THE EFFECT OF LAND USE PATTERNS ON FLOOD VULNERABILITY LEVELS. CASE STUDY: WEST LOMBOK REGENCY, WEST NUSA TENGGARA PROVINCE, INDONESIA

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ABSTRACT

Uncontrolled changes in land use patterns are one of the main factors causing increased levels of flood vulnerability in several areas. To overcome flooding problems, integrated planning is needed related to the suitability of the regional land use plan. However, inconsistencies still often occur in its implementation due to the emergence of various interests. This study aims to analyze the relationship between land conversion into built-up areas and increased flood risk, map the distribution of flood areas, and estimate the level of flood vulnerability. The methods used include spatial analysis, multicriteria analysis, and descriptive analysis using the Hierarchy Process (AHP) and Geographic Information Systems (GIS) applications. The input factors forming flood risk used in the analysis include rainfall intensity (I), slope gradient (S), land use (U), soil type (ST), distance from drainage/river networks (D), and altitude (E). The results of the study indicate that the potential for flood vulnerability in West Lombok Regency consists of a rather vulnerable class spread across all sub-districts, namely an area of 47.624 Ha (51.80%), not vulnerable to an area of 21.001 Ha (22.84%), and ± 25% of the remaining areas are divided into moderately vulnerable areas of 15.241 Ha (16.58%), vulnerable areas of 7.871 Ha (8.56%), and very vulnerable areas of 195.79 Ha (0.21%). Sustainable land use management is essential to reduce flood vulnerability, especially in areas experiencing rapid development.

Key-words: *Land use; Flood; Vulnerability, Risk; GIS;* Analytical Hierarchy Process (*AHP).*

1. INTRODUCTION

Indonesia is one of the countries in the world that has a fairly high potential for hydrometeorological disasters. Hydrometeorological disasters are disasters that are influenced by weather, climate, and water factors. It is recorded that 86% of disaster events are dominated by hydrometeorological disasters such as floods, droughts, typhoons or tropical cyclones, as well as tidal waves and coastal abrasion (Agonafir et al., 2023). The high frequency of flood disasters requires strategic steps to reduce the impacts caused. One of the steps in reducing the impact and potential for flood disasters is planning and managing land use appropriately and integrating with regional spatial planning (Stedinger et al. 2011; Yuniartanti, 2018; Haikal et al., 2024). However, in reality, there are often inconsistencies between regional spatial plans and actual land use. One of these inconsistencies is the spatial pattern that should function as a green and agricultural area, but the existing land use is used as a settlement (Seyam et al., 2023; Abdullah et al., 2019). Referring to the flood problems that occur in several places, flood control planning is needed by mapping flood-prone areas (Mulliss et al., 1996; Sinha et al., 2008; Györi & Haidu, 2011, Tehrany et al., 2017). Identification and mapping of flood-prone locations is the starting point in conducting disaster risk analysis (Andrade & Szlafsztein, 2015; Haidu & Ivan, 2016a; Lee et al., 2017). Disaster risk analysis is needed as an effort to reduce disaster risk both through physical development and awareness and increasing capacity in dealing with disasters. If spatial information on flood-prone areas through flood-prone maps is available, this information can be used as a basis for analyzing the factors that influence flooding.

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Likewise, evaluations can be carried out to prepare and improve spatial planning to reduce the potential and impact of flood disasters (Kay et al., 2015; Haidu & Ivan, 2016b; Sari et al., 2025). The vulnerability of an area to flooding and the volume of runoff caused by rainfall exceeding the filter flow rate are both influenced by how the land is used. Land with good vegetation has a high capacity to absorb water because the roots and stems delay the flow of runoff (Revitt & Ellis, 2016; Hidayah et al., 2022). Flood risk is reduced when land is densely vegetated because rainwater can absorb more and runoff takes longer to reach rivers (Seyhan, 1995; Crăciun et al., 2009).

Controlling the use of space is an effort to realize orderly spatial planning. Controlling the use of space is an effort to monitor and prevent inappropriate use of space, which can even result in damage and flooding (Miller & Hutchins, 2017). For this reason, in areas prone to flooding, monitoring efforts need to be carried out by observing the consistency (suitability and harmony) between spatial planning and spatial utilization. Analytical Hierarchy Process (AHP) is a model that can be used in decision-making, and it has a mechanism for sorting several optimal choices based on predetermined criteria. AHP is used to analyze a set of alternatives or objectives to rank them from best to worst using a structured approach (Sinha et al., 2008). The final output is a weight associated with the various alternatives. The weights indicate the preference of the alternatives relative to each other, which can be seen as the perceived gain or loss when changing from one alternative to another (Musungu et al., 2012; Elmoustafa, 2012).

A geographic information system (GIS) is a collection of hardware, software, geographic data, methods, and employees designed efficiently to receive, store, update, manipulate, analyze, and display all types of geographically related information (Malczewski, 2006). The information required can be broken down into two categories: graphical data and attribute data, both of which relate to a specific location. Points, lines, and polygons are standard containers for graphical data. Attribute data, on the other hand, can be qualitative or quantitative and correspond one-to-one to graphical information). As long as the data used contains geographic references, GIS applications can be used for various spatial information purposes. The results of the land use pattern mapping analysis can be used to determine regional spatial plans so that flood-prone areas are not used as residential, office, and industrial areas.

2. STUDY AREA

The research location (**Fig. 1**) was conducted in the administrative area of West Lombok Regency, West Nusa Tenggara Province, Indonesia. Geographically, West Lombok Regency is located at 115° 49.12’ 04” - 116° 20’15.62” East Longitude and 8° 24’ 33.82” - 8° 55’ 19” South Latitude.

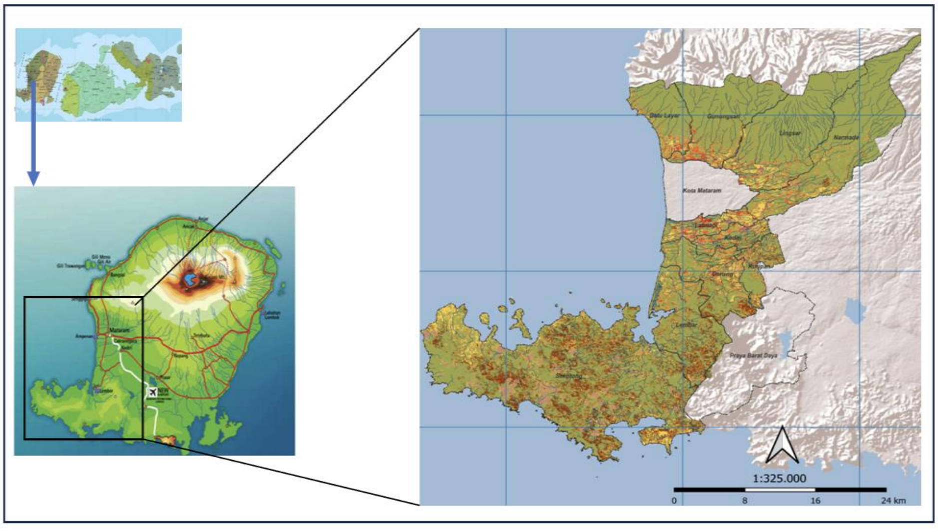

Fig. 1. Research location.

3. DATA AND METHODS

3.1. Data

This study uses primary and secondary data collected from various sources (**Table 1**). The data and parameters are used in the analysis because they are the main components of flooding in an area.

Table 1

Type of data needed in the analysis.

No	Name of data	Data type	Data sources	Use of data in analysis
1.	Administrative boundaries of villages and sub-districts	Secondary	tanahair.indonesia.go.id	As a research area boundary
2.	Watershed Map in West Lombok Regency 1:50,000	Secondary	Nusa Tenggara I River Basin Center	River basin area boundary
3.	Sentinel Image 2A	Secondary	earthexplorer.usgs.gov/	As a material for making land use maps
4.	Alos Palsar	Secondary	https://www.eorc.jaxa.jp/ALOS	As a material for making slope and elevation maps
5.	Rainfall Data 2012-2023 in West Lombok Regency	Secondary	Nusa Tenggara I River Basin Center	As a material for making rainfall maps
6.	Flood Incident Data 2017-2023 in West Lombok Regency	Secondary	Regional Disaster Management Agency, West Lombok Regency	As a consideration in determining flood frequency
7.	Soil Type Map 1: 50,000	Secondary	Nusa Tenggara I River Basin Center	As a risk-forming factor
8.	Spatial planning map of West Lombok Regency 1:50,000	Secondary	Regional Planning Agency, West Lombok Regency	As material for analysis of spatial pattern utilization
9.	Interview with respondents	Primary	Interview	Determining the weight of flood-prone factors

3.2. Analytical Hierarchy Process (AHP)

A decision support model called the Analytical Hierarchy Process (AHP) is used to sort several alternatives into optimal choices based on predetermined criteria (Sinha et al., 2008). Complex multi-criteria problems can be translated into a hierarchy using the Analytic Hierarchy Process (AHP). The purpose of this hierarchy is to solve a complex problem into groups, which are then arranged in a hierarchy to provide an overview of the conditions in are more organized.

The procedures for using the AHP method include:

1. Define the problem and determine the desired solution, then compile a hierarchy of the problems being analyzed;
2. Determine element priorities. The first step in determining element priorities is to make a pairwise comparison, namely by comparing elements in pairs according to the given criteria.
3. Synthetic. In this stage, the following are done:
   a. Adding the values of each column in the matrix;
   b. Dividing each value of the column by the total of the relevant column to obtain the normalization of the matrix;
   c. Adding the values of each row and dividing it by the number of elements to obtain the average value
4. Measuring consistency. In this stage, what is done is:
   a. Multiply each value in the first column by the relative priority of the first element, the value in the second column by the relative priority of the second element, and so on;
   b. Add up each row;

c. The result of the row summation is divided by the relevant relative priority element;
d. Adding the above quotient to the number of existing elements. The result is called λ max
e. Calculating the Consistency Index (CI) with the formula;

$$CI = \frac{\gamma maks - n}{n} \tag{1}$$

f. Calculate the Consistency Ratio (CR) with the formula:

$$CR = \frac{CI}{RI} \tag{2}$$

where:

n = the abundance of elements;
CR = consistency Ratio;
CI = consistency Index;
RI = in-deks Random Consistency (**Table 2**)

g. Check the consistency of the hierarchy. When the CR value is less than 10%, inconsistency of opinion is considered acceptable.

Table 2.

Random konsistensi indeks (RI).

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

The next stage is to score each flood-vulnerability-forming subfactor. The scoring is carried out with the provision of standardization of inverse scale scores, where the influencing factors will have a higher score value compared to the less influential factors, using the equation used by the Center for Soil and Agroclimatic Research:

$$Wj = \frac{(n - rj + 1}{\sum(n - rj + 1)} \tag{3}$$

where:

Wj = normalized value;
n = number of subfactors (k = 1,2,3, ..., n);
rj = subfactor sequence position

After the weights of each factor and subfactor are known, then the values of each factor and subfactor weight are included in the WLC equation as follows:

$$WLC = \sum_{i=1}^{n} X_{ij} x W_{ij} \tag{4}$$

where:

WLC = weighted Linear Combination;
X_{ij} = degree of suitability of the jth factor/subfactor at the Ith location;
W_{ij} = weight of the jth factor/subfactor in the first location;
n = sum of factors

3.3. Geographic Information System (GIS)

A geographic information system (GIS) is software for collecting, storing, retrieving, and displaying spatial data originating from real-world reality (Burrough, 1986). GIS consists of a collection of users, applications, data, software, and hardware that work together to store, change, delete, and display data in geographic-based information. The data processed in GIS is in the form of geospatial data, namely spatial data and non-spatial data. Data related to geographic conditions, such as rivers, administrative areas, soil types, settlements, vegetation, and so on are forms of spatial data. While data in the form of text or numbers, which are usually called attributes, are forms of non-spatial data.

3.4. Overlay

In the GIS analysis stage, overlay is a crucial stage. The ability to stack one map graphic on top of another map graphic and see the results on a computer screen or graph is called an overlay. In other words, overlay is the process of layering a digital map and its properties onto another digital map, resulting in a composite map that combines attribute data from both maps.

3.5. Research flow chart

Our research was based on a sequence of stages and on the combination of GIS and AHP-inspired working methods, as illustrated in **Fig. 2**.

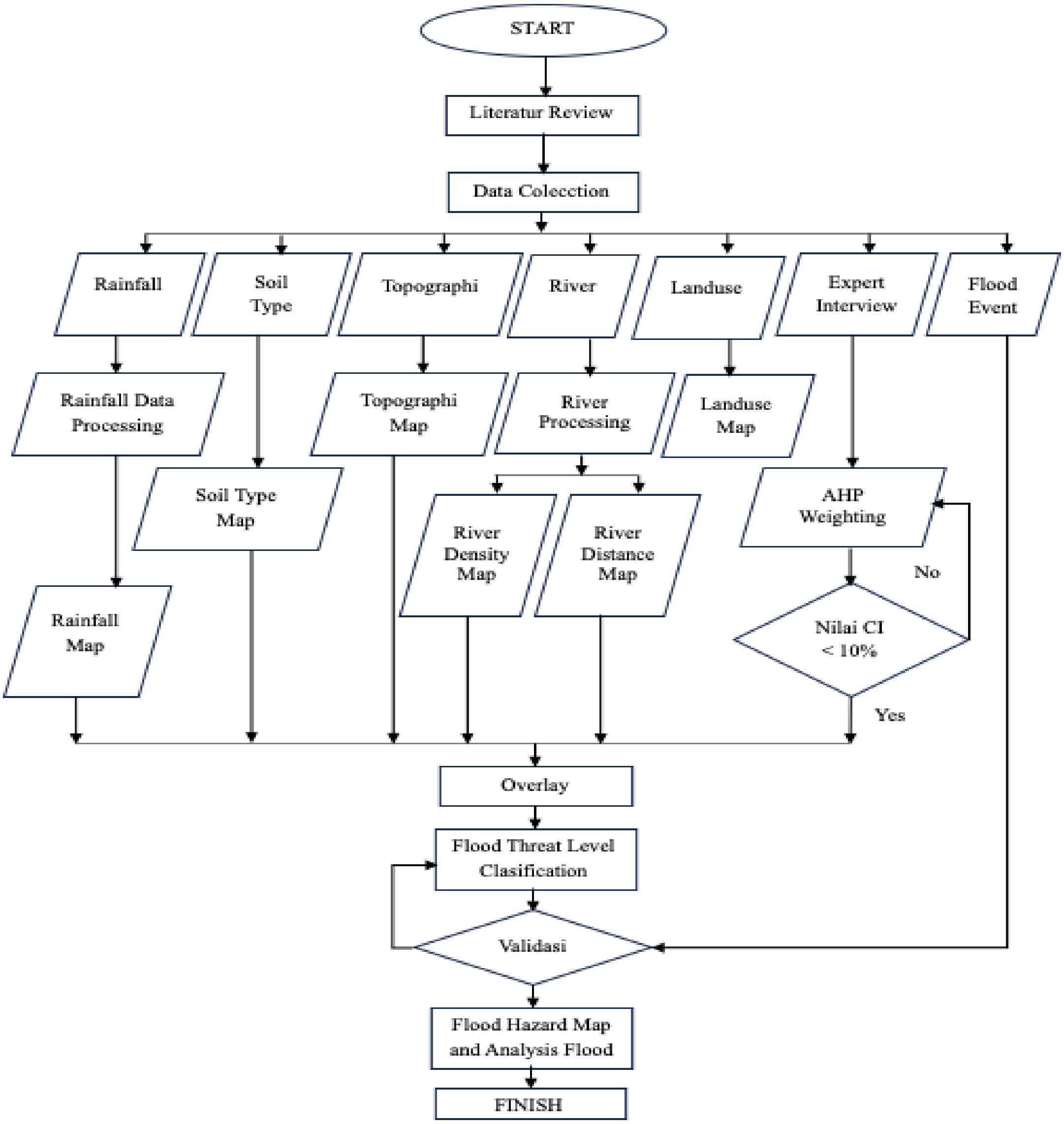

Fig. 2. Research flow chart.

4. RESULTS AND DISCUSSION

4.1. Analysis of Flood Disaster Occurrence

According to flood disaster data obtained from the West Lombok Regency Regional Disaster Management Agency, there were 59 flood incidents between January 2021 and February 2023. Of these, 39 villages across nine sub-districts were affected. The data is presented in **Table 3**.

Table 3.

Flood disaster occurrence per sub-district in West Lombok Regency for the period January 2021 – February 2023.

No.	Subdistrict	Number of Villages Affected	Number of events per year			Number of occurrences
			2021	2022	2023	
1.	Gerung	2	-	-	2	2
2.	Batu Layar	7	3	3	9	15
3.	Gunungsari	8	4	-	4	8
4.	Kediri	3	3	-	-	3
5.	Kuripan	-	-	-	-	0
6.	Labuapi	4	1	2	5	8
7.	Lembar	3	4	1	1	6
8.	Lingsar	3	3	-	-	3
9.	Narmada	2	1	-	1	2
10.	Sekotong	7	6	1	5	12
	Total Number of occurrences	**39**	**25**	**7**	**27**	**59**

Almost all sub-districts in West Lombok Regency experienced flood disasters from January 2021 to February 2023, except for the Kuripan Sub-district. Batu Layar District and Sekotong District occupy the top positions in terms of the number of flood disasters. Several villages in several sub-districts even experienced repeated flooding more than once, such as in Batu Layar Sub-district, Labu Api Sub-district, Lembar Sub-district, and Sekotong Sub-district.

4.2. Vulnerability Level Formation Analysis

This stage is carried out to calculate the level of influence of each factor that forms flood risk through the Analytical Hierarchy Process (AHP) analysis. To simplify and speed up the calculation and analysis process of weighting using Expert Choice 11 software. The assessment of the weighting of the flood vulnerability level in the Analytical Hierarchy Process (AHP) was obtained from primary data through questionnaires and interviews with several sources who are considered experts in determining flood threat parameters. The respondents selected came from several government and private agencies, namely: the Public Works Department, the Environmental Service, the Regional Disaster Management Agency, the Agriculture Service, and housing developers. The results of the Consistency Ratio (CR) from the sources show suitability. So, based on the AHP calculations that have been carried out, the weights per parameter are shown in **Table 4** below.

Table 4.

Scoring subfactors forming flood vulnerability.

No.	Factors and Subfactors	Sequence number	Dignity Values	Scor
1	**Land Slope**			
	0 – 3%	1	7	0.250
	3 – 8 %	2	6	0.214
	8 -15 %	3	5	0.179
	15 – 30 %	4	4	0.143
	30 – 45 %	5	3	0.107
	45 – 65 %	6	2	0.071
	> 65 %	7	1	0.036
2	**Land Use**			
	Water Bodies	1	6	0.286
	Rice Field	2	5	0.238
	Settlement	3	4	0.190
	Open Land	4	3	0.143
	Garden	5	2	0.095
	Forest	6	1	0.048
3	**Rainfall (mm)**			
	> 210	1	6	0.286
	190 - 210	2	5	0.238
	170 - 190	3	4	0.190
	150 - 170	4	3	0.143
	130 - 150	5	2	0.095
	110 - 130	6	1	0.048
4	**Soil Type**			
	Alluvial Brown-Gray	1	6	0.286
	Mediteran Chocolate Complex, Grey Grumusol, Chocolate Regosol and Litosol	2	5	0.238
	Mediterranean Brown and Mediterranean Scarlet Complexes	3	4	0.190
	Reddish-brown Lithosol and Mediterranean Complex	4	3	0.143
	Grey Brown Regosol and Litosol Complex	5	2	0.095
	Mediterranean Chocolate	6	1	0.048
5	**Distance to The River (m)**			
	0 - 50	1	7	0.250
	50 - 100	2	6	0.214
	100 - 150	3	5	0.179
	150 - 200	4	4	0.143
	200 - 300	5	3	0.107
	300 - 500	6	2	0.071
	> 500	7	1	0.036
6	**Elevation**			
	0 – 96	1	7	0.250
	96 – 235	2	6	0.214
	235 – 397	3	5	0.179
	397 – 600	4	4	0.143
	600 – 838	5	3	0.107
	838 – 1.186	6	2	0.071
	> 1.186	7	1	0.036

S*ource: analysis results (2024).*

4.3. Average Area Rainfall

Rainfall data is in the form of secondary data for recording rain events based on several observation stations, including Pelangan Station, Sekotong Station, Serumbung Station, Sesaot Station, Keru Station, Gunungsari Station, and Jurang Malang Station (**Table 5**). Rainfall data from several stations were obtained through the NT1 River Area Agency (attached). In the next stage, the secondary data is transformed into spatial data, where the maximum rainfall serves as a reference in determining the average rainfall based on the isohyet method (**Fig. 3**).

The isohyet method is used for mountainous areas with various elevation differences, this condition is under the description of West Lombok Regency. The average rainfall estimate on this method is based on lines with the same rainfall value. The lines are based on interpolation between rain observation stations.

Table 5.

Average daily rainfall.

Rainfall Station	Elevation	High Rainfall (mm)
Pelangan	37	166
Sekotong	35	113
Serumbung	10	120
Sesaot	302	173
Keru	476	213
Gunung Sari	138	146
Jurang Malang	445	199

Source: analysis results (2024).

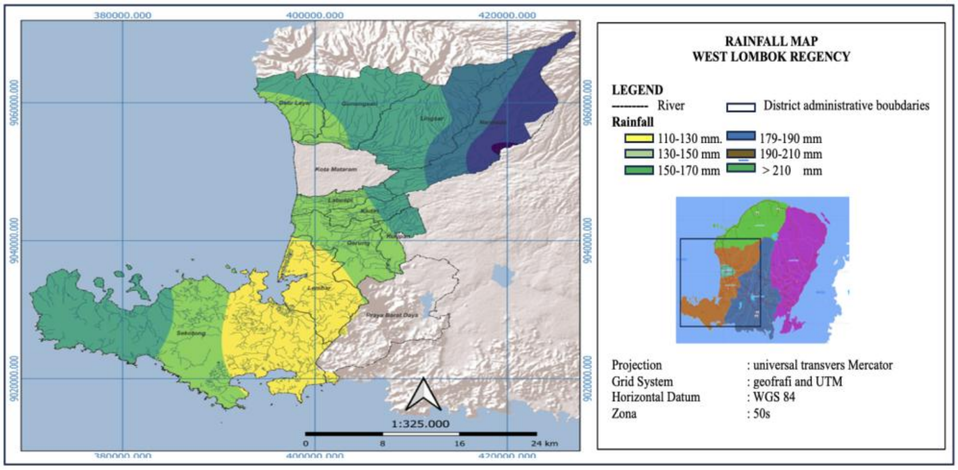

Fig. 3. Map of the distribution of height rainfall in West Lombok Regency.

4.4. Land use map

Land use as a parameter for forming flood vulnerability (**Fig. 4**) was obtained based on the processing of Sentinel-2A remote sensing image data (*data recording/acquisition in July 2023*) which was downloaded in a level-1C product through the USGS website (https://earthexplorer.usgs.gov/), where the data is geometrically and radiometrically corrected, so that the data is by the Top of Atmosphere (TOA) reflectant value. Another fundamental consideration in the selection of remote sensing data is the cloud cover on the image used by <10%; the data used has good multispectral quality (EOSDIS, 2021).

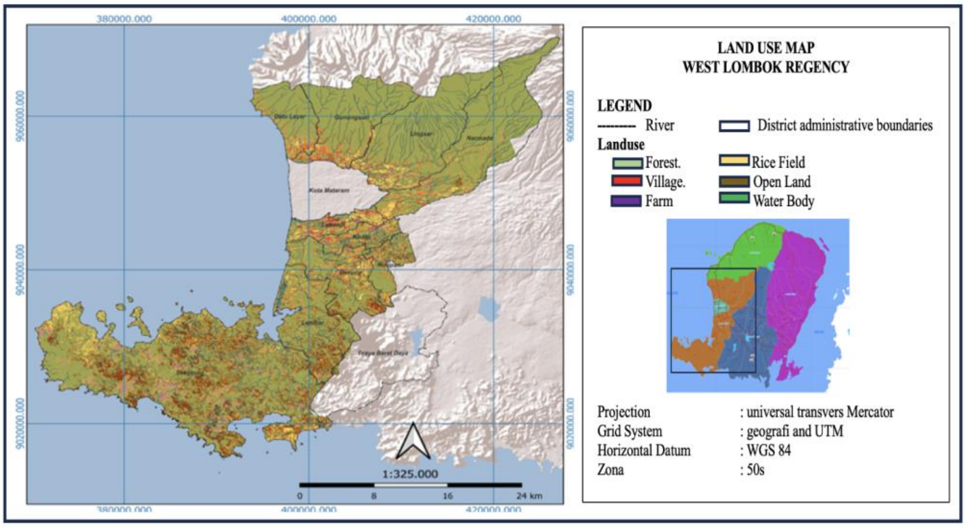

Fig. 4. Landuse map West Lombok Regency.

4.5. Distance to river

Distance data to the river as a parameter for shaping flood vulnerability is spatial data in the form of river vector data in West Lombok Regency (**Fig. 5**). The data is accessed and downloaded through the BIG (*https://tanahair.indonesia.go.id*) website. Processing distance data to rivers as a parameter for forming flood vulnerability, river data is processed using the Buffer feature which is one of the spatial analysis functions in QGIS software.

Through this analysis, river distance parameters are grouped into 7 classes starting from the closest to the farthest distance from the river boundary as follows: 0 – 50 m; 50 – 100 m; 100 – 150 m; 150 – 200 m; 200 – 300 m; 300 – 500 m; and >500 m.

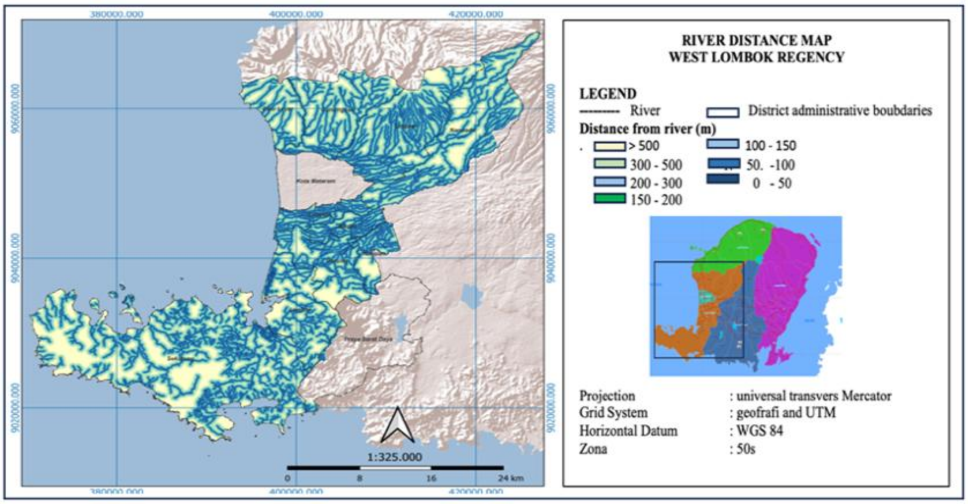

Fig. 5. Distance of the river map.

4.6. Land slope

The slope of the land as a parameter for forming flood vulnerability was obtained based on the processing of DEM (Digital Elevation Model) ALOS Palsar data downloaded through the ASF website (https://search.asf.alaska.edu/#/). To obtain slope maps, DEM data is processed using the Slope feature (**Fig. 6**), which is one of the spatial analysis functions in QGIS software.

In the next stage, slope reclassification is carried out based on slope classes. Map of the slope of West Lombok Regency, the slope classes are classified into 7 classes as follows; slope class 0 – 3%, slope class 3 – 8%, slope class 8 – 15%, slope class 15 – 30%, slope class 30 – 45%, slope class 45 – 65% and slope class > 65%.

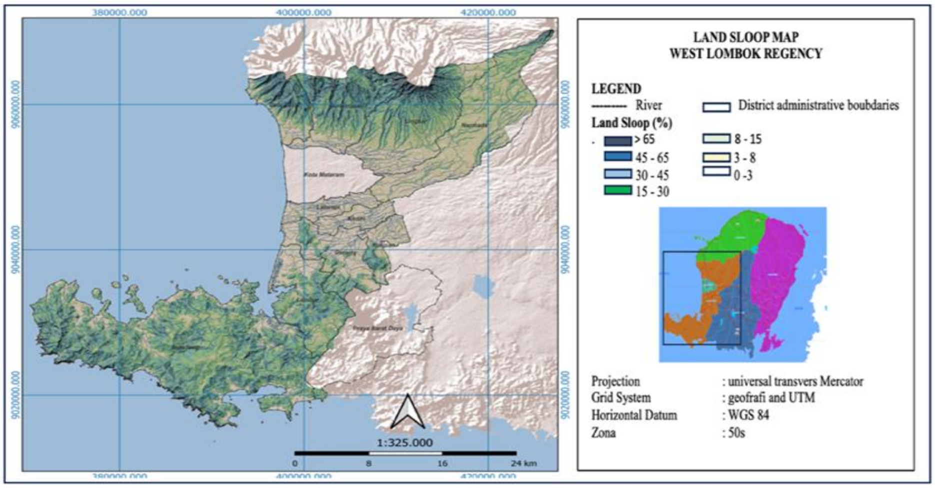

Fig. 6. Land slope map.

4.7. Type of soil

Soil type data as a parameter for forming flood vulnerability is spatial data in the form of vector data sourced from the NT1 River Area Agency. The processing of soil type data as a parameter for forming flood vulnerability includes cutting soil type data according to the scope of the research area, then at the stage of determining the weight and scoring, classification is carried out by considering the characteristics of soil types based on the formation process. An overview of the results of the classification of soil type characteristics. The soil type parameter class is classified into 6 classes covering the following areas:

1. Alluvial brown-grayish, covering a small part of Sekotong and Lembar Districts.
2. The Mediterranean complex of chocolate, gray grumose, brown regosol, and lithosol, covers most of the area of Sekotong District; part of Lembar District; and a small part of Gerung District.
3. The brown Mediterranean and reddish Mediterranean complexes cover a small part of the Kuripan District.
4. The reddish-brown lithosol and Mediterranean complex, cover parts of Gunungsari and Batu Layar Districts.
5. The regosol and lithosol complex, covering the entire area of Labuapi, Kediri, and Kuripan Districts; as well as most of the areas of Gerung District, Lembar District, Narmada District, Lingsar District, Gunungsari District and Batu Layar District.
6. Chocolate Mediteran, covers most of the areas of Narmada District, Lingsar District and Gunungsari District; and a small part of Batu Layar District.

4.8. Elevation area

Elevation as a parameter for forming flood vulnerability was obtained based on DEM (Digital Elevation Model) ALOS Palsar data, which was reclassified into elevation classes (**Fig. 7**). The higher the elevation of an area, the less chance of flooding in that area.

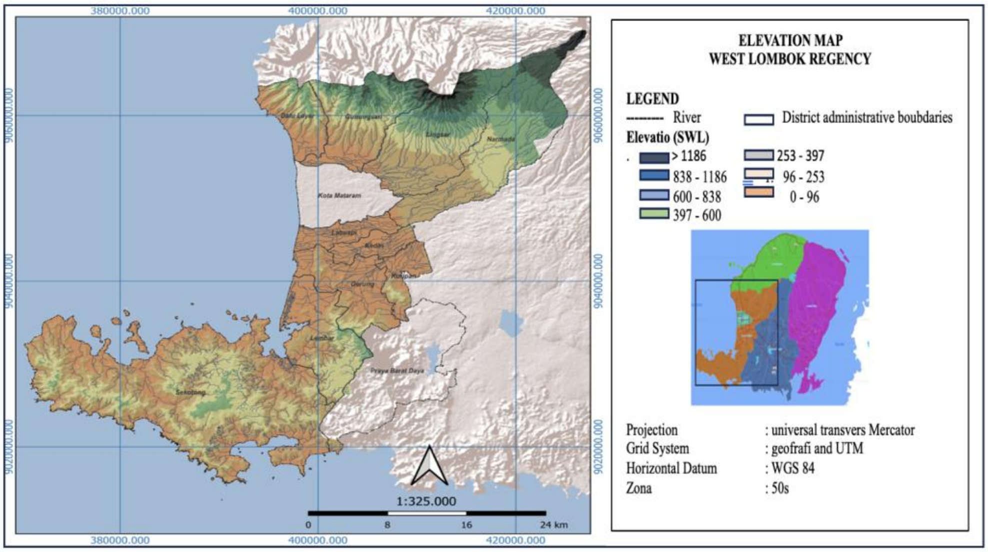

Fig.7. Map of elevation, West Lombok Regency

4.9. Flood vulnerability level

Flood-vulnerability maps with their vulnerability levels are obtained through the integration of flood-vulnerability shaping factors using MCE analysis into the Geographic Information System (**Fig. 8**). As a result of integration into the GIS, the event data was matched (validated) in the field to see the extent of the percentage of match between the flood-vulnerability map and the actual event data. Based on the results of the weighting of flood-vulnerability forming factors, the WLC equation can be written:

$$WLC = 0.0527X1 + 0.1210X2 + 0.1567X3 + 0{,}1660X4 + 0.1843X5 + 0{,}3190X6. \quad (5)$$

where:

WLC	= weighted linear combination
X1	= elevation
X2	= soil Type
X3	= slope Slope
X4	= distance to the River
X5	= rainfall
X6	= land Use

AHP weights were obtained by filling out questionnaires and interviews with sources considered experts in determining flood threat parameters in West Lombok Regency. The sources of this research came from several experts, namely from the Regional Disaster Management Agency, the Public Works and Spatial Planning Service, the Nusa Tenggara I River Basin Center, the Agriculture Service, and the Environmental Service. The consistency index (CI) value is 0.1, meaning that the inconsistency value (CR) is still below or equal to 10%, so that the criteria set by Saaty <10% indicates that the inconsistency that occurs is considered acceptable. Determination of flood vulnerability class is done using the equal interval method, namely dividing the highest vulnerability value minus the lowest vulnerability value by the number of class intervals (**Table 6**). The number of flood vulnerability classes is 5: not vulnerable, rather vulnerable, moderate, vulnerable, and very vulnerable.

Table 6.

Symbols and classification of flood vulnerability classes.

Symbol	Interval	Vulnerability criteria
	0.0129 – 0.0339	Not vulnerable
	0.0339 – 0.0549	Rather vulnerable
	0.0549 – 0.0759	Moderat vulnerable
	0.0759 – 0.0969	Vulnerable
	0.0969 – 0.1180	Very vulnerable

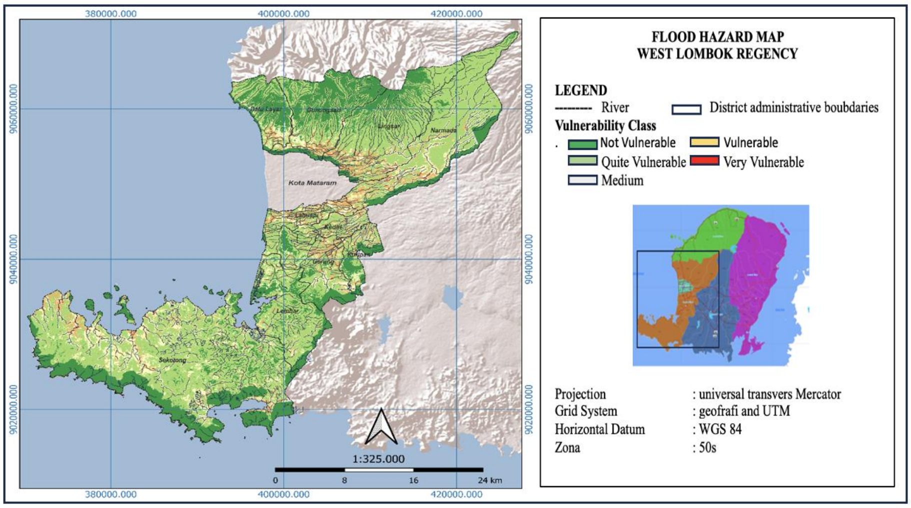

Fig.8. Flood vulnerability classes in West Lombok Regency.

4.10. Distribution of flood areas in West Lombok Regency

Almost all sub-districts in West Lombok Regency have experienced flood disasters in the two years January 2021 – February 2023, except for Kuripan District. Batu Layar District and Sekotong District rank at the top of the number of flood disaster events. Several villages in several sub-districts have even experienced repeated flood events more than once, such as in Batu Layar District, Labu Api District, Lembar District, and Sekotong District. Several sub-districts have become flood areas in the last three years, namely Batu Layar District, Labu Api District, Lembar District, and Sekotong District. Spatially, the distribution of flood events is presented in **Fig. 9**.

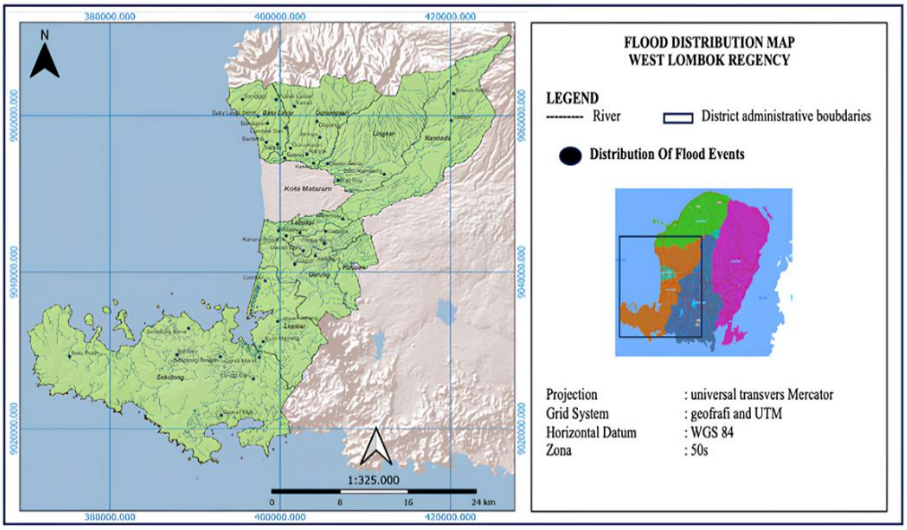

Fig. 9. Map of the distribution of flood Areas in West Lombok Regency.

4.11. Distribution of land use patterns in flooded areas

Based on data from the Sentinel-2/MSI remote sensing satellite acquired in July 2022, there are 6 classes of land use in West Lombok Regency, namely forests, settlements, gardens, rice fields, open land, and water bodies. Land use areas are generally dominated by forest areas with a percentage of area up to 70%, and cultivation activity areas such as rice fields with an area percentage of 12%, and gardens with a percentage of area of 10%.

The forest is an area with an area of 642,711 hectares, which dominates West Lombok Regency and is distributed into several sub-districts, including Sekotong, Narmada, Lingsar, Lembar, Labuapi, Kuripan, Kediri, Gunung Sari, Gerung, and Batu Layar. In more detail, the proportion of area and distribution of land use in West Lombok Regency are presented in **Fig. 10**.

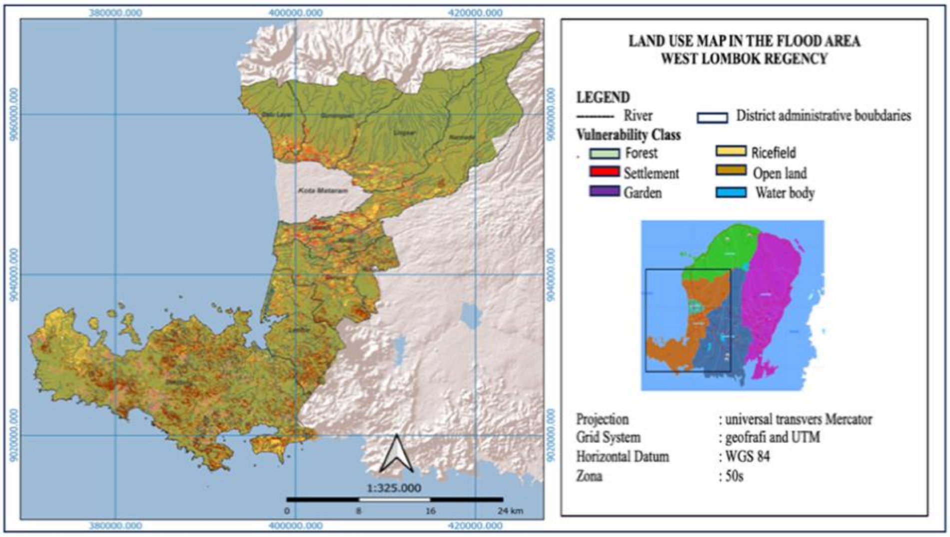

Fig. 10. Map of the spatial distribution of land use in West Lombok Regency.

4.12. Flood Event Validation

Validation of flood hazard maps is carried out by identifying the distribution of sub-districts based on potential hazard classes. The data used are in the form of disaster reports obtained from the West Lombok Regency Regional Disaster Management Agency. The distribution point of the incident is the incident data for each village affected in the period 2021 to 2023, which represents one village affected by the incident, which is the village centre point.

The approach used to determine the level of accuracy of the flood vulnerability map is by looking at the position of the flood event point from the Regional Disaster Management Agency flood disaster data for each vulnerability class on the map. The five flood vulnerability classes need to be grouped again into only 2 classes to adjust the characteristics of the flood incident data, which also consists of 2 (two), namely: there was an incident, and there was no incident.

The two new classes of vulnerability are the class with no potential for flooding (including: not vulnerable and rather vulnerable) and the class with potential for flooding (including: moderate, vulnerable, and very vulnerable). The results of the flood hazard map validation process with flood disaster data (**Table 7**) show that a total of 27 flood points fall into areas with the potential for flooding from the moderate, high, and low vulnerability classes. As many as 32 flood points fall into the non-high and low vulnerability classes.

Table 7.

Validation of hazard map with flood incident data 2017-2023.

Flood Vulnerability Class	Distribution of flood Vulnerability	
	Number of occurrences	Percent (%)
No potential for flooding	***32***	***54.24***
Not vulnerable	20	33.90
Rather Vulnerable	12	20.34
Potential for flooding	***27***	***45.76***
Moderately Vulnerable	10	16.95
Vulnerable	17	28.81
Very vulnerable	0	0.00
Total	**59**	**100**

Table 7 shows that 45.76% of flood disasters occurred in areas that are included in the flood potential class (which includes moderate and vulnerable vulnerability). The remaining 54.24% of flood incident points are included in the non-flood potential class (not vulnerable and rather vulnerable). Thus, this flood vulnerability map shows a level of accuracy that is close to sufficient when associated with the distribution points of flood incidents in West Lombok Regency.

5. DISCUSSION

Based on the scoring results shown in **Table 3,** of the scoring results on the slope factor, the flatter an area (0-3%), the higher the influence on the potential for flood-vulnerability formations, so the score given for flat areas becomes high, on the contrary, with the level of slope classification from flat to steep.

The highest rainfall factor in West Lombok Regency is at >210 mm per year while the lowest is at 110 -130 mm per year. The higher the rainfall in an area, the higher the level of influence on the formation of potential flood vulnerability, so the score given is also high.

The altitude factor in West Lombok Regency shows that the plains area is at 0 – 96 meters above sea level, while for high elevation areas, it is at >1,186 meters above sea level. The lower an area, the higher the potential for flood vulnerability, contrary to the level of altitude classification in West Lombok Regency. The distance to the river in West Lombok Regency, the closest distance is classified as 0 – 50 m from the river boundary line, while the farthest distance is> 500 m. The closer to the river, the higher the potential for flood vulnerability in an area, so the score given is also high, on the contrary, by the classification level of distance to the river in West Lombok Regency.

For land types and land use that are immeasurable factors, the consideration of scoring is carried out based on the characteristics of land use and the type of soil. Land use dominated by vegetation the less influence it has on the potential for flood vulnerability, but if an area is more open/unvegetated, covered with water, and built, the influence on the potential for flood vulnerability is higher. Likewise, the characteristics of soil types are seen from the formation process. Soil formed in floodplain areas will certainly have characteristics that are easily inundated with water, related to the texture of the soil that has absorbed water into the soil. Research on flood disaster risk mapping using the AHP method was conducted in the city of Pekalongan (Wijayanti et.al., 2024), showing that flood classification with high vulnerability occurs in residential locations with low elevations and very extreme changes in land use

Land use and elevation are two important factors that influence the level of vulnerability of an area to flooding. Land use patterns such as the conversion of natural land (forests, swamps, and agricultural land) into built-up areas (settlements, industry, and urban areas) reduce the soil's ability to absorb rainwater. Surfaces covered by layers of pavement, such as concrete and asphalt, increase the volume of surface runoff, thereby increasing the risk of flooding. Meanwhile, areas with low elevations, especially those close to rivers, floodplains, or coasts, tend to be more prone to flooding because gravity slows the outflow of water. Conversely, areas with higher elevations have a lower risk of flooding, although other factors such as extreme rainfall and poor water management can still increase vulnerability. The interaction between land use change and elevation factors often exacerbates the situation. In lowland areas that previously functioned as natural catchment areas, conversion into built-up areas without considering drainage aspects accelerates the occurrence of flooding even at moderate rainfall intensity. Therefore, land use management that takes elevation characteristics into account is a key strategy in flood risk mitigation. Analysis shows that in West Lombok Regency, there has been an increase in the distribution of flood risk areas and an increase in the frequency of flooding, especially in the Sekotong and Batulayar Districts

6. CONCLUSIONS

Based on the results of research conducted in West Lombok Regency, it can be concluded that:

The area in West Lombok Regency based on the potential level of flood vulnerability is dominated by the rather vulnerable class spread throughout the sub-district, namely 51.80 of the total area, not vulnerable by 22.84%, and ± 25%, the remaining 25% of the remaining areas are divided into the medium by 16.58%, vulnerable by 8.56% and very vulnerable by 0.21%.

The distribution of flood vulnerability based on land use in West Lombok Regency is divided into six classifications of land use, including forests, settlements, gardens, rice fields, open land, and water bodies. As for the classification of flood vulnerability, it is further grouped into two classes, namely the non-vulnerable class (not vulnerable and rather vulnerable) and the vulnerable class (moderate, vulnerable, and very vulnerable). Land use in the form of forests with a total area of 20.8% is included in the flood-vulnerability class, settlements with a total area of 48.3% are included in the flood-vulnerability class, gardens with a total area of 24.5% are included in the flood-vulnerability class, rice fields with a total area of 44% are included in the flood-vulnerability class, open land with a total area of 32.4% is included in the flood-vulnerability class, and the total area of water bodies of 24.8% is included in the flood vulnerability class.

The allocation of space in the spatial pattern plan has followed disaster-based planning, especially flood disasters, where 80% of the protected area is included in areas that do not / have less potential for flooding under its function as an area that protects the area under it. Likewise, 70% of the cultivation areas are located in areas that are free / less vulnerable to flooding.

The results of the analysis can provide a strong basis for the government in designing more effective flood disaster mitigation policies based on data. By mapping locations that have high levels of vulnerability, the government can carry out wiser spatial planning, such as limiting development in red zones and directing development to safer areas. And the results of this mapping can be used as an important reference in formulating regulations and revising development plans that are more resilient to hydrometeorological disaster risks.

The limitation of the study is in the validation of the results, where the data used for validation is only 3 years. This is because the recording of flood incident data carried out by the West Lombok Regency Regional Disaster Management Agency has only started in 2019.

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