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ANALYSIS OF CARRYING CAPACITY FOR SETTLEMENT LOCATION BASED ON SPATIAL PLANNING IN EAST SERANG

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ABSTRACT

The problem of land conversion for industrial areas is a phenomenon that occurs in many cities, including East Serang. This phenomenon is a reference in the importance of calculating carrying capacity, settlement capacity and projecting settlement land needs until 2045. The research is located in part of the East Serang area in the settlement spatial pattern, with the research objective: a) analyzing land capacity, b) analyzing the carrying capacity and settlement capacity, and c) determining the distribution of locations that have high carrying capacity and settlement capacity. The approach of this research is quantitative with technical analysis: a) processing through mapping software, b) determination of land capability scale, and c) calculation of carrying capacity and settlement capacity. The results of the research show that: a) the ability class of the East Serang area in the settlement spatial pattern is divided into two, namely medium and high development ability, b) carrying capacity and settlement capacity in the research areas can still be developed into research locations, and c) areas that have high carrying capacity and settlement capacity, namely Kopo and Pamarayan sub district.

***Keywords**: Carrying Capacity,Geographic Information System, Land Capability, Spatial.*

INTRODUCTION

A house is a primary need that is highly valued. Demand for housing is increasing every year, but there is limited land available. This is due to the increasing rate of population and land conversion to encourage economic activities. A study is required to calculate the space requirements for settlements and predict trends so that the direction of planning and determining the function of the area is right on target.

Serang Regency is one of the largest areas in Banten Province. This region consists of 29 sub-districts. The direction of development of the Serang Regency area is regulated in Regional Regulation Number 5 of 2022. The Regional Regulation describes the designation of regions based on their functions. This research study focuses on the location of East Serang. Based on Regional Regulation Number 5 of 2020, East Serang is designated as a

Regency strategic area in the form of an industrial zone.

The location of the East Serang industrial zone covers Cikande, Kibin, Kopo, Binuang, Bandung and Jawilan sub-districts. The demand for residential needs in industrial areas is directly proportional to the region's development as an industrial location. Workers usually buy land or build houses near their workplace to reduce the distance between their residence and work location in the industrial area. The Regional Regulation of Serang Regency Number 5 of 2020 contained in Article 68 paragraph 8 (i) regulates that it is permissible to carry out low-income community development conditionally and still maintain its spatial utilization function in the form of an industrial area.

The East Serang area, designated as a residential area, consists of the sub-districts of Bandung Binuang, Carenang, Cikande, Ciruas, Jawilan, Kibin, Kopo, Kragilan, Lebakwangi, Pamarayan, and Tunjungteja. The Regional Regulation of Serang Regency No. 5 of 2020 states that almost all sub-districts in the East Serang region are designated as residential areas. Although most of the East Serang region is designated as a residential area, in building housing, it still considers the direction of the utilization of spatial functions regulated by legislation.

The actual condition shows a problem with land conversion for industrial estates, which impacts the reduction of land availability for settlements in East Serang. The high demand for housing will ignore the carrying capacity and capacity of the environment, which has the potential to cause ecosystem degradation and imbalance in space utilization. An analysis of land suitability and carrying capacity is carried out for sustainable development. Prediction of future residential land needs for the East Serang area is carried out so that growth is more planned and minimizes environmental damage, such as soil degradation, water quality decline, and increased disaster risk, can improve.

The theory of land suitability and carrying capacity is the basis for spatial management (Muta'ali, 2015), and it can be applied in the East Serang area. Land suitability assesses the physical suitability of an area for settlement development based on biophysical parameters such as morphology, slope stability, foundation stability, disaster risk, and water supply. This ensures that development is carried out on land with optimal potential and minimal risk to support sustainability. The calculation of carrying capacity is used to evaluate the capacity of the region to support human activities without damaging the environment by considering the availability of resources such as water, space, and infrastructure. Meanwhile, the capacity ensures that human activities do not exceed the maximum capacity of the environment, thus maintaining a balance between development and ecosystem sustainability. To strengthen the study, it also considered the prediction of the need for residential land.

The results of research from Ernamaiyanti and Yunanda (2019) predict that in 2030, the Banten Province can provide residential needs, but especially for the Serang Regency, it is not capable of being a residential location. This research examines the carrying capacity and capacity in East Serang using a new approach and a narrower scope, focusing on the settlement pattern area and considering the function of space utilization, namely residential areas, concerning the general provisions of zoning regulations contained in the Regional Regulation of Serang Regency Number 5 of 2020.

RESEARCH METHODS

The type of study used includes descriptive research and quantitative methods. The method is based on secondary data collected from government agencies. The data types are spatial data in shapefile format, statistical data, and local regulation documents. Secondary data includes land use, geology, soil type, rainfall, slope, and population data. The data is processed using Geographic Information System software with overlay analysis and assessed to produce land capability units. The conduct of this research is from June to August 2023. The study location is visualized in Figure 1.

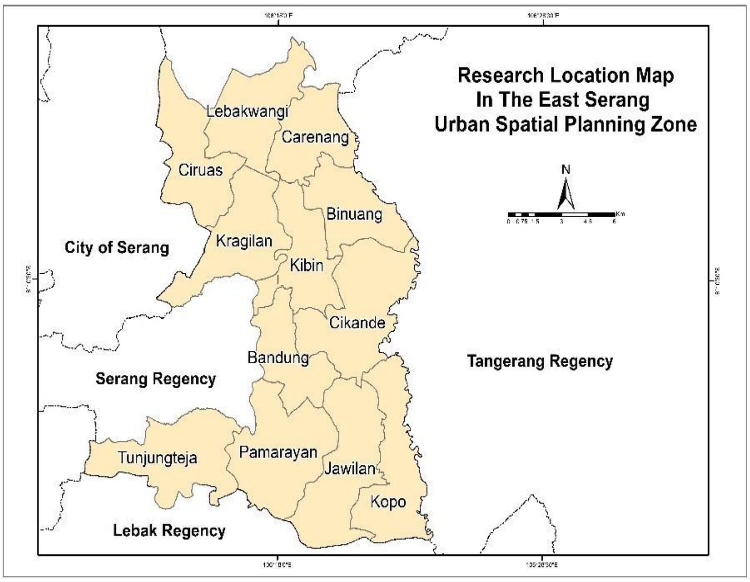

Figure 1. Research Location Map

The stages of this research data processing are as follows: (a) overlay and weighting analysis to determine the scale of land capability, and (b) calculation of carrying capacity.

The reference for assessing land capability unit parameters is based on the Minister of Public Works Regulation No.20/PRT/M/2007 concerning technical guidelines for analyzing physical, environmental, economic, and socio-cultural aspects of preparing spatial plans. Land capability is used to select locations that are suitable for settlement. Land capability units in settlement development are divided into five classes, as shown in Table 1. On the other hand, the process of this research is depicted in the following Figure 2.

Table 1. Classification of Land Suitability

Class	Score	Classification of Settlement Development
A	32-58	Under development
B	59-83	Lack of development
C	84-109	Intermediate development
D	110-134	Adequate development
E	135-160	Enhanced development

Source: Minister of Public Works Regulation Number 20/PRT/M/2007.

The location determination is used to measure the carrying capacity of the settlement. In this analysis, it is necessary to determine the population projection in the specified time. The equation is as follows: $Ps = Pb\ (1+r.t)$

Description of Formula, this population that has been projected is a location that can support the population in the future. The formulas are as follows:

PS : Total population in year s
Pb : Total population in the first year
r : The population growth rate
t : Range of time between starting year and years

Source: (Muta'ali, 2015).

The classification of carrying capacity is as described below; 1) DDPm > 1 are areas that can be used as settlement sites, 2) DDPm = 1 is the area equal to the total number of people living in the neighborhood, and 3) DDPm < 1 is an area that can no longer sustain the population in that location.

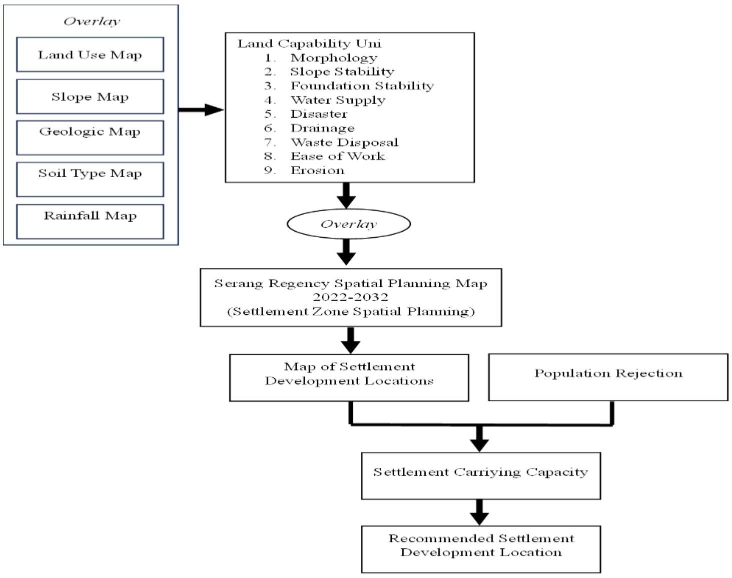

Figure 2. Flowchart

RESEARCH RESULTS AND DISCUSSIONS

Analysis of Land Capability Unit

The land capability of the settlement location provides a baseline for assessing the land's carrying capacity by observing the constraining factors and as a basis for developing the area according to its function. (Pratiwi et al., 2023; Widyastuti, 2020). Land capability units are a consideration for residential development in an area. The components that compose land capability consist of nine assessments, namely morphology, slope stability, foundation stability, water supply, disaster, drainage, waste disposal, erosion, and ease of work.

Morphology

Morphology describes the physical condition of the land. This can be seen in land use and slopes. If the slope value is low, morphology is characterized as very well. Development of settlements on low slopes means the risk of disasters such as landslides is very low. The development of settlements in locations with steep slopes or uphill areas requires a great deal of attention because of the specially characterized terrain of hilly areas and the wide variety of soil layers. As the location is vulnerable to landslides, an in-depth study on the safety of house construction is required. (Lashari, 2011). The morphology class has a slope of >40% (mountains/very rugged hills). The slope of the morphology class is 25-40% (mountains/escarpment).

The study area's morphology describes the land's diverse physical conditions, with flat and undulating types. On-site research shows that the area with flat morphology has an area of 15,291 ha, while the undulating area covers 41 ha. Locations with slope values of 0-8% and 8-15% are classified as very good for settlement development because the risk of disasters such as landslides is very low, as shown in Figure 3. On the other hand, areas with a slope of >40% are included in the very steep category, which is more suitable for use as a protected area because it has minimal residential development capabilities.

A low slope supports construction safety and reduces the risk of landslides. Locations with a slope of >40% must be protected, and when used as a settlement, studies related to soil structure and building foundations must be conducted (Lashari, 2011). This argument is strengthened by the findings of Aldiansyah et al. (2023), which shows that areas with high slopes have a high risk of disaster and are recommended to be managed as protected areas.

Slope Stability

The slope's sustainability describes the land's condition to determine whether the land is robust in resisting the weight of the building. The results from the overlay analysis are moderate and high slope stability located on flat and sloping morphology. The type of soil in this location is alluvial and podzolic. Alluvial soil is suitable for settlements. The podzolic soil type is less suitable for residential locations. It is unsuitable for a residence because it is poorly fertile, unyielding, and susceptible to erosion. The slope of the topography, situated on a flat and undulating topography, is a consideration for the area to be used as a settlement site. Topography has a significant role in determining ecological sensitivity (Hermawan & Rudiarto, 2023).

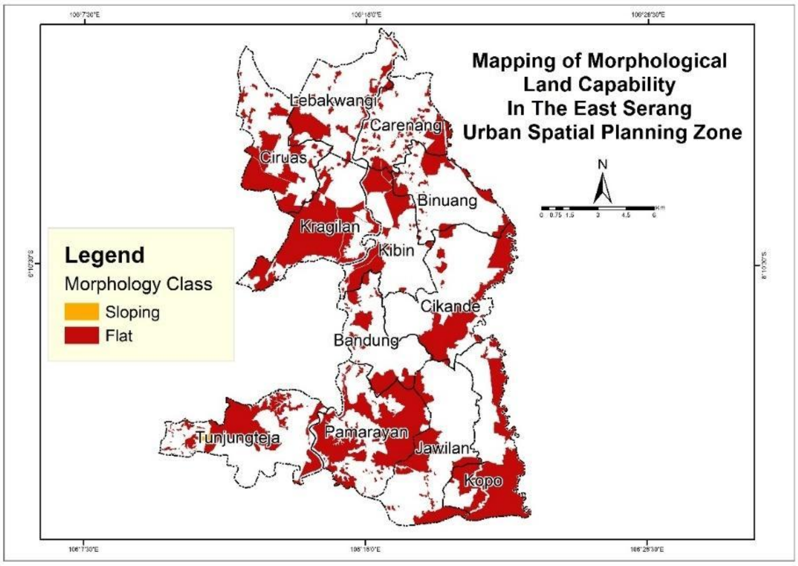

Figure 3. Mapping of Morphological Land Capability

From data processing, two classifications were identified, namely high and moderate slope stability. Higher slope stability means that settlement development does not require engineering and saves costs. Adequate slope stability facilitates the construction of buildings without the need for structural engineering, making it more cost-efficient. This argument is in line with the findings of Ali et al. (2021), who stated that areas with low slopes are more feasible for settlement development because of the lower risk of disasters. The land capability map of slope stability in this study is presented in Figure 4.

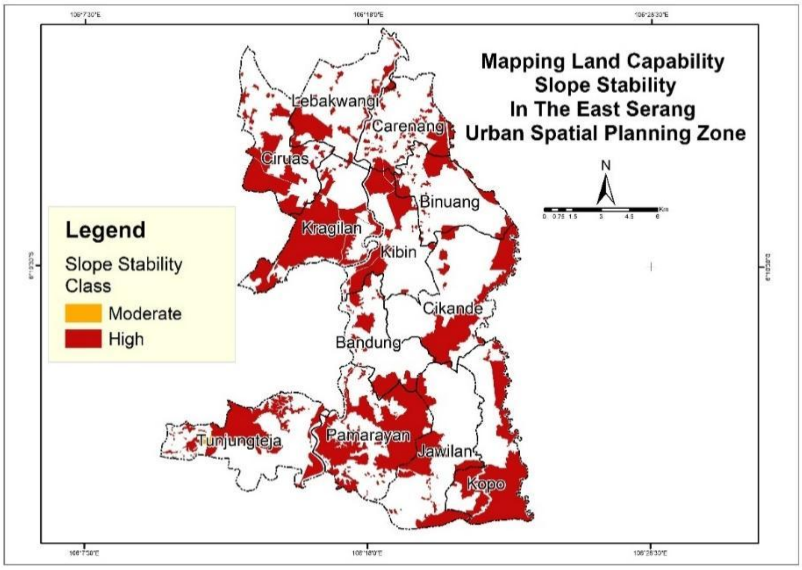

Figure 4. Mapping Land Capability Slope Stability

Foundation Stability

This assessment aims to determine the quality of soil-bearing capacity to withstand heavy construction for urban development and the various types of foundations for each grade. The parameters to be considered in foundation stability include morphology, slope, elevation, and soil type. A solid foundation minimizes the risk of damage due to earthquakes or other disasters so that buildings are more durable and can reduce the potential for casualties (Ihsan, 2017). The results of the data processing are displayed in Figure 5. Based on the foundation stability map (Figure 5) shows that the area with medium foundation stability is 10,844.36 m², larger than the high foundation stability, which covers 4,487.41 m². The higher the stability value of the foundation, the more suitable an area is (Sari & Halil, 2021).

Based on the study's results, the foundation's stability in the research area has two classifications: medium and high classes. Areas with high foundation stability are ideal for urban development because they minimize the risk of structural damage, especially in disaster-prone areas. However, areas with moderate stability still require additional analysis to ensure that the planned construction can adapt to the characteristics of the soil to support safe development. This is in line with the findings of Haeri and Fathi (2015), which stated that the interaction of soil and structure determines the stability of the foundation, especially in soft soil types.

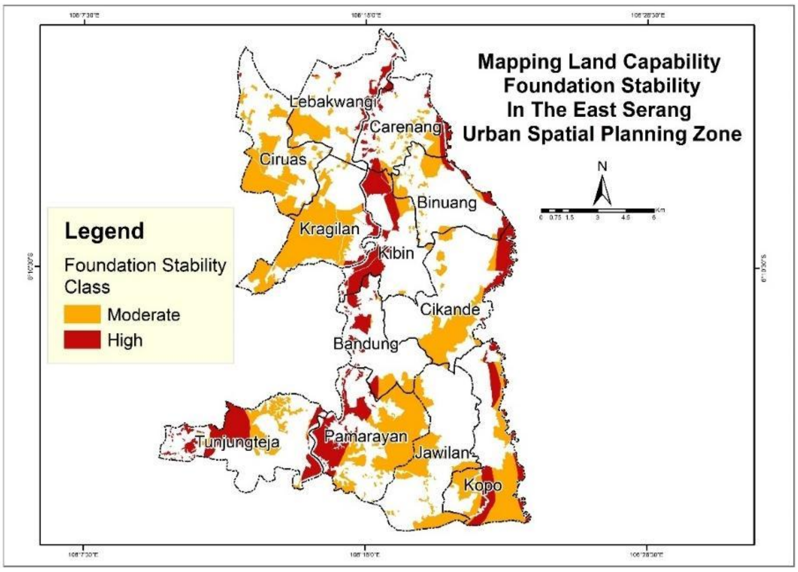

Figure 5. Mapping Land Capability Foundation Stability

Water Supply

Available water is a water source (Sari et al., 2011). Water resources are important for the living needs of the population because water is needed continuously for a sustainable life (Kumalajati et al., 2015). The development of settlements impacts the land's ability to absorb and keep water, thus affecting the availability of water (Awaludin, 2022; Pertiwi et al., 2021). This analysis is to determine the capacity of the area to provide water in each location of the area. At the research site, several small rivers and reservoirs provide water sources for their residents, but their capacity and distribution vary depending on the presence of water sources and the quality of the soil for absorption. The results of the analysis show that water availability at the research site is divided into two classes, namely medium and high. Figure 6 shows the spatial distribution of water availability, which is influenced by the ability of land to absorb and store water (Dewi et al., 2012). Considerations regarding water availability are articulated by Sutikno (2017), who states that the imbalance between water availability and demand will trigger water crises in various regions. Therefore, water management must be carried out to maintain water availability in the future.

Disaster

Disasters result from the interaction between natural phenomena and human and environmental vulnerabilities (González & London, 2021). This analysis is to identify the state of the land in response to disasters. It aims to detect the location of land early with the potential for disaster occurrence to prevent damage to buildings with hazard mitigation. The land is in the low class for disaster capability at the research site. A lower grade means the location has a reduced potential for natural disasters, and the area is suitable for housing and the construction of settlements.

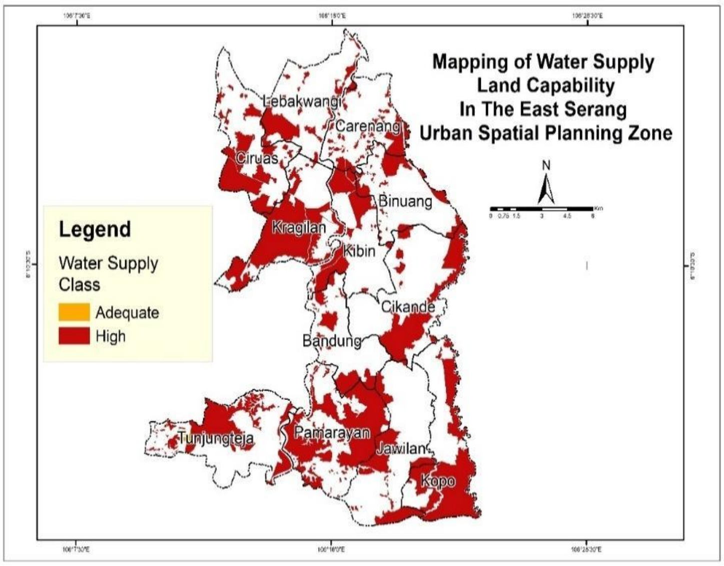

Figure 6. Mapping of Water Supply Land Capability

Based on the disaster risk map, as shown in Figure 7, the East Serang area has a low land slope, soil with good water absorption, and is far from active fault zones. Therefore, this area is suitable for housing and settlement development so people can live safely. In line with the findings of Hadi et al. (2023), it shows that areas with low slopes are more suitable for settlement development.

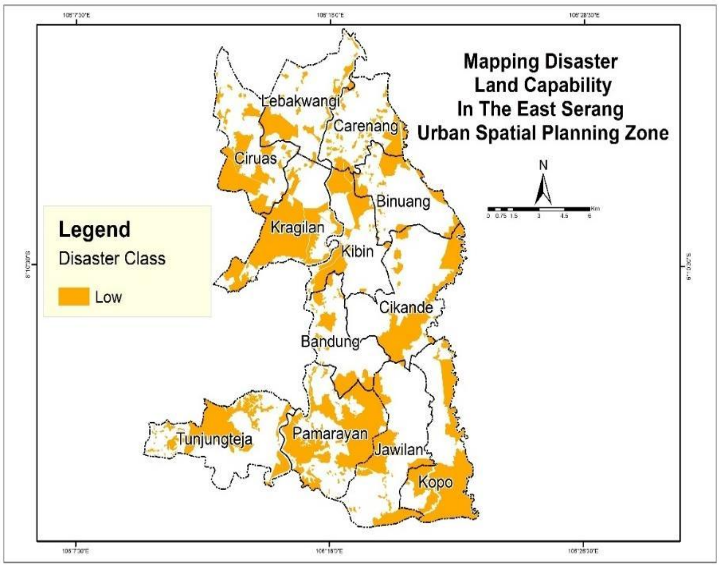

Figure 7. Mapping Disaster Land Capability

Drainage

Drainage can prevent many problems, including soil erosion, flooding and waterlogging, and damage to residential buildings. Especially in the case of urban environments, the problems caused by drainage are inundation and flooding. This is due to 1) changes in land use that affect the amount of flood discharge, 2) soil types that have low permeability conditions resulting in less than optimal rainwater catchment, 3) location of the territory in the basin area, 4) there are channels caused by buried garbage (Supriyani et al., 2012). The drainage in this study is in moderate and high classes, as displayed in Figure 8. Higher drainage is usually found in flat areas with a small river network and no inundation, and it is supported by the ability to absorb rainwater. The drainage area is adequately located on undulating terrain and functions as a water catchment area, and the density of the river is dense.

Trijeti and Liestyowening (2021) stated that good drainage reduces flood intensity and controls waterlogging during high rainfall. A well-planned drainage system can reduce infrastructure damage and prevent the risk of adverse disasters. The following research should include rainfall as a parameter of land drainage capability. Rainfall is considered during drainage engineering, especially in urban areas. Rainfall is used to estimate the flood discharge plan so that flooding will not occur during the rainy season.

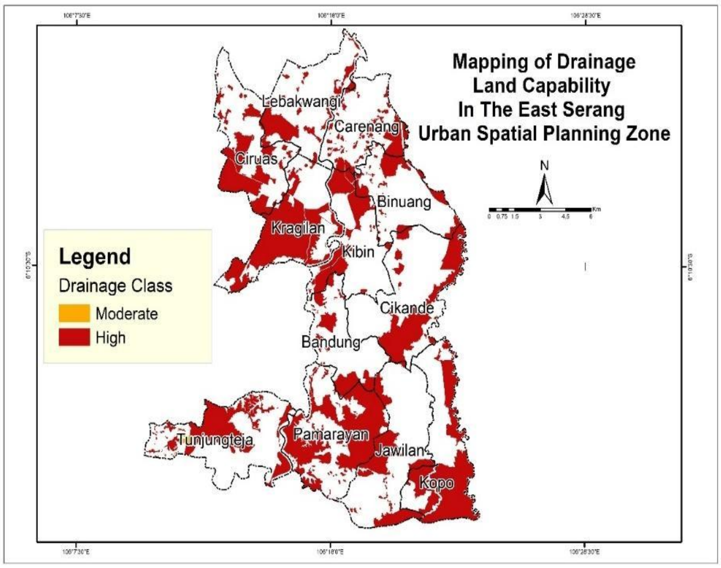

Figure 8. Mapping of Drainage Land Capability

Waste Disposal

Human settlement development is inseparable from the study of environmental management. A significant problem in many neighborhoods is waste disposal. Hazardous waste disposal must be considered because it will cause contamination of the environment, thus damaging the surrounding ecosystem. Planning locations for residences considers the conditions for sewage disposal. Parameters for assessing waste disposal include slope, rainfall, altitude, and land use. The condition of waste disposal at the research site is shown in Figure 9.

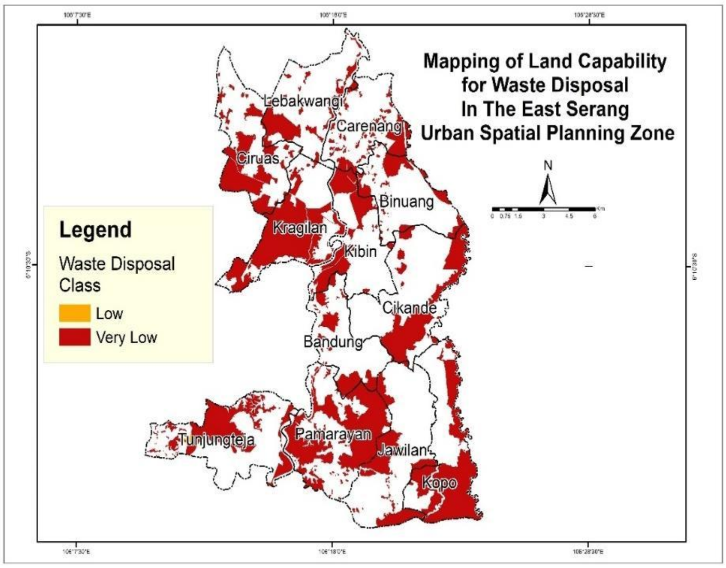

Figure 9. Mapping for Waste Disposal

The results of this process show that in the study locations, most waste disposal is classified as low and very low. Very low waste disposal means that household waste is very low. A wastewater disposal system is required for residential areas in the township planning. Household waste is called domestic waste. The wastewater originating from settlement sites is domestic effluent. Two types of domestic waste disposal systems are localized and centralized. Septic tanks exemplify local disposal systems. On the other hand, a centralized disposal system transports wastewater to a disposal site according to quality standards (Mende, 2015). Widyarani et al. (2022) stated that selecting an appropriate waste disposal system through local systems, such as septic tanks or centralized systems, is needed to ensure good sanitation quality and minimize negative environmental impacts.

Erosion

Erosion is a condition of surface soil erosion due to runoff and rainwater factors that are influenced by rainfall erosivity, soil erodibility, slope, vegetation, and conservation (Sukriyanti, 2010). An analysis of erosion is used to estimate whether the study field has the potential to cause damage. Erosion hurts the environment. In the East Serang area, dominated by dense residential areas, the erosion rate tends to be low compared to hilly areas. Visualization of the results of erosion is given in Figure 10. The state of erosion is a risk factor for the security and sustainable development of urban areas, so disaster mitigation is required for settlements located on hills (Lasaiba, 2023).

Erosion is moderate in areas with a hilly topography with an 8-15% slope. This area is not densely settled or spread out. A low erosion rate can be found in areas with 0-8% slopes or the plains. It has a medium to high population density. The findings of Mujiyo et al. (2021) show that the steeper the slope, the more and more the speed of surface flow increases, thereby increasing the kinetic energy and the ability to transport soil particles that increase erosion. In addition, Tarigan and Mardiatno (2019) stated that a steeper slope will accelerate the flow of the surface so that erosion will increase.

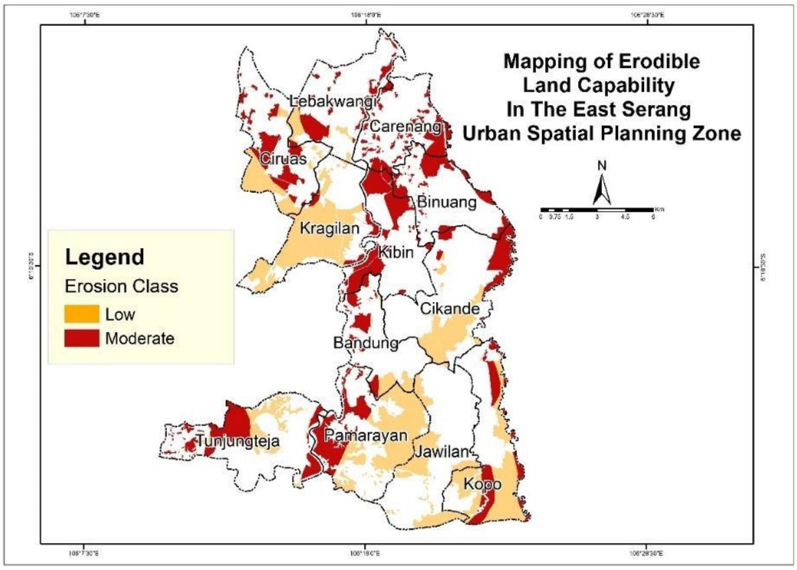

Figure 10. Mapping of Erodible Land Capability

Ease of Work

Easements are made to determine whether the land is challenging to build settlements on and to determine techniques for excavating the land, so it is easy to build a building. The results are reported in Figure 11. This study classified the land capability unit of easy workability as high. The location can be developed as a place to live. This is in line with the findings of Kudiai et al. (2024), which show that most of the areas in the study site have high land suitability for settlement.

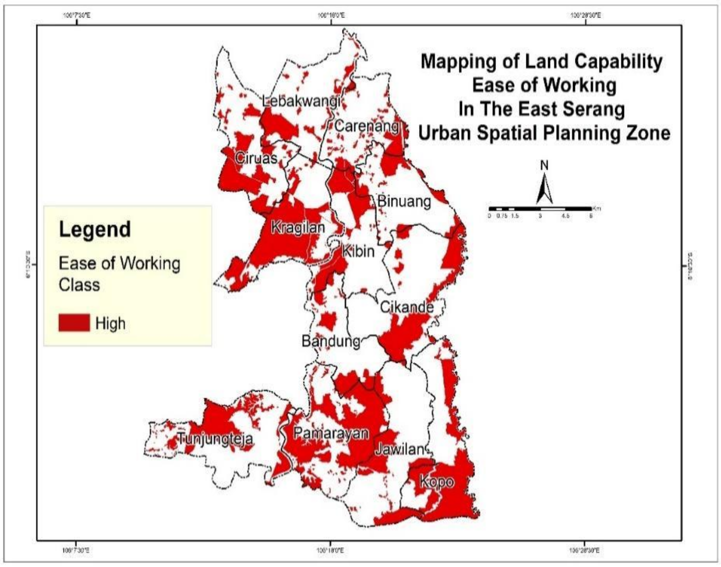

Figure 11. Mapping Land Capability Ease of Working

The results obtained of the nine processes described are all overlaid and produce a land capability map. From the overlay process, there are two classes of land capability: moderate and higher. Based on Figure 12, the higher development capability class has a larger area than the moderate category. The area of the higher development capability class is 15256 ha. The capacity of the developing moderate class is 42 ha. The land capability map in Figure 11 is used as a reference for determining settlement carrying capacity.

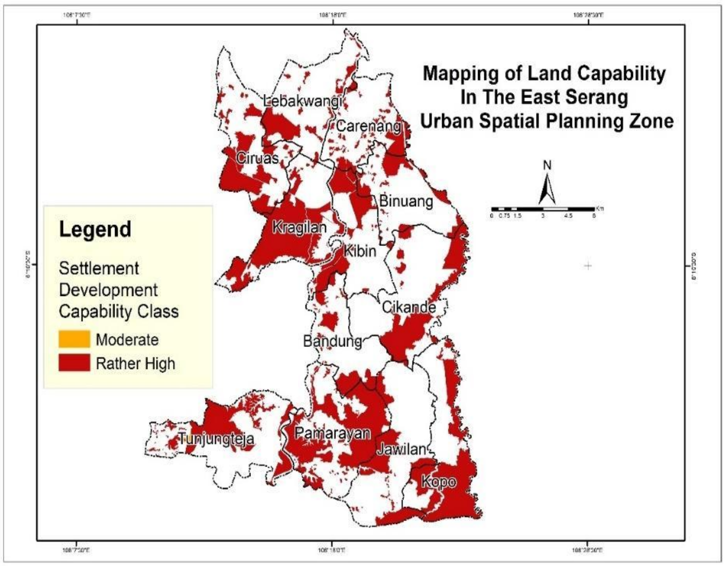

Figure 12. Mapping of Land Capability

Settlement Carrying Capacity Analysis

Increasing demand for residential housing affects land use change and environmental sustainability. Required analysis to measure the potential of the land for residential use (Paddiyatu et al., 2022). Carrying capacity involves biophysical, economic, social, and cultural features. "Carrying capacity" is defined as the amount of population and human activities at various scales of intensity that can be supported by land resources, which include economic, social, technological, and environmental aspects (Shi et al., 2019). The carrying capacity of urban areas means that the land resources of an area support the population on a continuously growing and expanding level of economic and social growth (Tsou et al., 2017). The parameters needed to determine the carrying capacity include the number of residents and the land area that qualifies for housing construction. The population in this study is the result of a projection. More details on population projections from 2025, 2030, 2035, 2040, and 2045 are explained in Table 2.

Table 2. Carrying Capacity Result

District	Capacity of Settlements					Average
	2025	2030	2035	2040	2045	
Bandung	5	4	4	3	3	4
Binuang	8	8	8	9	9	8
Carenang	6	5	5	4	4	5
Cikande	4	4	4	3	3	4
Ciruas	6	5	5	4	4	5
Jawilan	6	6	5	5	5	5
Kibin	7	7	8	9	10	8
Kopo	13	13	12	11	11	12
Kragilan	10	10	9	9	8	9
Lebakwangi	7	7	7	7	6	7
Pamarayan	14	12	11	9	8	11
Tunjungteja	11	9	8	7	7	8

Source: Data processing results, 2023.

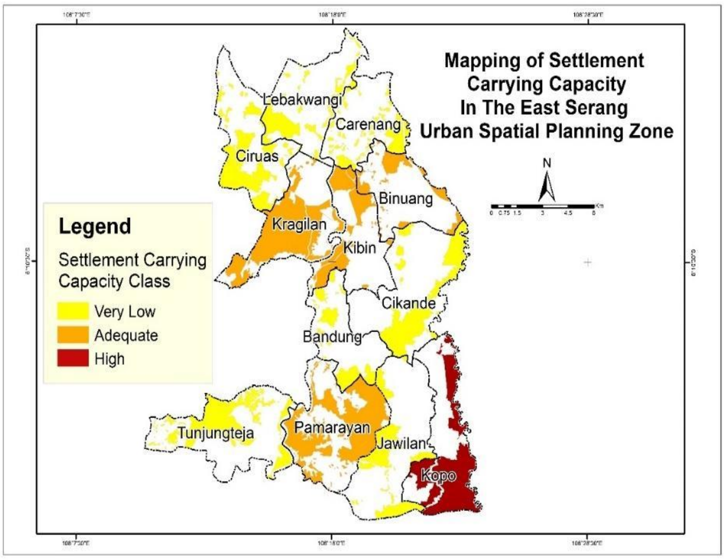

Figure 13. Mapping of Settlement Carrying Capacity

Analysis of land capability and suitability for living settlements should be considered. Although an area can be used to allocate people's living space, the land is rarely suitable for a residential building. Land suitability is to predict the area that can be used to resettle and consider the site's physical characteristics, such as rock mass movement, rock weathering, and depth of groundwater level (Sari, 2013).

CONCLUSION

This study concludes that the land capability class in the East Serang Area in the spatial pattern of settlements is divided into medium and high development capabilities. Most of the land in this area is highly suitable for residential development, with the carrying capacity of settlements still suitable for construction. Research locations with high residential carrying capacity scores are in the Kopo and Pamarayan Districts. The land capacity in this area is also quite large. The suggestions that can be put forward from the research results are that it is appropriate to implement effective and efficient space management so that settlement development remains in line with future needs and does not ignore environmental elements.

RECOMMENDATIONS

This research needs further physical studies related to predicting carrying capacity. In addition, rapid land use conversion to support the prediction of settlement location requires land use and land cover analysis.

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