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Spatial Analysis of Physical Characteristics of Mataram City Using GIS and Remote Sensing Techniques

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ABSTRAK

Studi yang dilakukan di kota Mataram bertujuan untuk menganalisis karakteristik geografis dan fisiknya menggunakan teknik SIG dan penginderaan jauh. Penelitian ini difokuskan pada topografi, hidrologi, dan klimatologi untuk memahami faktor lingkungan yang membentuk kota tersebut. Melalui analisis faktor-faktor seperti pola curah hujan, kemiringan lahan, dan penggunaan lahan, studi ini memberikan wawasan tentang ciri khas kota tersebut. Hasil penelitian menunjukkan bahwa Mataram memiliki iklim tropis dengan musim hujan dan kemarau yang berbeda, dipengaruhi oleh pola angin dan ketinggian. Pemeriksaan kemiringan tanah menunjukkan berbagai jenis medan di dalam kota, mulai dari daerah pegunungan hingga dataran. Penggunaan lahan dominan di Mataram ditemukan adalah pemukiman, dengan area terbatas yang dialokasikan untuk ekosistem pendukung. Temuan ini menekankan pentingnya praktik pengelolaan sumber daya yang berkelanjutan di wilayah perkotaan seperti Mataram, dengan menekankan kebutuhan akan pengambilan keputusan yang tepat untuk menjaga integritas lingkungan kota dan mendukung pertumbuhan penduduknya.

ABSTRACT

The study conducted on the city of Mataram aimed to analyze its geographical and physical characteristics using GIS and remote sensing techniques. The research focused on topography, hydrology, and climatology to understand the environmental factors shaping the city. Through the analysis of factors such as rainfall patterns, land slopes, and land use, the study provided insights into the city's unique features. The results revealed that Mataram is characterized by a tropical climate with distinct wet and dry seasons, influenced by wind patterns and elevation. The examination of land slopes indicated diverse terrain types within the city, ranging from mountainous to flat areas. The dominant land use in Mataram was found to be residential, with limited areas allocated for supporting ecosystems. The findings underscore the importance of sustainable resource management practices in urban areas like Mataram, emphasizing the need for informed decision-making to preserve the city's environmental integrity and support its growing population.

1. INTRODUCTION

Housing is a group of houses that functions as a residential environment or dwelling equipped with environmental infrastructure, which is the basic physical completeness of the environment, such as the provision of drinking water, waste disposal, availability of electricity, telephone, roads, which allows the residential environment to function properly (Nasution, 2019). The increase in residential development activities will be accompanied by a growing need for land that accommodates such development. Development activities are often limited by physical constraints, namely land quality (Guo & Jin, 2025; Jiang et al., 2025; Li et al., 2020). The limitation of land capability indicates that not all land utilization efforts can be supported by the land itself. Developing residential areas in inappropriate locations will endanger the surrounding environment as well as the lives of humans living in those residential areas.

According to (Baja, 2012), land identification becomes necessary when changes are to be made to land, both in terms of its structure and function. A process of identifying the potential and

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land use regarding its allocation and utilization must be adjusted to the land capability class and suitability, thus an initial assessment is needed as a description of a piece of land. Land suitability assessment can be made absolutely, but it can also be made based on the current condition of the land or based on the state of the land after major improvements, which can significantly change the characteristics of the land. In the development of new residential land, the characteristics of the land suitable for development must be known. The aim is so that the establishment of settlements can fulfill citizens' rights to adequate housing in a healthy, safe, harmonious, and orderly environment, as well as ensure the certainty of residence as regulated in Law No.1 of 2011 (Yumai, Y., Tilaar, S., & Makarau, 2019).

Development of settlements often encounters problems, namely the presence of physical limiting factors in the form of topography, geology, and hydrology. Determining the appropriate location for a settlement based on land suitability for habitation is important in the spatial aspect, as this will determine the durability of a building, its economic value, and reduce the impact of the settlement on the surrounding environment. (Foster, 2020; Nugroho et al., 2022; Yang et al., 2020). The selection of residential areas that do not match the suitability of the land will hinder the development of the settlement because the land has limiting physical factors, and if development in that area is allowed, it will impact both the durability of the buildings and the impact on the surrounding environment (Bazen et al., 2021).

Mataram City, as the capital of West Nusa Tenggara Province, is experiencing rapid development. The increasing population density is a result of urbanization and birth rates. This process, while bringing economic progress, also poses its own challenges, particularly concerning the utilization of residential space. The population in Mataram City also increases every year, with a population growth rate of 1.34% during 2020-2023 (Agustina, 2024; Ernawati et al., 2024; Suripto et al., 2021). This increase in population certainly results in a growing need for developed land.

Based on the Mataram City RTRW for the years 2011-2031, the population density in Mataram City is already very high, so the utilization of residential space will increase. This will certainly affect land use for residential areas in Mataram City, which is feared to experience a surplus. Based on data obtained from the Central Statistics Agency (BPS) of Mataram City in 2024, it is recorded that the area of Mataram City is 6,130 ha, while the residential land use in Mataram City reaches 2,508.48 ha. Rapid population growth, changes in settlement patterns, and pressure on environmental resources demand careful planning in utilizing residential land in Mataram City.

The high population and activity in Mataram City will, of course, also increase the demand for residential land. It is even feared that environmental degradation will occur if it is not managed properly. Therefore, this study aims to analyze the topography, hydrology, and climatology of Mataram City using Geographic Information System (GIS) and Remote Sensing techniques. It aims to understand the patterns of rainfall, land slope, and land use in Mataram City, as well as to provide insights into the unique characteristics of the city.

2. METHOD

The research method used in this study is a geographical analysis approach combined with remote sensing techniques. The geographical analysis approach is used to examine the physical characteristics of the Mataram City area, including aspects of topography, hydrology, and climatology, while remote sensing techniques are utilized to obtain satellite image data as a basis for spatial analysis. This study uses a combination of qualitative and quantitative data. Qualitative data is obtained through literature studies to understand environmental conditions and resource management in the research area, while quantitative data is obtained from processed satellite image results and climatological data used to analyze rainfall patterns, land slope, and land use (Strijker et al., 2020).

The data collection process is carried out through two main stages, namely satellite image analysis and literature study. Satellite image analysis is used to obtain spatial information such as land use and rainfall patterns, while literature study is conducted to supplement secondary data related to environmental conditions, climate, and natural resources in Mataram City.

Furthermore, data analysis is performed using Geographic Information System (GIS) software combined with remote sensing image processing techniques . The analysis stages include processing spatial data for regional mapping, analyzing land slope to understand topographic characteristics, analyzing rainfall to understand climatology patterns, and mapping land use to identify spatial utilization patterns in Mataram City. Through these stages, this research produces comprehensive spatial information regarding the physical characteristics of the area and their relation to resource management in the City of Mataram.

3. RESULT AND DISCUSSION

General Overview of Mataram City

Geographically, the City of Mataram is located at the western end of Lombok Island, precisely at the coordinates 116°04' – 116°10' East Longitude and 08°33' – 08°38' South Latitude. The City of Mataram has a land area of 61.30 km^2 (6130 Ha) and a water area of 56.80 km^2 (5680 Ha). Administratively, the City of Mataram is divided into six districts and 50 urban villages.

The administrative boundaries of Mataram City are as follows:

North: Gunungsari Subdistrict and Lingsar Village, West Lombok Regency

East: Narmada Subdistrict and Lingsar Village, West Lombok Regency

South: Labuapi Subdistrict, West Lombok Regency

West: Lombok Strait

The basic physical conditions of Mataram City can be understood from the topography, hydrology, geology, soil types, and climatology.

a. Topography

In general, the city of Mataram is at an altitude below 50 meters above sea level with an elevation range of 9 km. Meanwhile, in the coastal areas (Ampenan District and Sekarbela District) the altitude is around +5 meters above sea level. The topography with 0-8% slope is found in Ampenan District, Sekarbela District, and Mataram District. Meanwhile, the 10-15% slope is found in Cakranegara District, Selaparang District, and Sandubaya District.

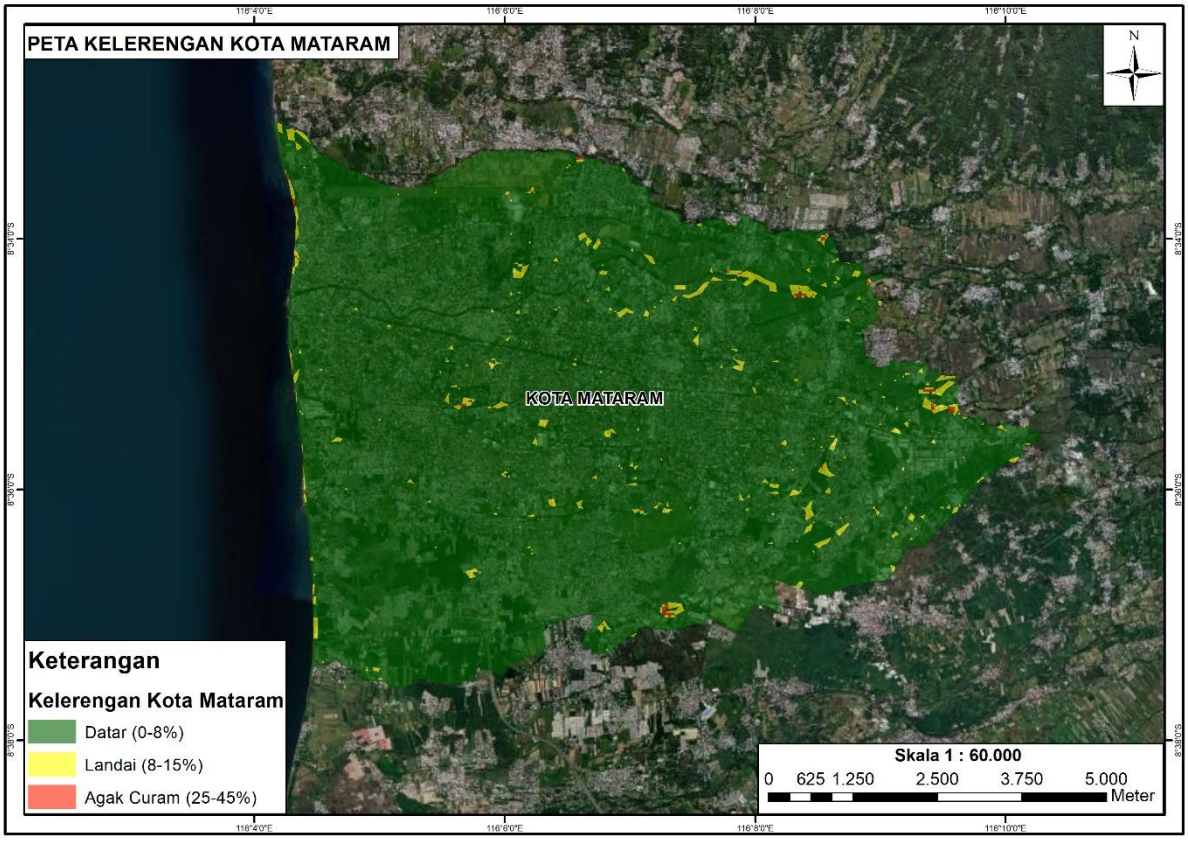
b. Hydrology

The city of Mataram is traversed by four major rivers that serve as the main drainage, namely the Jangkok River with a length of 86 km and an area of 1,712.12 Ha, the Ancar River with a length of 21 km and an area of 858.47 Ha, the Brenyok River with a length of 42 km and an area of 2,277.55 Ha, and the Midang River with a length of 26 km and an area of 562.47 Ha. The sources of these rivers are located around Mount Rinjani and they flow into the Lombok Strait.

c. Climatology

The city of Mataram has a tropical climate, with an average temperature ranging from 24-32°C and an average humidity of up to 75-85% per year. Generally, from April to October, dry winds blow from the southeast causing the dry season, while from November to March, winds carrying water vapor blow from the northwest direction which causes the rainy season. During the rainy season, wind speeds are quite high, while during the dry season, wind speeds are lower. The rainfall in Mataram City is 1,256.66 mm/year with a relatively consistent number of rainy days, namely 110 days/year. The highest rainfall was recorded in December at 302 mm, and the highest number of rainy days also occurred in December with 29 days.

Slope Map of Mataram City



Land slope is the difference in certain heights in the relief of a landform. Determining the average land slope for each mapping group can be done by establishing connections between points. The length of a line indicates the same steepness. Land slope indicates the character of the area that must be considered in land use directions. The land slope in each area varies, but generally can be classified into several groups. Land slope is influenced by the elevation of the land relative to the sea because the closer it is to the sea tends to become flatter, the land slope classes are divided into five types as follows:

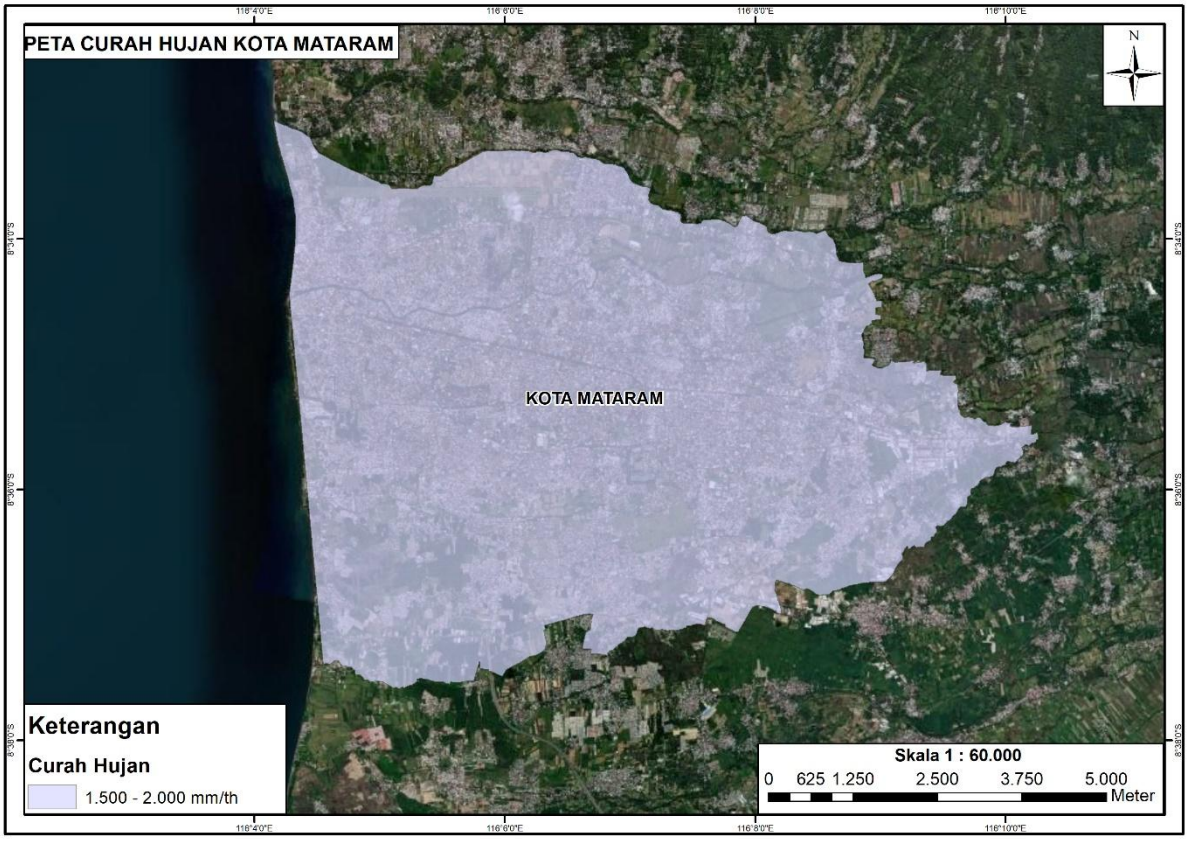
a. Mountainous with a slope of more than 45% (greater than 24°)
b. Hilly with a slope of 25-45% or 14°-24°
c. Undulating with a slope of 15-25% or 8°-14°
d. Gentle with a slope of 8-15% or 5°-8°

Flat with a slope of 0-8% or 0-5°. Most of the Mataram City area is lowland, while the northern part consists of mountainous and hilly terrain. Overall, the topography of Mataram City is at an elevation below 50 meters above sea level with an elevation range of 9 km. This condition shows that most of Mataram City is flat (98.07%), gently sloping (1.81%) and somewhat steep (0.12%). Therefore, based on the slope data analysis in the ArcGIS application, Mataram City is very suitable to be developed into an urban area intended for residential and regional economic centers.

Table 1. Distribution of Land Slope Classes in Mataram City

Slope of Mataram City		
Class	Area	Percentage (%)
Flat	5871,67	98,07
Gentle slope	108,58	1,81
Somewhat steep	7,25	0,12
Total	5987,50	100,00

Rainfall Map of Mataram City



According to Climatology Station I, the average air temperature in Mataram ranges around 28.65 ˚C. The average air humidity varies at 78.59%. The highest rainfall in 2021 was recorded in December at 344.00 mm, and the month with the most rainy days was recorded in January, November, and December with 27 days. Months with monthly rainfall >200 mm/month occurred in November, December, January, February, and June. Based on Oldeman climate classification, these months are categorized as wet months. In the Oldeman climate classification, a wet month is defined as a month with rainfall >200 mm and a dry month <100 mm. In the following Table 2.4, data on monthly rainfall over the past 6 years is presented. From the table, it can be seen that the number of wet months varies each year, so the rainfall for the city of Mataram falls into the Moderate category.

These seasonal changes and rainfall will affect the flow and quality of surface water (rivers) and groundwater. Because the groundwater in Mataram City and parts of Lombok Island are within the same groundwater basin system, rainfall in other parts of Lombok Island will also influence the groundwater flow in Mataram City. The same applies to the river flow passing through Mataram City, since the river's upstream is located at the foot of Mount Rinjani and passes through other regencies on Lombok Island (Firdaus et al., 2024).

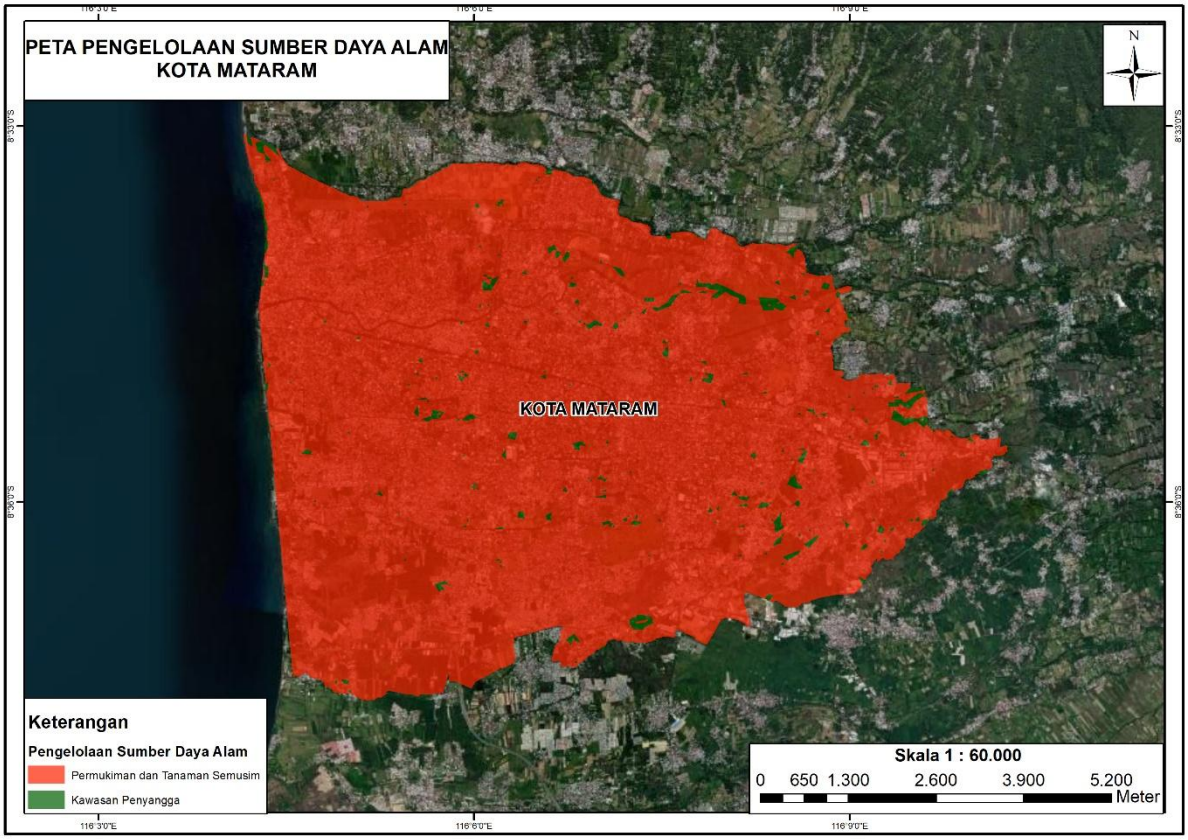
The dry season is characterized by a lack of rain or only a little rain. During this period, the groundwater table continues to decline due to the reduction of groundwater storage through groundwater flow into rivers, groundwater extraction from wells, and transpiration that takes water from the capillary zone. Meanwhile, at the beginning of the rainy season, part of the rainfall will become interception water that immediately evaporates, and part will be stored and infiltrate into the soil. Surface runoff almost does not occur during this period. This is because the rainfall that falls wets the soil, seeps in, and fills the soil pores that were empty due to groundwater exploitation.

Table 2. Annual rainfall amount in Mataram City from 2016 to 2021

No	Bulan	2016	2017	2018	2019	2020	2021
1	January	360,00	250,00	449,00	259,00	182,20	259,00
2	February	294,00	403,00	227,00	104,00	150,80	309,00
3	March	158,00	138,00	176,00	314,00	273,80	173,80
4	April	297,00	262,00	95,00	144,00	214,10	109,00
5	May	146,00	194,00	18,00	63,00	173,60	144,50
6	June	211,00	163,00	41,00	8,00	37,70	323,00
7	July	65,00	40,00	1,00	13,00	13,30	0,00
8	August	38,00	-	12,00	-	65,90	41,00
9	September	195,00	115,00	89,00	-	51,50	65,00
10	October	243,00	211,00	55,00	-	213,20	126,50
11	November	504,00	473,00	361,00	95,00	281,90	291,40
12	December	323,00	158,00	149,00	200,00	203,70	344,00
Mataram City		**236,20**	**218,80**	**139,40**	**133,33**	**155,12**	**182,18**

Source: BMKG West Lombok Station in the Mataram City BPS. Unit in millimeters (mm).

Natural Resource Management Map of Mataram City



The land use pattern of Mataram City tends to develop in a linear, concentric, and partial manner. The development of a linear pattern is a land use that follows the existing road network, such as in the commercial service areas of Mataram City along Yos Sudarso Street – Langko Street – Pejanggik Street – Selaparang Street – Sandubaya Street, also known as the Ampenan-Mataram-Cakranegara route. The development of a concentric pattern is land use supported by a road network in a grid or clustered form. This type of land use can be found in the Cakranegara area and its surroundings. Meanwhile, the partially developed land use pattern is found in Rembiga

Village, the northern part of Sayang-sayang, Jempong Baru Village, Pagutan, and the residential center in Bertais. Since 1980, built-up areas have remained concentrated in the areas of Ampenan, Mataram, Cakranegara and have expanded radially following the main city routes. However, over the last 10-20 years, the development of built-up areas has begun to spread from the city center to the outskirts. This is due to the very limited availability of vacant land in the city center, with a pattern of concentrated built-up area development.

Table 3. Land Use Distribution in Mataram City

Fungsi	Luas	Persen
Permukiman dan Tanaman Semusim	5843,08	98,17
Kawasan Penyangga	109,17	1,83
Total	5952,25	100,00

Thus, it can be seen in the table above that the management in Mataram City is predominantly intended for residential areas and partially intended for buffer zones for the livelihood of the people of Mataram City. In the process of analyzing resource management in Mataram City, three main components are involved (slope, soil type, rainfall) each given weighting (weight) as follows: slope factor = 20, soil type = 15, and rainfall intensity = 10. The parameter scores according to the rules above for each component factor are as follows:

Table 4. Classification and Land Slope Score Based on Minister of Agriculture Decree No. 837/Kpts/Um/11/80

Kelas	Kelas	Tingkat Kelerengan	Skor
I.	Datar	0 % - 8%	20
II.	Landai	8 % - 15%	40
III.	Agak Curam	15% - 25%	60
IV.	Curam	25% - 40%	80
V.	Sangat Curam	> 40%	100

Slope class score according to Minister of Agriculture Decree Number 837/Kpts/Um/11/80 (processed).

Table 5. Rainfall Classification and Scores Based on Minister of Agriculture Decree No. 837/Kpts/Um/11/80

Kelas	Kepekaan terhadap Erosi	Jenis Tanah	Skor
I.	Rendah/ tidak peka	Alluvial, Tanah Glei, Planosol, Hidromorf kelabu, Laterit air tanah	15
II.	Sedang/ agak peka	Latosol	30
III.	Tinggi/ kurang peka	Kambisol, Mediteran, Tanah Brown Forest, Non Calcic Brown	45
IV.	Sangat tinggi/ peka	Vertisol, Andosol, Grumusol, Laterit, Podsol, Podsolik	60
V.	Amat sangat tinggi/ sangat peka	Litosol, Organosol, Rendzina, Regosol	75

Scores of each soil type class according to the Minister of Agriculture Decree Number 837/Kpts/Um/11/80 (processed)

Kelas	Tingkat Curah Hujan	Curah Hujan	Skor
I.	Sangat Rendah	< 13,6	10
II.	Rendah	13,6-20,7	20
III.	Sedang	20,7-27,7	30
IV.	Tinggi	27,7-34,8	40
V.	Sangat Tinggi	> 34,8	50

The rainfall score of each class according to the Minister of Agriculture Decree Number 837/Kpts/Um/11/80 (processed)

4. CONCLUSION

The city of Mataram has a topography dominated by lowlands, but there are also some mountainous and hilly areas in the north. The majority of Mataram is at an elevation below 50 m above sea level, with variations in slope that affect land characteristics. Rainfall in Mataram has a variable pattern, with the highest rainfall recorded in December. This indicates the importance of understanding rainfall patterns in the management of natural resources and the environment in the city. Land use in Mataram City is dominated by residential areas and seasonal crops, indicating that most of the area is used for residential and agricultural purposes. However, there are also buffer areas that are important for maintaining environmental balance. Analysis of slope data, soil types, and rainfall is an important factor in natural resource management in Mataram City. By taking these factors into account, sustainable and environmentally conscious management can be carried out.

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