Study of Environmental Carrying Capacity for Settlement Development in Ranah Batahan District, Pasaman Barat Regency

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Abstract. This study aims to determine the evaluation of land suitability in the development of settlements, the carrying capacity and the capacity of the environment for settlements, as well as the direction of settlement development in Ranah Batahan District, West Pasaman Regency. Data collection techniques include observation data, remote sensing data, Bappeda, BPS, interviews, and documentation. The sampling technique of this study was Total Sampling. Data analysis techniques used GIS analysis and Analytical Hierarchy Process. The results showed that: (1) land suitability for the development of settlement in Ranah Batahan District resulted in 4 classes of land suitability. Very suitable land consists of 9 land units, suitable land consists of 19 land units, land suitably consists of marginal land consists of 3 land units, unsuitable land consists of 8 land units. (2) the carrying capacity of land in the two Rural in Ranah Batahan District is very low. The carrying capacity of the land in Rural Desa Baru is 0.026 and in Rural Batahan 0.048, this means that the land here is less able to support livelihoods in the area. The capacity of the land obtained results of 0.555. The population of the region has exceeded the carrying capacity of the environment (beyond the threshold); (3) Direction for Settlement Development produces policy priorities. The results obtained are: a) developing settlement locations based on land suitability, b) tightening IMB, c) availability of land for settlements, d) suppressing population growth rates, e) managing settlement development effectively and efficiently.

1. Introduction
The problem of settlement has long been a concern because it has a broad dimension of problems along with socio-economic development and regional growth. In-Law Number 4 of 1992 concerning residential housing article 29 states that every citizen has the same and broadest rights and opportunities to participate in the construction of housing and settlements [2]. Thus every citizen has the right to receive services for housing needs. Therefore, meeting the needs of housing and settlements is a demand and the needs of the people of Indonesia.

The increase in population requires expansion of land as a means for activities that will later grow and develop. If the development is not well controlled, land conversion can occur for activities that are not in accordance with the functions and carrying capacity that will have an impact on reducing the carrying capacity of the environment. Population growth that is not balanced with the availability of land causes many residents who use disaster-prone land as residential land. Utilization of disaster-prone areas as settlements is a form of mismatch in land use.

Ranah Batahan Subdistrict is one of the Districts located in West Pasaman. In recent times, when the rainy season comes, it often results in frequent floods, especially in the District of Ranah Batahan. Almost every year the Batahan River overflows and floods the central and downstream regions. Based on data from the Regional Disaster Management Agency in 2017 floods began to hit Ranah Batahan District in several places starting from April. In April 2017 floods hit the Silaiyang and Tamiang regions, then in May floods again hit the Tamiang region. Then in September, floods hit the Ranah Batahan Subdistrict precisely at Jorong Sukorejo. The biggest flood occurred in October 2017 that hit most of the areas of Ranah Batahan including Simpang Tolang, Paraman Sawah, Kampung Baru, Kampung mosque, Air Napal, Simpang Tolang Baru. Impacts caused by this flood include the collapse of roads between several
jorong, flooding settlements, and damage to agricultural land. The most severe impacts caused by floods that occurred in October, namely 14 houses severely damaged, 15 houses slightly damaged, 76 houses were flooded, and community agricultural land was flooded.

Changes in land use that are not in accordance with the function of land use will put pressure on existing natural resource ecosystems. If the pressure exceeds the carrying capacity, there will be environmental degradation problems, such as floods, erosion, landslides and other environmental damage. According to Law No. 32 of 2009 concerning environmental management, the carrying capacity of the environment is defined as the ability of the environment to support the lives of humans and other living things. The previous law, namely Law Number 23 the Year 1992 concerning the environment, distinguishes the carrying capacity of the environment into the carrying capacity of nature, the capacity of the built environment, and the capacity of the social environment as follows: (1) carrying capacity of the natural environment is the ability of the natural environment along with all its elements and sources to sustainably support the lives of humans and other creatures. (2) the capacity of the built environment is the ability of the man-made environment to meet the lives of the population. (3) the capacity of the social environment is the ability of humans and different population groups to live together as a harmonious, balanced, orderly and peaceful society.

The importance of this research was carried out based on the discussion above there were several problems, namely: a) population growth, b) flood disasters due to overflowing Batahan rivers, c) damage to human settlements due to flooding, and d) land availability issues. Based on these problems in order to direct the use of residential land in accordance with the carrying capacity of the environment, it is necessary to study the environmental carrying capacity of residential areas located in the District of Ranah Batahan and to know the direction of settlement development.

2. Methods
This research was conducted in the District of Ranah Batahan, West Pasaman Regency, West Sumatra Province. Geographically Ranah Batahan District is located at longitude 99 ° 19 ' to 99 ° 35 ' East Longitude and 00 ° 33 ' North Latitude to 00 ° 19 ' South Latitude. For more details, see the map of the following research locations:

![Figure 1. Research Location in Batahan Rahan Regency](image)

The types of data in this study are primary and secondary data. Primary data in this study include drainage, gravel, texture, effective depth, slope, and AHP assessment data, while secondary data in this study is the data on flood slopes of land area and population.
Data analysis technique; 1) Land suitability for residential areas based on USDA (1971), [3], namely: slopes, floods, drainage, gravel, texture, and effective depth. Land suitability classes for settlements can be divided into four categories: very suitable (S1), suitable (S2), marginal (S3), and Inappropriate (N). Land unit map is obtained from the overlay thematic map, namely: slope map, land type map, and landform map. The slope map is produced from the Digital Elevation Model (DEM) using the Arc Secon Shuttle Radar Topography Mission (SRTM) image with a scale of 1: 25,000. The soil type map is derived from soil maps scale 1: 250,000 to scale 1: 25,000. Landform maps are produced from topographic maps and geological maps. Overlay of the map produces a map of land units.

Zoning of land suitability for settlements can be determined using the formula proposed by Dibyosaputro [1], namely:

\[ I = \frac{c - b}{k} \]

Description:
I = large class interval
K = number of classes desired
b = lowest number of scores
c = highest number of scores

Based on the results of the calculation of the intervals, the suitability level of land for settlements is divided into 4 zones, which are very suitable, Suitable, marginal and Inappropriate. Land suitability interval classes are presented in the following table:

| Adaptability Class | Interval Class | Suitability Index for Residential Areas |
|--------------------|---------------|----------------------------------------|
| Very suitable (S1) | 270.8 – 307.7 | The settlement zone is very suitable    |
| Suitable (S2)     | 232 – 268.9  | The settlement zone is suitable         |
| Marginal (S3)     | 196 – 231.9  | The zone of settlement is marginally appropriate |
| Inappropriate (N) | 159 – 195    | The settlement zone is not appropriate   |

Source: Analysis of Research Results Data, 2018

Determination of the carrying capacity of the area for settlements can use the equation. The carrying capacity of the area for settlements uses the equation: The carrying capacity of settlements (CCS) is generated from the area of land suitable for settlements (ASS) divided by the population (P), and divided by the coefficient of need area (needs).

\[ CCS = \frac{ASS/P}{\dot{a}} \]

Description:
CCS = the carrying capacity of the settlement
P = population
\dot{a} = constant
ASS = area of land suitable for settlement (m²)
Based on the regulation of the State Minister of Public Housing No.11/Government regulation/M/2008 that the coefficient of area needs (ά) of land for settlements is 300 m² for 6 people. For the determination of the carrying capacity index of settlements (CCS) with the provision that the CCS value is greater than 1 (CCS > 1), conversely, if the CCS value is below 1 (CCS < 1) then there is no region's ability to support the settlement area.

According to Yeates (1980) [3] the carrying capacity of land can be identified from the carrying capacity and is calculated based on the area of land function divided by the number of existing population calculated from the per capita land requirements as follows:

\[ LC = \frac{A}{P} \]

**Description:**
- \( LC \) = Land Capability
- \( A \) = Area (ha)
- \( P \) = Population (people)

After obtaining the carrying capacity of the land, then compare the value of \( A \) with the land consumption table below.

| No | Population | Land Consumption (/ha) |
|----|------------|------------------------|
| 1  | 10,000     | 0.100                  |
| 2  | 25,000     | 0.091                  |
| 3  | 50,000     | 0.086                  |
| 4  | 100,000    | 0.076                  |
| 5  | 250,000    | 0.070                  |
| 6  | 500,000    | 0.066                  |
| 7  | 1,000,000  | 0.061                  |
| 8  | 2,000,000  | 0.057                  |

**Source:** Yeates, 1980 in Muta'ali, 2012

If the carrying capacity of the land (A) exceeds the value of the specified land consumption (Yeates standard), it is said that the population of the area has exceeded the carrying capacity of the environment (outside the threshold). The carrying capacity value of land is indicated by per capita land consumption for various city population sizes according to Yeates (1980) above.

Directions for the development of settlements in Ranah Batahan Sub-district are adjusted to the carrying capacity of the environment and land suitability in Ranah Batahan Sub-district by using a map of environmental carrying capacity for settlements as a source of data. Furthermore, the selection of policy alternatives is made into several priorities which are carried out using the AHP (Analytical Hierarchy Process). In the priorities of policy directives, the implementation strategy and its implications are decomposed in a descriptive manner which is stated by the experts/experts.

| Point | Description                                            |
|-------|--------------------------------------------------------|
| 1     | A is just as important as B                            |
| 3     | A is slightly more important than B                     |
| 5     | A is clearly more important than B                      |
| 7     | A is clearly more important than B                      |
| 9     | A is absolutely more important than B                   |
| 2,4,6,8 | When in doubt between two values close together        |

**Source:** Marimin in Umar (2017)
3. Results and Discussion

Land suitability is the level of suitability of a parcel of land for certain land uses by taking into account its requirements. Information obtained from land suitability will provide a clue about the suitability of land with end-use [4]. The results of the sum of the scores of each sample point in the District of Batahan domains produce 4 land suitability classes namely; Very suitable (S1), suitable (S2), Marginal (S3), and Inappropriate (N).

Suitability of land for development of settlement in the District of Ranah Batahan produces 4 classes of land suitability. The land that is classified as very suitable consists of 9 land units. Land classified as suitable consists of 19 land units. Land classified as marginal is composed of three land units. Land classified as inappropriate consists of 8 land units. The following is the land suitability diagram.

![Land Suitability Diagram](image)

**Figure 2.** Land Suitability Diagram

The picture above shows that the suitability of land for settlement development in Ranah Batahan Subdistrict is classified as good because the land suitable to be developed as a settlement is more than the land that is not suitable to be developed as a residential area. However, on land that is suitable and marginal suitable has a limiting factor that can impede the development, but the limiting factor can still be overcome by serious handling or with greater capital.

![Land Suitability Map](image)

**Figure 3.** Land suitability for District Residential West Pasaman
Furthermore, the carrying capacity and carrying capacity of the land for settlements. The carrying capacity of the area for settlements is calculated using the equation: The carrying capacity of settlements (CCS) is generated from the area of land suitable for settlements (ASS) divided by the total population (P) and divided by the coefficient of area requirements (а).

Data on the area of land available for settlements is obtained based on a map of the availability of suitable land for settlements after limiting factors. Data on population is obtained from the Central Statistics Agency of West Pasaman Regency. The total population of Ranah Batahan Subdistrict is 53,774. The area of need constant (а) that is used according to the regulation of the Minister of Public Housing No. 11 / PERMEN / M / 2008 that the coefficient of area needs (а) of land for settlements is 300 m² for 6 inhabitants. So, the constant is 6 peoples. The results are as follows:

| No | Rural  | Land area suitable for settlement | Population | Value of Land Carrying Capacity |
|----|--------|----------------------------------|------------|---------------------------------|
| 1. | Desa   | 2284,96                           | 14378      | 0,026                           |
| 2. | Batahan| 11539,82                          | 39396      | 0,048                           |

Source: Analysis of Research Results Data, 2018

Table 4 shows that the carrying capacity of the land in both Rural in Ranah Batahan District is very low. So, it can be said that the land here is less able to support livelihoods in the region. This is because the carrying capacity of the land is closer to zero.

Environmental capacity for residential areas is calculated based on the area of land divided by the population. After getting the results, it is compared with land consumption. As for the results obtained, the area of Ranah Batahan District is 29,847, 08 Ha and the total population of Ranah Batahan District is 53,774 inhabitants. After calculating, the land capacity is 0.555. If the carrying capacity of the land (A) exceeds the value of the specified land consumption (Yeates standard), it is said that the population of the area has exceeded the carrying capacity of the environment (outside the threshold). The value of the acquired capacity exceeds the value of land consumption according to the Yeates standard [3], it can be concluded that the land is already outside the threshold.

![Map of Residential Development Eligibility on Rahan Batahan](image_url)
Based on the land suitability map, the following is presented a map of the area of land that is still suitable to be developed for settlements. This map is produced based on the calculation of the area of land that is suitable to be developed for settlements, namely the area of land available in less forest areas and disaster-prone areas. Then obtained the results of land that is still suitable to be developed for settlement.

Directions for the development of settlements in the District of Ranah Batahan are adjusted to the carrying capacity of the environment in the District of Ranah Batahan by using a map of the carrying capacity of the environment for settlements as a source of data. The direction of settlement development was obtained from the results of discussions with related agencies in handling the development of settlements in the District of Ranah Batahan. During the discussion, the experts determined several implementation strategies and the implications of policy priorities that had been obtained using the previous AHP.

The direction of settlement development in Ranah Batahan District. Of the nine alternatives, 5 policy priorities will be chosen based on the calculation of the Consistency ratio, with the condition that the data must be consistent or <0.1. The results obtained based on the calculation of the consistency ratio is 0.09. This means that the policy hierarchy compiled in this study is consistent and can be used.

![Figure 5. Policy Directions](image)

In the picture, there are various alternative policies which are then arranged to become the direction of settlement development policies with decision scores, which are the highest scores. The five highest directives results are: 1) developing settlements based on land suitability, 2) tightening the IMB, 3) availability of land for settlements, 4) suppress the rate of population growth, 5) availability of land for settlement development.

4. Conclusion

Land suitability based on the sum of the scores of each sample point in the District of Ranah Batahan produces 4 land suitability classes namely; the land is very suitable (S1), the land unit is suitable (S2), marginal appropriate (S3) and land is not suitable (N). The carrying capacity and carrying capacity of the land for settlement development: results obtained, carrying capacity of the two regions does not support for settlements. The capacity of the region is obtained from the land capacity of 0.555. This value exceeds the assumed land use-value. Then it can be said that the population of the region has exceeded the carrying capacity of the environment (beyond the threshold). Direction for settlement development: the highest policy alternatives are obtained, namely: 1) developing settlements based on land suitability, 2) tightening IMB, 3) availability of land for settlements, 4) suppress the rate of population growth, 5) availability of land for settlement development.
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