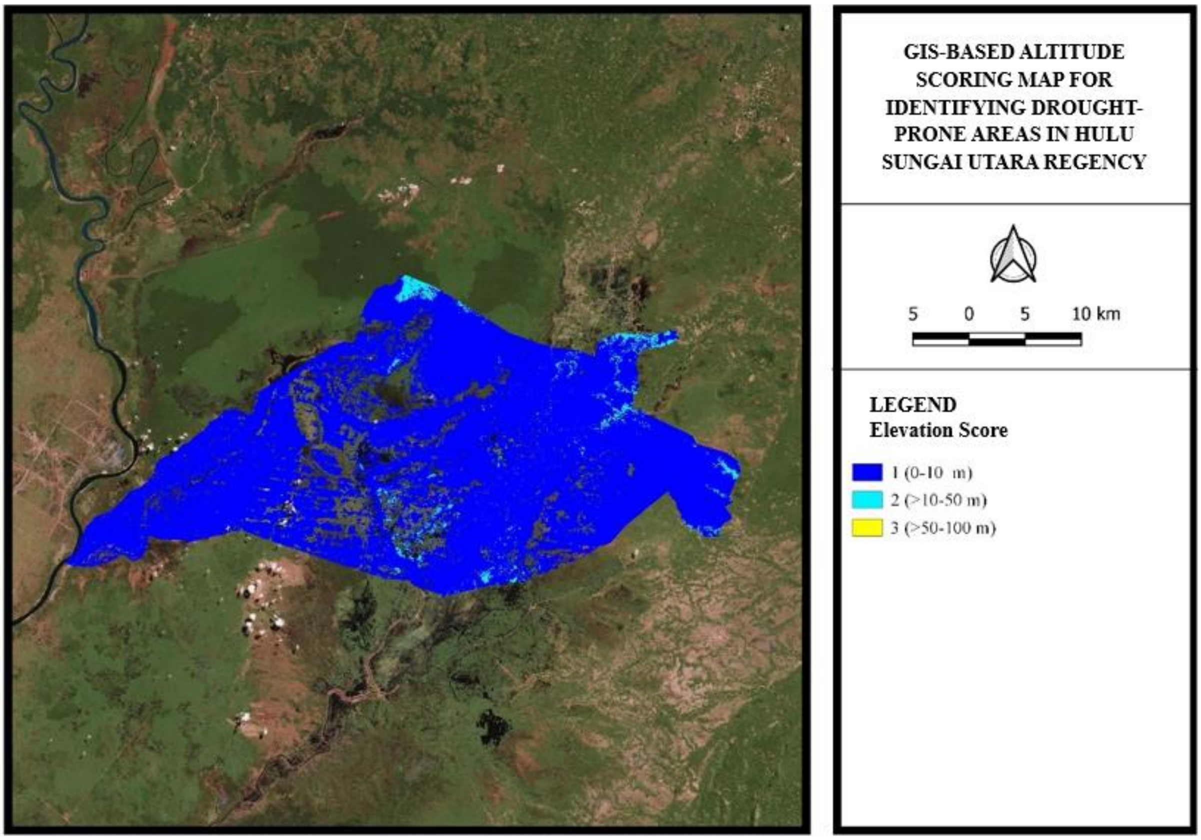

Figure 2. Map of altitude distribution in North Hulu Sungai Regency

Rainfall

Precipitation generally refers to the amount of rainfall that falls over a specific area during a particular period. It is calculated based on the depth of water accumulated on a flat surface within a certain time interval, such as daily, monthly, or yearly, and is usually expressed in millimeters (mm) (Fairman et al., 2017). Rainfall can be defined as the depth of water that accumulates on a horizontal surface over a certain period if there are no losses due to evaporation, infiltration, or surface runoff. The amount of rainfall is commonly measured using a rain gauge, which collects precipitation and records the depth of water accumulated within the instrument (Food and Agriculture Organization (FAO), 2019). The weights (scores) for rainfall parameters can be seen in Table 4.

Table 4. Rainfall scoring classification for drought analysis

Average Rainfall (mm/yr)	Description	Value
3500 – 4500	Heavy	1
3000 – 3500	Rather dense	2
2500 – 3000	Currently	3
2000 – 2500	Somewhat Light	4
1000 - 2000	Light	5

Source: Sarkar et al. (2024)

Hulu Sungai Utara Regency has an average annual rainfall of between 2,000 and 2,500 mm, which is categorized as relatively light rainfall and receives a score of 4 out of 100%. The map and results of the rainfall scoring analysis can be seen in Figure 3.

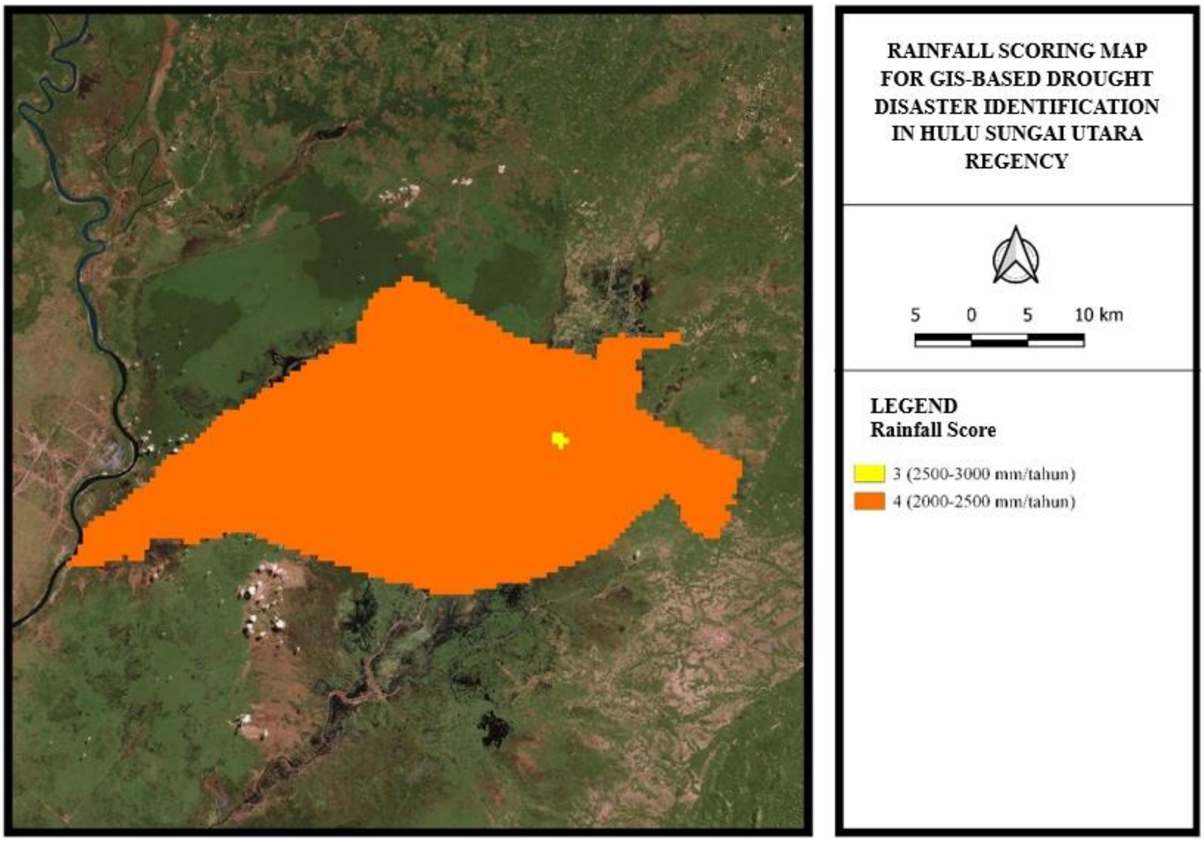

Figure 3. Map of rainfall scoring results in Hulu Sungai Utara Regency

Soil Type

Soil type plays an important role in determining the capacity of soil to retain water. This capacity is reflected in soil moisture conditions, which are widely used as an indicator of drought because they are directly related to water availability for plant roots (Wankmüller et al., 2024). Soil type refers to the classification of soils based on their physical and chemical properties, such as texture, structure, fertility, and mineral composition, which influence the ability of soil to support plant growth and determine its utilization for human activities (FAO & Intergovernmental Technical Panel on Soils, 2017). Soil type in a particular area strongly influences the ability of the soil to absorb water, which is known as the infiltration process. Infiltration refers to the movement of water from the soil surface downward into the soil profile driven mainly by gravitational forces (Rahmati et al., 2018). Soils with fine textures generally exhibit lower infiltration rates, which can increase the potential for surface runoff. In contrast, coarse-textured soils tend to have higher permeability and allow water to infiltrate more easily into the soil profile (Rahma et al., 2023). The soil type weights (scores) can be seen in Table 5.

Table 5. Classification of soil type scoring for drought analysis

Soil Type	Description (Drought Susceptibility)	Value
Regosol, Lithosol, Organosol, Renzina	Coarse texture, fast drying, very sensitive	5
Andosol, Lateric, Grumosol, Podsol, Podzolic	Moderate porosity, dryness sensitivity	4
Brown forest soil, Mediterranean soil	Moderate retention, moderate sensitivity	3
Latosol	Fairly smooth texture, somewhat resistant	2
Alluvial, Planosol, Gray Hydromorph, Lateric Groundwater	High water retention, not sensitive	1

Source: Arwanto et al. (2021)

Table 5 shows the classification used in the Geographic Information System (GIS)-based disaster vulnerability analysis with weighting and overlay methods, where soil types are assessed based on infiltration capacity and water retention capacity that influence the level of vulnerability to drought (Rahmanita & Idarwati, 2025). In the study coverage area, there are only two categories of soil types based on the scoring level used. Soil types included in the Regosol, Litosol, Organozol, and Renzina groups dominate with a percentage of 57.990% and are classified into a score of 5. Meanwhile, other soil types such as Alluvial, Planosol, Gray Hydromorph, and Groundwater Lateric cover approximately 42.010% of the total area, and are included in the score category 1. The map and results of soil type scoring can be seen in Figure 4.

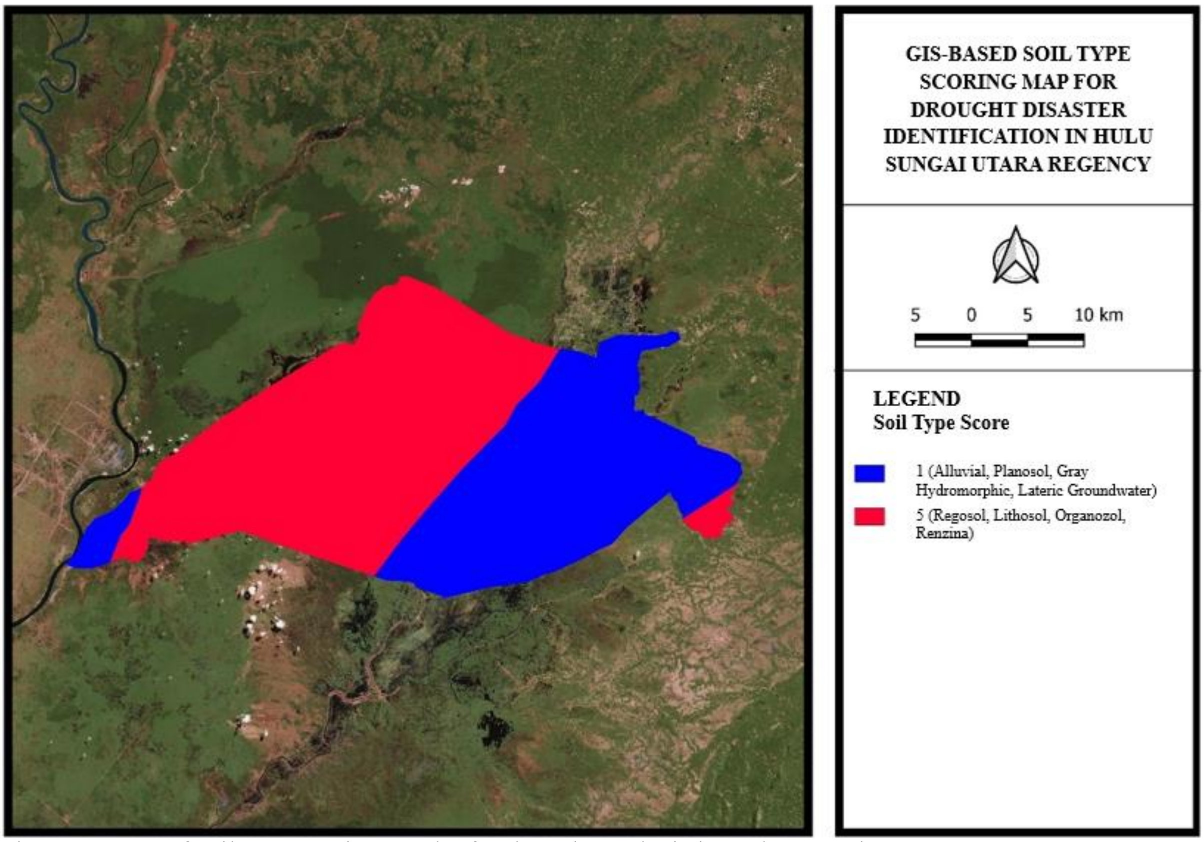

Figure 4. Map of soil type scoring results for drought analysis in Hulu Sungai Utara Regency

Land Use

Land use can generally be divided into two main categories, namely agricultural land use and non-agricultural land use. Agricultural land use is commonly differentiated based on water availability, types of cultivated commodities, and the vegetation or crops grown on the land (Rondhi et al., 2019). Land use influences the amount of surface runoff generated when rainfall exceeds the infiltration capacity of the soil, because different land cover types modify surface characteristics and water infiltration processes (Liu et al., 2025). Areas dominated by trees tend to slow down surface runoff because vegetation can intercept rainfall and enhance soil infiltration through their root systems and canopy structures. Changes in land use can alter soil physical properties through human management activities, which ultimately influence the soil's capacity to absorb and store water (Chávez-Collantes et al., 2025). In inputting land cover parameters, land cover scoring is used as in Table 6.

Table 6. Land Cover Scoring

Land Use	Value
Forest	1
Scrubs/shrubs	2
Fields/dry fields, grass, gardens	3
Irrigated rice fields, rain-fed rice fields, and ponds	4
Rocky soil, settlements, buildings	5

Source: Lestari et al. (2021)

Based on Table 6, land cover with dense vegetation, such as forests, has a high capacity to retain water, increase infiltration, and maintain soil moisture, so the level of vulnerability to drought is relatively low. In contrast, settlements, open land, and rocky soil have low infiltration and increase surface runoff, making them more vulnerable to drought or hydrological degradation (Suprapto et al., 2022). The most dominant land cover category is shrubs or bushes with a percentage of 70.689%. This indicates that most areas are dominated by medium vegetation, which is still quite effective in absorbing water and retaining soil moisture, although not as effective as primary forests or dense vegetation. The category of fields/dry fields, grass, and gardens ranks second with a percentage of 10.331%. Irrigated rice fields, rain-fed rice fields, and ponds have a percentage of 15.687%. The least land area is forest, with only 0.064% of the total area. Rocky soil, settlements, and buildings cover 3.228%. The map and results of the land use scoring can be seen in Figure 5.

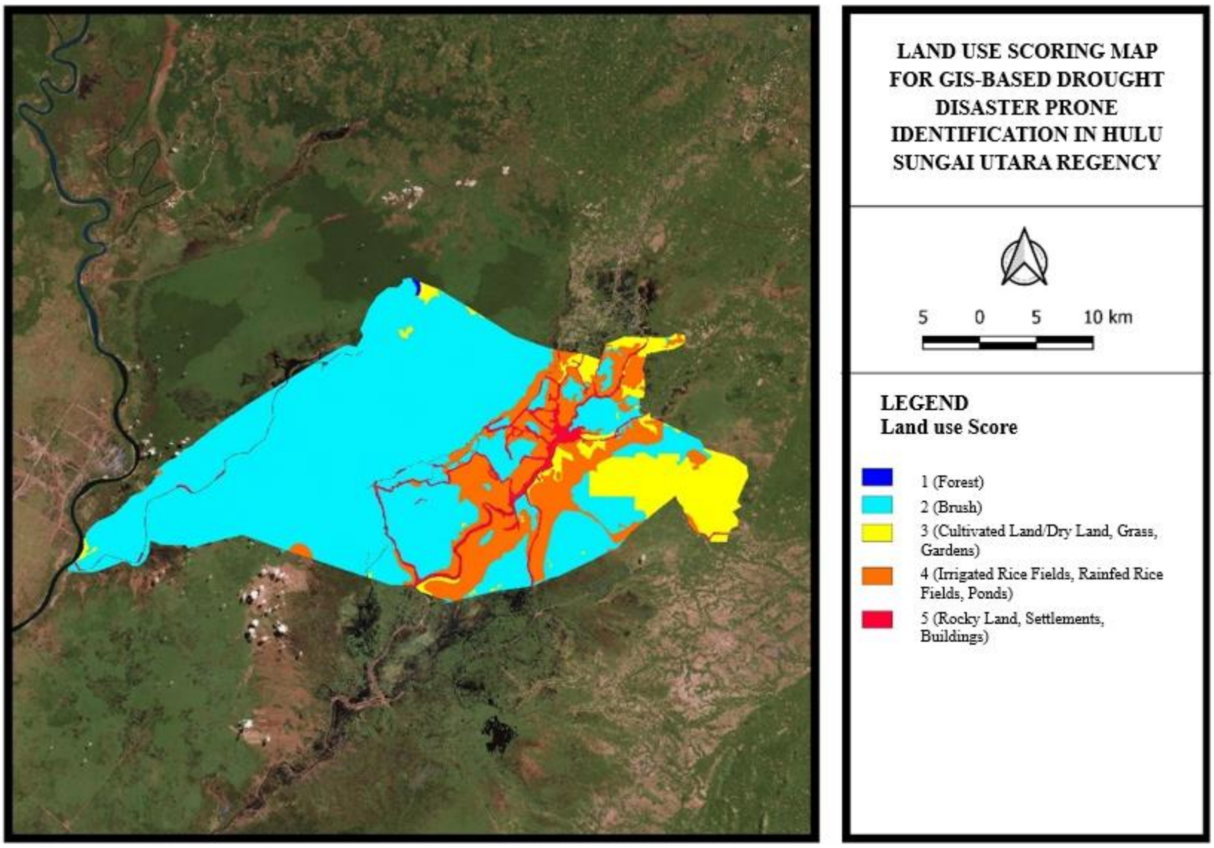

Figure 5. Distribution map of land use scoring results in Hulu Sungai Utara Regency

River Density

Drainage density is the total length of the river network per area (km/km²) and is often used as a parameter in hydrological vulnerability analysis (Hagos et al., 2022). Drainage density refers to the total length of river channels per unit area within a watershed. A higher drainage density indicates that the drainage network is more efficient in conveying surface runoff, but it also means that rainfall water flows rapidly into river channels and leaves the basin quickly. As a result, less water infiltrates into the soil and groundwater storage decreases, which can increase the susceptibility of an area to drought during dry periods (Kim et al., 2023). Conversely, areas with low drainage density generally have higher infiltration potential, enabling greater groundwater storage and making these regions relatively more resistant to drought conditions (Kawara et al., 2024). Linsley (1975) in (Peraturan Direktur Jenderal Bina Pengelolaan Daerah Aliran Sungai dan Perhutanan Tentang Pedoman Identifikasi Karakteristik Daerah Aliran Sungai Pub. L. No. P.3/V.SET/2013, 2013) states that if the drainage density is lower than 1 mile/mile² (0.62 km/km²), the watershed will experience waterlogging. Conversely, if the stream density is higher than 5 mi/mile² (3.10 km/km²), the watershed is likely to experience drought. The stream density parameter input uses land cover scoring, as shown in Table 7.

Table 7. Stream density scoring classification for drought analysis

River Density (m/Km^2)	Value
<620	5
620 - 1440	4
1440 - 2270	4
2270 - 3100	2
>3100	1

Source: Nyayapathi et al. (2023)

Most of the Hulu Sungai Utara Regency area, namely 58.364%, is included in the category with medium to low river density (>620-1440 m/km²) with a score of 4. Furthermore, around 23.681% of the area has a very low river density (0-620 m/km²) with a score of 5, indicating an area with a sparse river network. The category with medium to quite high river density, namely a score of 3 (>1440-2270 m/km²), covers around 11.724% of the area. Meanwhile, areas with high and very high river density (scores 2 and 1) only cover a small portion of the area, amounting to 2.672% and 3.559%, respectively. The results of the analysis and river density map are shown in Figure 6.

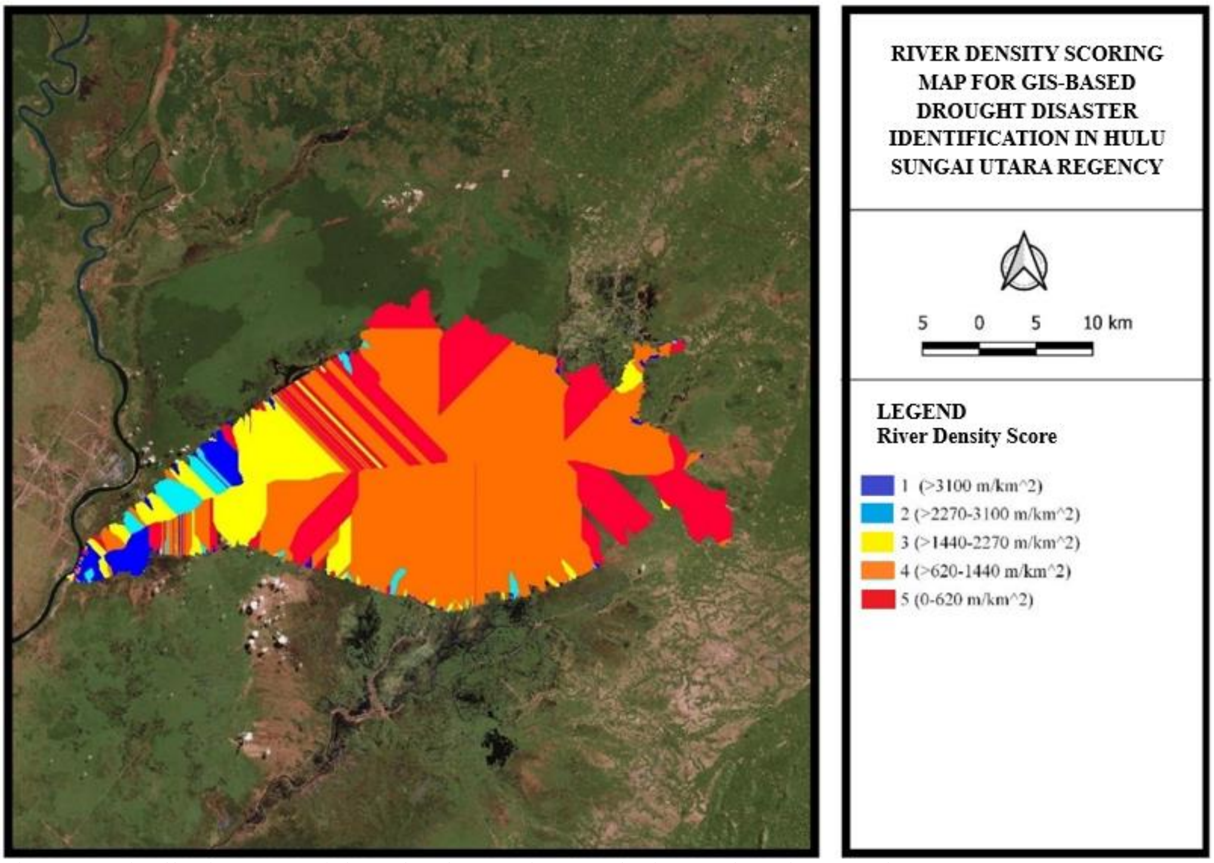

Figure 6. Distribution map of river density scoring results in North Hulu Sungai Regency

Normalized Difference Vegetation Index (NDVI)

The transformation of the Normalized Difference Vegetation Index (NDVI) is commonly used to analyze its relationship with drought potential. High NDVI values indicate areas with dense vegetation cover and higher water absorption capacity, whereas low NDVI values represent areas with sparse vegetation cover and lower water retention capacity, which are often associated with drought conditions (Irsyad et al., 2025). NDVI values generally range from −1 to 1, with negative values indicating non-vegetated surfaces such as water or open land, while positive values indicate the presence of vegetation with increasing density. In remote sensing analysis, surface moisture conditions are often studied alongside other indices such as the Tasseled Cap transformation, which produces brightness and wetness components to describe the characteristics of soil and vegetation in an area (Rahman & Mesev, 2019). The scoring for the vegetation index can be seen in Table 8.

Table 8. Scoring Classification for the Normalized Difference Vegetation Index

NDVI Value Range	Vegetation Interpretation	Drought Score
>0,6	Dense/healthy vegetation	1
0,3-0,6	Moderate vegetation	3
<0,3	Low/dry vegetation	5

Source: Jamil et al. (2013)

Based on Table 8, high NDVI values generally indicate dense and healthy vegetation, while moderate values indicate sparse or transitional vegetation, and low NDVI values are associated with bare soil or degraded vegetation (Anwer et al., 2025). For the vegetation index, the entire study area had a score of 3 with a percentage of 70.697%, or equivalent to an area of 65,091.576 hectares, while a score of 5 with an area of 22,281.248 hectares and a score of 1 with an area of 4,698.983 hectares were found with a percentage of 5.103%. This condition indicates that the overall study area is dominated by the moderate vegetation index class, and there are variations in low and high vegetation classes. The map and results of the vegetation index (NDVI) scoring for identifying drought-prone areas in Hulu Sungai Utara Regency can be seen in Figure 7.

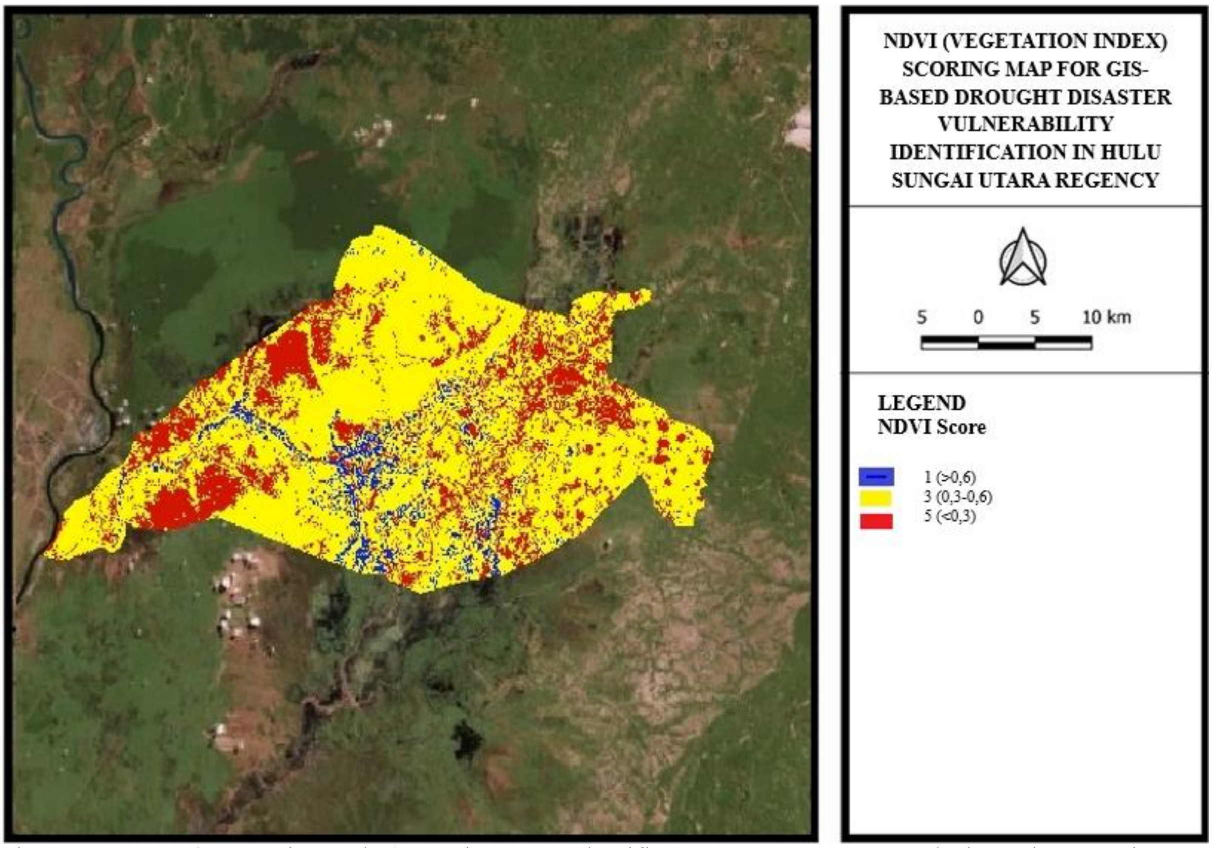

Figure 7. NDVI (Vegetation Index) Scoring Map Identifies Areas Prone to Drought in Hulu Sungai Utara Regency

Normalized Difference Water Index (NDWI)

The Normalized Difference Water Index (NDWI) is a spectral index used in remote sensing to estimate water content in vegetation, making it highly relevant in drought analysis. NDWI utilizes two spectral channels from satellites: near-infrared (NIR) and short-wave infrared (SWIR). In the context of remote sensing, a channel is a specific range of light wavelengths recorded by a satellite sensor, allowing each channel to detect specific physical or chemical properties of the Earth's surface. The SWIR channel is highly sensitive to water content in leaves, so its reflectance reflects changes in plant water content. Conversely, the NIR channel is influenced by the internal structure of the leaf and dry matter content, not by water content directly. By combining these two channels, reflectance variations caused by differences in leaf structure can be reduced, allowing the NDWI to provide a more accurate estimate of water content and the degree of dryness of vegetation (Serrano et al., 2019).

Table 9. Normalized Difference Water Index (NDWI) Wetness Index Scoring Values

NDWI Value Range	Humidity Description	Droughtness Score
>0,3	Very wet area (water visible)	1
0,0 – 0,3	Wet/Moderate humidity	3
<0,0	Dry/water-free surface	5

Source: Noraini et al. (2022)

Based on Table 9, higher NDWI values indicate increased water content in vegetation or surface moisture, while negative NDWI values are generally associated with bare soil or urban areas with very low humidity (Maashi et al., 2025). NDWI values less than 0.0 indicate dry areas, with the soil surface containing no significant water. These areas include open, arid, or areas that have lost their moisture. These conditions are highly susceptible to drought, as the soil's ability to retain water is very low. Therefore, areas with NDWI <0.0 are given the highest drought score (5). The wetness index map in Hulu Sungai Utara Regency can be seen in Figure 8.

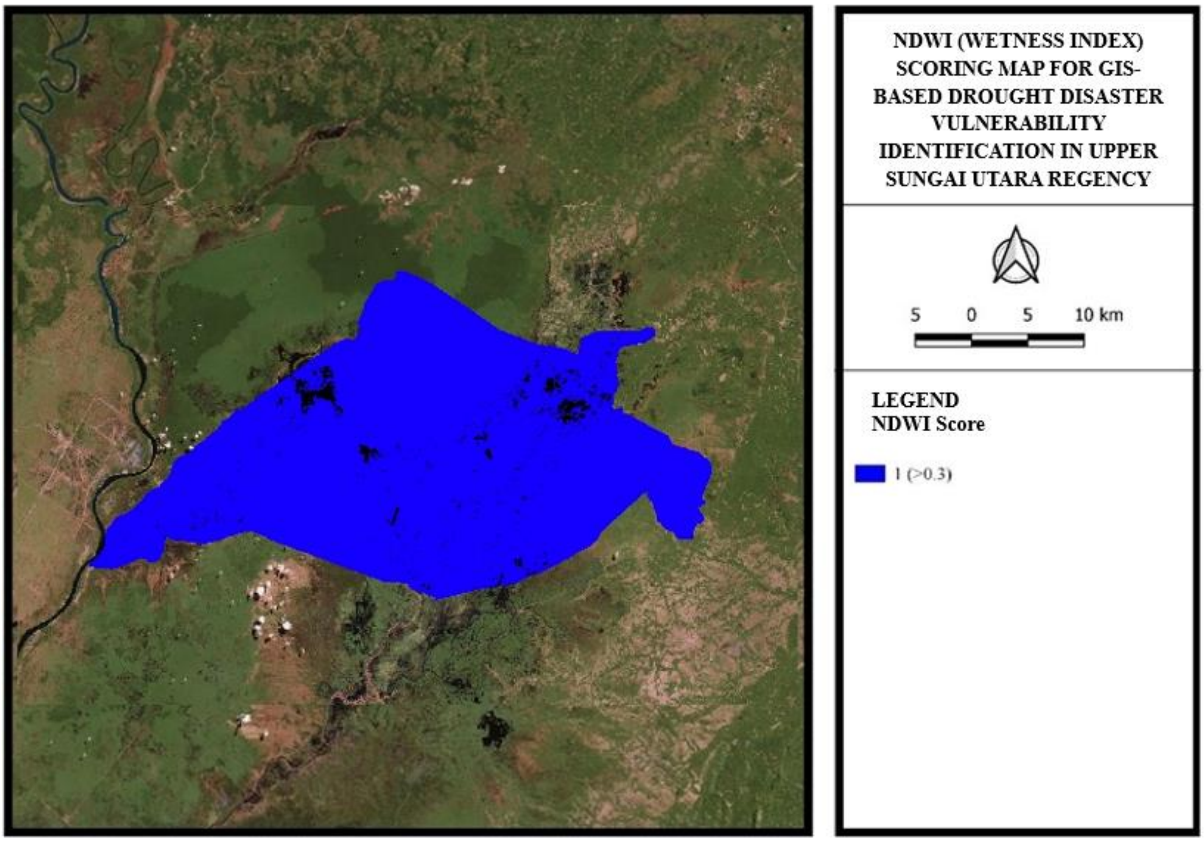

Figure 8. North Hulu Sungai wetness index map

Land Surface Temperature (LST)

Land surface temperature (LST) is the temperature on the Earth's surface that interacts directly with the atmosphere and is often referred to as the skin temperature of the land surface. This parameter is very important in climate, hydrology, and environmental studies because it reflects the energy exchange between the Earth's surface and the atmosphere, and is generally obtained through remote sensing using thermal sensors on satellites such as Landsat and MODIS (Fong et al., 2025). The relationship between land surface temperature (LST) and vegetation shows a strong negative correlation, where a decrease in vegetation cover tends to cause an increase in surface temperature. This condition often occurs in urban areas experiencing land use changes, potentially increasing environmental heat stress and exacerbating the risk of drought in an area (Fenta et al., 2019).

Table 10. Land Surface Temperature scoring value

LST (Land Surface Temperature) °C	Description	Drought Score
<25	Cool/tends to be humid	1
25 - 30	Moderate conditions	3
>30	Hot/often dry	5

Source: Juniarti et al. (2017)

Land surface temperature (LST) is closely related to drought conditions, where higher surface temperatures indicate greater drought intensity and environmental stress in an area (Mandal et al., 2025). The results of the Land Surface Temperature (LST) scoring show that the study area is dominated by Score 1 with a percentage of 75.794% or an area of 69,784,905 hectares, indicating that most areas have low land surface temperatures. Furthermore, Score 2 covers 24.206% or around 22,286,902 hectares, which represents areas with moderate surface temperatures. Meanwhile, Score 3, which describes high surface temperatures, was not found in the study area. The results of the scoring analysis and the land surface temperature map are shown in Figure 9.

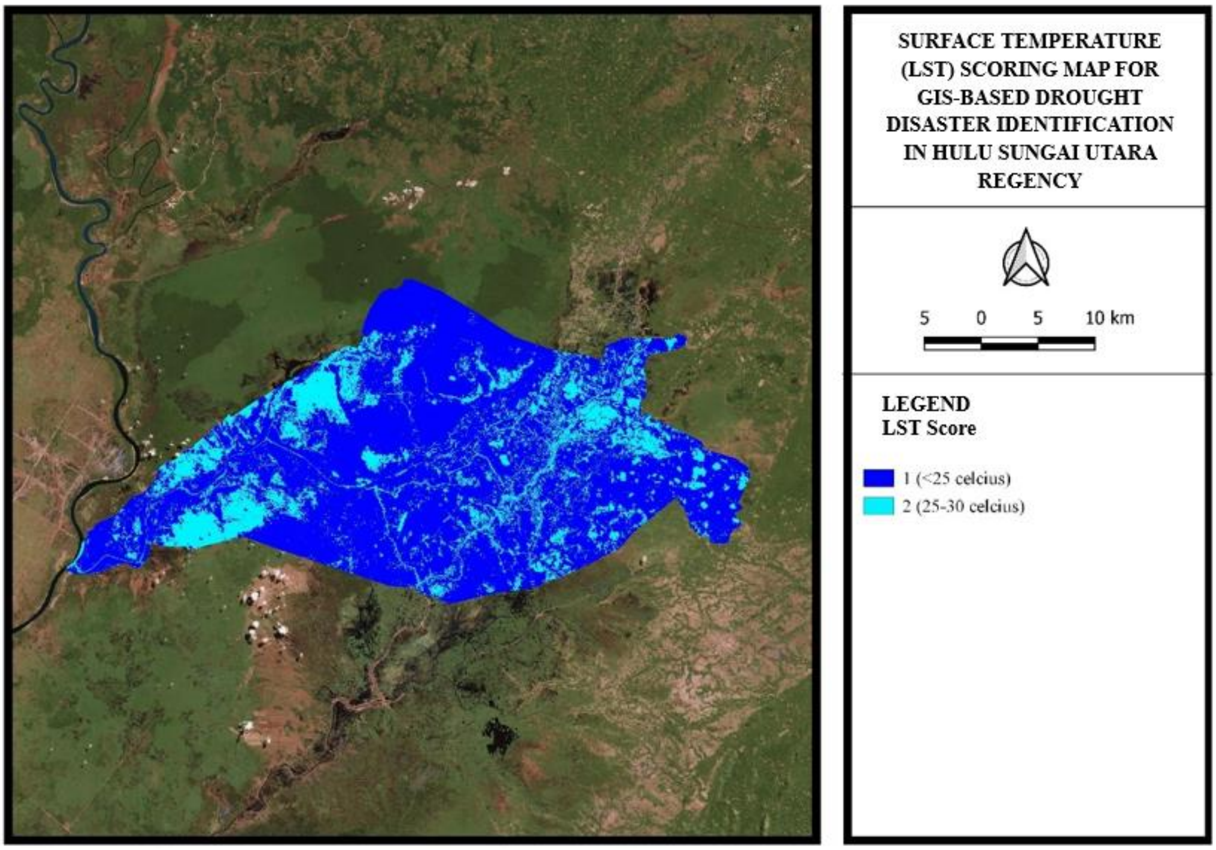

Figure 9. Map of surface temperature scoring results in Hulu Sungai Utara Regency

Analytical Hierarchy Process (AHP)

AHP (Analytical Hierarchy Process) is a method used to solve complex and unstructured problems by grouping elements in a hierarchy. This method applies numerical values to replace human perception through relative comparison, resulting in a synthesis that determines the elements with the highest priority. In general, the Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions, allowing decision makers to prioritize alternatives and evaluate multiple criteria within a hierarchical framework (Xi & Qin, 2013).

Table 11. CR value of the drought vulnerability parameter of the AHP method

Criteria	AHP	
Slope Gradient	0,0564	5,64%
Land Elevation	0,0744	7,44%
Rainfall	0,2501	25,01%
Soil Type	0,0841	8,41%
Land Cover	0,1048	10,48%
River Density	0,0786	7,86%
Vegetation Index (NDVI)	0,1133	11,33%
Wetness Index (NDWI)	0,1510	15,10%
Surface Temperature (LST)	0,0873	8,73%

AHP (Analytical Hierarchy Process) is a method used to solve complex and unstructured problems by grouping elements in a hierarchy. This method applies numerical values to replace human perception through relative comparison, resulting in a synthesis that determines the elements with the highest priority. In general, the Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions, allowing decision makers to prioritize alternatives and evaluate multiple criteria within a hierarchical framework.

Drought Probability Analysis

Drought occurs when water availability is significantly lower than what is needed for life, agriculture, economic activity, and the environment. This phenomenon begins when rainfall decreases below normal levels over a prolonged period, resulting in insufficient water supply in the soil and preventing plant growth (Direktorat Pemetaan Dan Evaluasi Risiko Bencana, 2021). The drought probability map was compiled by combining various parameters that influence the potential for drought in the Hulu Sungai Utara Regency through a data overlay process.

Table 12. Drought vulnerability classification

Score	Range (Drought Vulnerability)	Description	Color
1	0,00 – 1,66	Not Vulnerable	Green
2	>1,66 – 3,33	Moderately Vulnerable	Yellow
3	>3,33 – 5,00	Very Vulnerable	Red

Source: Hayuningsih dkk. (2024)

Based on Table 12 of the drought scoring classification, the study area is divided into three vulnerability categories: Not Vulnerable (Score 1, green), Moderately Vulnerable (Score 2, yellow), and Very Vulnerable (Score 3, red). These scores are obtained through processing several parameters that influence drought, including vegetation index, wetness index, land surface temperature, rainfall, soil type, land use, and elevation.

Table 13. Area of drought-prone areas in North Hulu Sungai Regency

Vulnerability	Score	Percentage (%)	Total Area (hectares)
Not vulnerable	1	4,639	4271,211
Quite vulnerable	2	95,361	87800,596
Very vulnerable	3	0,000	0,000

Based on Table 13, the results of the drought scoring classification in the study area, the majority of areas are in the moderately vulnerable category. Specifically, areas with a score of 2 (moderately vulnerable) cover 95.361% of the total area, or approximately 87,800,596 hectares, indicating that almost the entire study area is at moderate risk of drought. Areas with a score of 1 (not vulnerable) cover only 4.639%, or approximately 4,271,211 hectares, representing areas with relatively better conditions and therefore more resilient to drought.

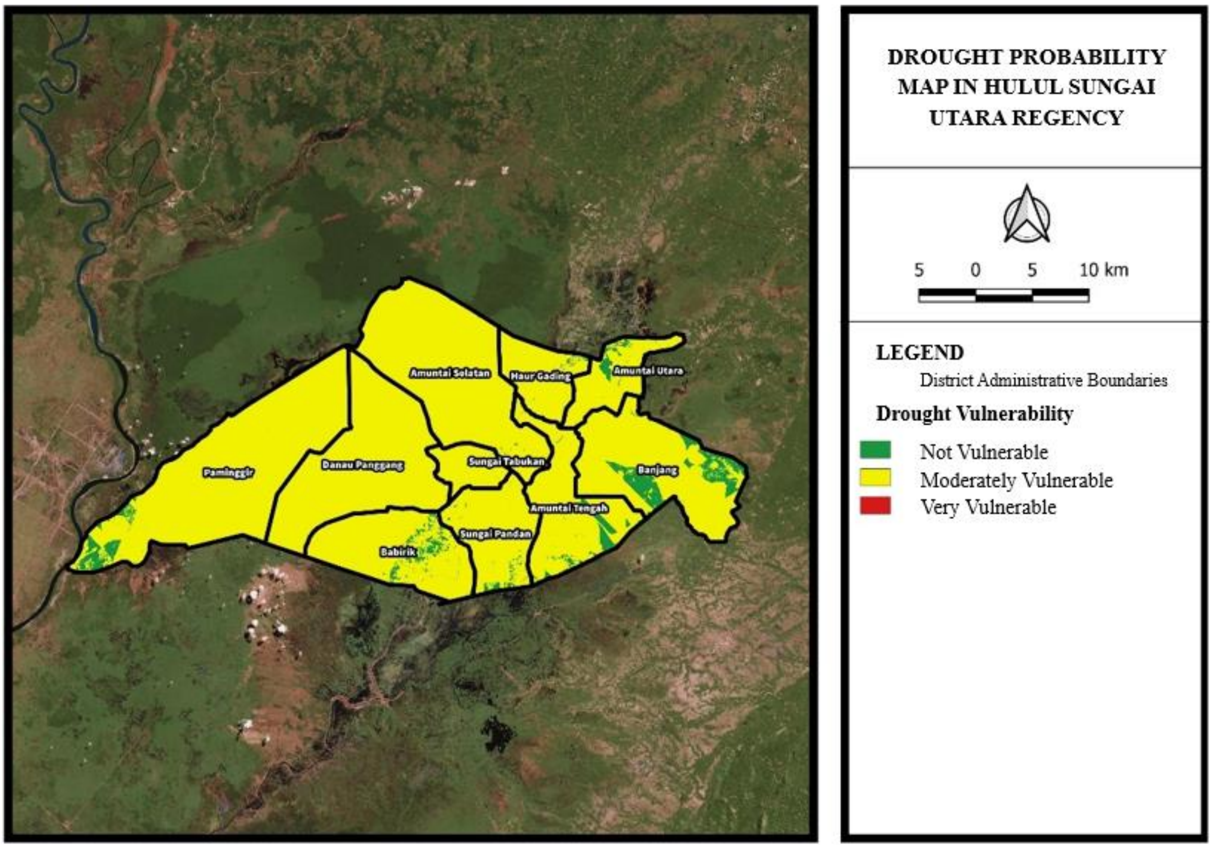

Figure 10. Drought probability map of North Hulu Sungai Regency

Overall, Figure 10 shows that the Hulu Sungai Utara Regency area is dominated by the moderately drought-prone category (Score 2). The total area of Score 2 reaches 87,800 ha of the total area of all sub-districts, while the area with a score of 1 (not vulnerable) is relatively small, only around 4,271 ha. There are no areas in the Score 3 category (very vulnerable), so in general, there are no areas currently experiencing extreme drought. Paminggir District has the largest area of Score 2, namely 18,592 ha, followed by South Amuntai (15,267 ha) and Danau Panggang (13,958 ha). This indicates that these three sub-districts have the most extensive level of moderate drought vulnerability in the study area. Banjang, Babirik, and Central Amuntai Districts also have a dominant Score 2, with areas ranging from 5,919 ha to 9,435 ha. Areas with a Score of 1 are distributed in a limited manner within each sub-district. The largest areas are in Banjang (1,746 ha) and Paminggir (780 ha), while other sub-districts, such as Danau Panggang, Sungai Tabukan, and Amuntai Selatan, have very small areas with a score of 1, even less than 15 ha, indicating that only a small part of the area has conditions that are more resistant to drought.

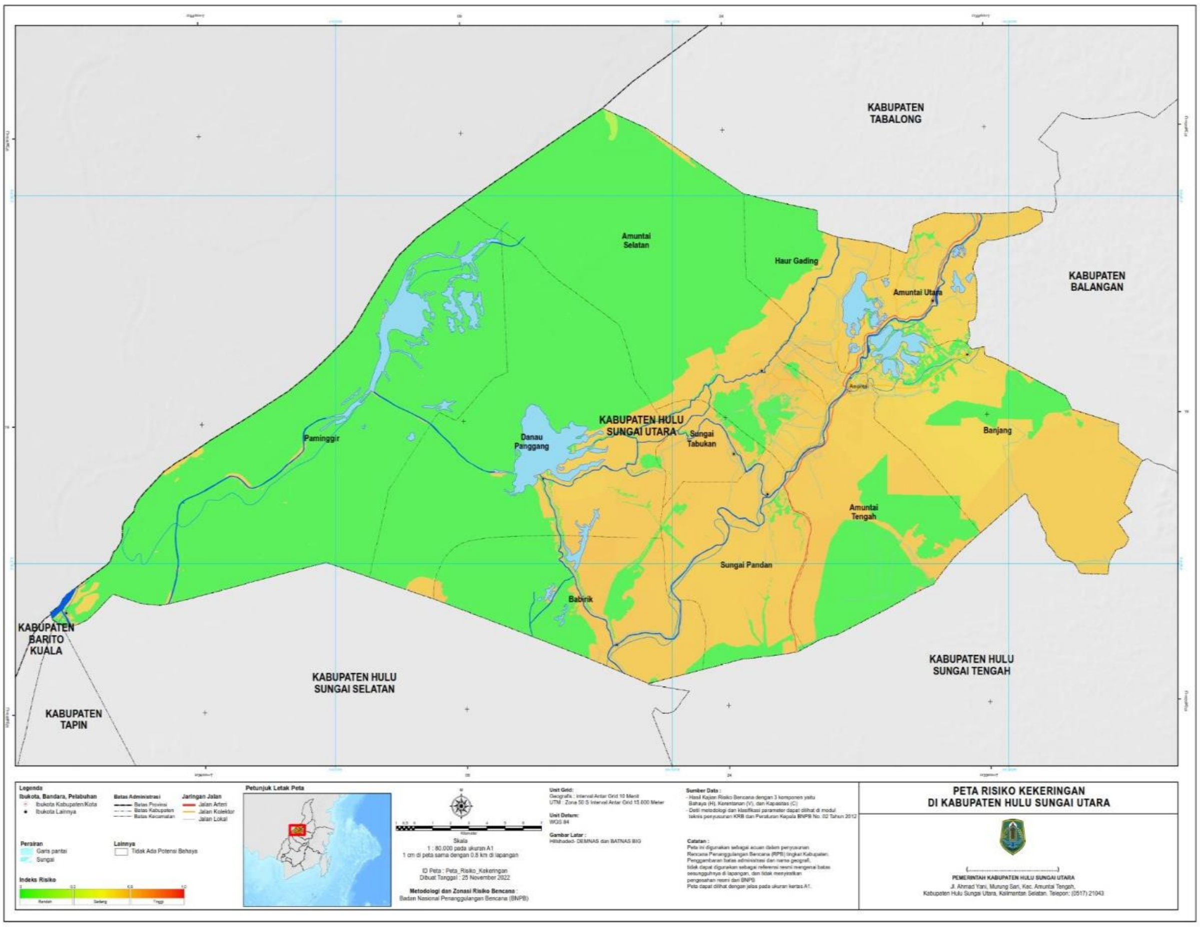

Figure 11. Drought Risk Map of North Hulu Sungai Regency (BPBD, 2022)

Based on Figure 11, contained in the 2023–2027 Hulu Sungai Utara Regency Disaster Risk Assessment Document and in InaRISK, Hulu Sungai Utara Regency is categorized as having a moderate drought risk. This classification indicates that although the region is not categorized as high risk, the potential for drought still requires vigilance. Based on the research scoring map, on average, Hulu Sungai Utara Regency is categorized as moderately drought-prone, indicating drought vulnerability in most areas, although it has not yet reached the very vulnerable level.

CONCLUSION

The distribution of drought hazard potential in Hulu Sungai Utara Regency is dominated by the moderately vulnerable category (Score 2) in almost all sub-districts, while the non-vulnerable category (Score 1) is found only in small areas, and there are no highly vulnerable areas (Score 3). Paminggir, South Amuntai, and Danau Panggang sub-districts have the largest moderately vulnerable areas, indicating the most extensive moderate drought potential. Other sub-districts such as Banjang, Babirik, and Central Amuntai are also dominated by Score 2, although to a lesser extent. Overall, this pattern indicates that drought risk in Hulu Sungai Utara Regency is relatively evenly distributed at a moderate level.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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