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ANALYSIS OF SUITABILITY LAND FOR FLOOD-FREE SETTLEMENT IN BAOLAN DISTRICT TOLITOLI REGENCY

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ABSTRACT

Baolan District, Tolitoli Regency, as a urban area is quite worrying, because it is often hit by floods. The settlement area is an area that is often affected, because the settlement area of Baolan District is in the vulnerable to very vulnerable class. This research was conducted in Baolan District from April to August 2021. The tools and materials used in this study were: a laptop, ArcGis 10.4 software, and secondary data (rainfall data, DEM data or Digital Elevation Model, soil type maps, and maps). RBI scale 1:50000). This type of research is quantitative descriptive with a spatial approach and using saturated sampling rules obtained from the entire population. The purpose of this study was to determine the distribution and level of suitability of land designated for flood-free settlements in Baolan District. The results of the analysis show that the suitability class that has the largest distribution area is the QS class (Quite Suitable) with an area of 31570.148 or 79.97%. Class S (Suitable) is the class with the smallest area of distribution, which is 538.892 or 1.37%, while the other class is class that is not suitable (N) with an area of 7368.287 or 18.66%. Class S (Suitable) indicates that the class is very wide good if it is developed for a useful area and inversely proportional to class N (Not Suitable). While QS (Quite suitable) is a class that is good enough to be developed into a useful area, but there are several things to consider. the condition of the area is quite steep and the topography is high, as a result it will cause natural hazards such as erosion and land slides. Another thing to consider is the area that covers the rain catchment area which should be predominantly functioned as a buffer zone.

Keywords: *Analysis; Flood-Free Settlement; Suitability Land*

INTRODUCTION

Indonesia is a developing country that has a very large population. The total population of Indonesia in 2019 was 271.1 million, an increase from the previous year of 1-1.5% (BPS, 2019). An increase in population will always be followed by an increase in land demand (As-syakur et al., 2010)

Land has a function as a place for humans to carry out activities to maintain their life and existence. Development is one of the community activities, but many people do not know / pay attention to the legality / Building Permits (IMB) which will eventually trigger a disaster. In addition, there are changes in land use by local

communities sub-watershed that is not in accordance with its function. This indicates that there is regional spatial planning that does not pay attention to it existing policy directions, while the policy itself has gone through academic studies disaster risk. (Taslim & Akbar, 2019)

One of the areas of Indonesia that has experienced an increase and population density is Central Sulawesi, which has an impact on the development problems of Central Sulawesi, especially in Tolitoli Regency, namely the need for land for settlement facilities. Law Number 1 of 2011 states that settlements are part of the environment outside protected areas, whether in the form of areas, urban areas, or rural areas that function as a place to live or a settlement environment and a place for activities that support life and livelihood. Settlement areas are dominated by residential areas with the main function as a place to live equipped with environmental infrastructure and facilities, a place to work that provides services and limited job opportunities that support livelihoods and livelihoods (Keman, 2005).

Housing and settlement problems are one of the problems that are directly caused by population growth and distribution (Setyowati, 2007). Population growth and development that goes hand in hand with the economy in an area will encourage increased use of space/land for settlement areas, so that many settlement areas develop in zones that are not in accordance with their designation (Burhanuddin, 2010). Development of settlement areas that are not according to its use will have an impact to the decline in environmental quality and lead to natural disasters (Umar et al., 2017). One of the natural disasters that are classified as hydrometeorological disasters is flooding. The problem of flood disasters has become a concern in recent years for example flood risk assessment. In fact, several publications discuss the consequences of flooding, such as loss of life (Jonkman & Vrijling, 2008), economic losses (Pistrika & Tsakiris, 2007) and damage to buildings (Kang et al., 2005; Schwarz & Maiwald, 2008; Zuccaro et al., 2012). Flooding is an unusually high level of a river due to runoff from rainfall and/or snowmelt in amounts that are too large to be confined to the normal water surface elevation of the river or stream, as a result of an unusual meteorological combination (H. M. Raghunath, 2006).

Settlements in Baolan Sub-district (capital of Tolitoli Regency) are often affected by flooding, because they are built on land that is prone to flooding and is at risk of flooding. The settelement area as a place of activity has buildings that are very densely populated and located around riverbanks

are indicated as areas of high danger and prone to flooding in Baolan District (Ferdi et al., 2021). Lack of knowledge and information related to land or areas that are not suitable for settlement by the community, is the basis for the need for structuring and controlling the development of settlements in areas prone to or prone to flood disasters. This is the reason for choosing this research which focuses on the level and distribution of land suitable for flood-free settlements in Baolan District.

MATERIALS AND METHODS

This research was conducted in Baolan District, Tolitoli Regency, Central Sulawesi Province from May to August 2021. Baolan District is the capital of Tolitoli Regency which consists of 10 sub-districts/villages with an area of 394.90462 Km^2 or 39490.462 Ha. There is one island that is included in the administration of the Baru Village. The tools and materials used in this research are: laptop, ArcGis 10.4 software, and secondary data (rainfall data, DEM or Digital Elevation Model data, soil type maps, and RBI maps with a scale of 1:50,000). The variables used in this study are flood hazard, soil type, topography, slope, rainfall and land use.

This type of research is quantitative descriptive with a spatial geography approach. This study uses a saturated sampling rule in which the entire population of the sub-district/village in Baolan District is used as a sample **(see Figure 1)**. The data analysis technique used is spatial analysis with ArcGIS 10.4 software tools.

Scoring and overlaying methods are used to process research parameter data. The scoring method is used to give the value of large, small, high, and low influence of parameters on land designated for flood-free settlements **(see table 2)**. The overlay method combines all parameter data for each aspect that was previously given a score and weight proportionally in order to obtain new data or information (Widiawaty & Dede, 2018; Riadi, 2017).

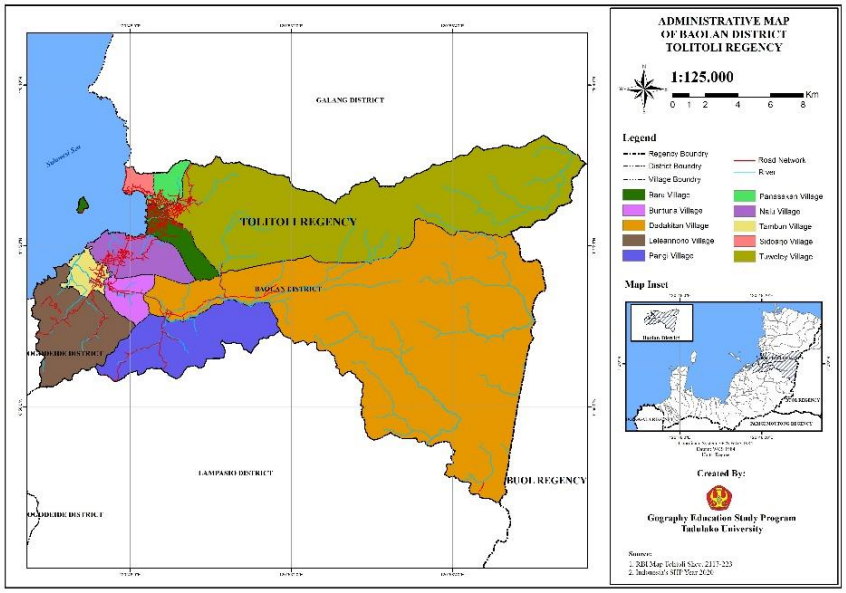

Figure 1. Research Location in Baolan District, Tolitoli Regency

The hazard of flooding is one of the main parameters for analyzing land for flood - free settlements. This needs to be done to identify the distribution of potential and safe areas when floods occur. The analysis process uses the overlay and assessment method **(see Table 1)** carried out in several parameters used, namely; Types of soil, topography, slope, rainfall, and distance to the river (JTAS).

Table 1. Scoring Flood Hazard Parameters

Parameter	Criteria Flood Hazard	Score
Slop Map (%)	0-8 (Flat)	1
	8-15 (Declivous)	2
	15-25 (Wavy)	3
	25-40 (Steep)	4
	>40 (Very Steep)	5
Topography Map	0-12.5 (Very Low)	1
	12.5-25 (Low)	2
	25-50 (Medium)	3
	50-75 (High Enough)	4
	75-100 (High)	5
	>100 (Very High)	6
Soil Type Map	Regosol	5
	Alluvial, Andosol	4
	Latosol	3
	Lhitosol, Mediterranean	2
	Grumosol	1
Rainfall Map (mm/year)	0-1000 (Very Low)	1
	1000-2000 (Low)	2
	2000-3000 (Medium)	3
	3000-4000 (High)	4
	>4000 (Very High)	5

Parameter	Criteria Flood Hazard	Score
Distance to River Flow (JTAS)	0-50 m (Very Near)	5
	50-100 m (Near)	4
	100-250 m (Medium)	3
	250-500 m (Far)	2
	>500 m (Very Far)	1

Source: Hermon (2012) modification

The analysis of the land suitability model for flood-free settlements is as follows (Hermon, 2012 Modification).

PFB=PCH+PT+PL+PLU+3 (PPB)

Information:

PFB = Flood-Free Settlement
PCH = Rainfall Map
PT = Soil Type Map
PLU = Land Use Map
PPB = Flood Potential Map

Table 2. Criteria and Scoring of Land Suitability Parameters for Flood-Free Settlements

Parameter	Criteria Suitability Land for Flood-Free Settlement	Score
Flood Hazard Map	Low	3
	Medium	6
	High Enough	9
	High	12
Slop Map (%)	0-8 (Flat)	1
	8-15 (Declivous)	2
	15-25 (Wavy)	3
	25-40 (Steep)	4
	>40 (Very Steep)	5
Topography Map	0-12.5 (Very Low)	1
	12.5-25 (Low)	2
	25-50 (Medium)	3
	50-75 (High Enough)	4
	75-100 (High)	5
	>100 (Very High)	6
Soil Type Map	Regosol	5
	Alluvial, Andosol	4
	Latosol	3
	Lhitosol, Mediterranean	2
	Grumosol	1
Rainfall Map (mm/year)	0-1000 (Very Low)	1
	1000-2000 (Low)	2
	2000-3000 (Medium)	3
	3000-4000 (High)	4
	>4000 (Very High)	5
Land Use Map	Forest/Protected Forest/Mangrove	7
	Settelemnt/Built-up Land	6
	Ricefield/Field	5
	Swamp/Pond	4
	Plantation	3
	Empty Land/Bush	2
		1

Source: Hermon (2012) modification

As for how to determine the interval for each class using the equation (Dibyosaputro, 1999 in Hermon, 2012).

I = (c-b)/k

Information

I = Class interval distance

c = Total highest score

b = The lowest total score

k = Number of classes desired

The results of the calculation of the profit interval for flood-free can be divided into three zones:

- Zone S (Suitable) with interval <19; suitable for settlements, there is absolutely no danger of flooding that threatens community settlements.
- Zone QS (Quite Suitable) with interval 20-29; quite suitable for settlements, the chance of a flood disaster 1 time in 5 years that afflicts community settlements.
- Zone N (Not Suitable) with interval >29; not suitable for settlements, the chance of flooding once in 1 year that afflicts community settlements.

RESULTS AND DISCUSSION

Parameter Analysis of Land Designated for Flood-Free Settlement

The results of processing and analysis of parameter data showed that in Baolan District there were only two types of soil, namely Latosol soil and Mediterranean Red-yellow soil. Red Yellow Mediterranean soil types are spread over an area of 37907.566 hectares or about 96%. While the type of soil latosol with an area of 1580.896 ha or 4%.

The research area has a dominant topography in the very high class (> 100 m) which is 86.89% (34198.023 Ha) and the smallest is the high class (732.100 Ha or 1.86%). The higher the elevation of the research area to the east, the higher the area. The slope of the slope is one of the factors that affect the occurrence (amount) and speed (phase) of runoff, surface drainage, erosion and land use. Based on the slope classification, Baolan District is classified into five classes. In general, the slope of the study area is wavy (15-25%) with an area of 15109.584 Ha or 38.40%. The distribution of slopes in Baolan District is indicated by the presence of water sources such as the sea, rivers, swamps which will affect the level of the slope.

The rain with high intensity for a long time (phase) will trigger flooding. Rainfall data recorded in 2020 with rainfall intensity reaching 3839.9 mm for

269 days. High rainfall contributes and is usually the main cause of flooding in rivers and in high-risk areas. The frequency of flooding cannot be separated from the frequency of rain (high rainfall and long time) which results in the smaller capacity or capacity of the area. This makes Baolan Regency often hit by floods which have a direct impact on the community.

The results of the analysis of the collected rainfall data show that Baolan District rains every year with an intensity of 2000->3000 mm. Based on the cluster data of rainfall intensity, the most widely distributed area is the rainfall class > 3000 mm/year (very high) reaching 20358.580 Ha or 51.72%. Extreme/very high rainfall data, which is transformed through a particular catchment area and the topography of the area, will estimate the flood height and velocity for various modes within the zone (Risi et al., 2013) **(Table 3)**.

Table 3. Parameter Analysis Result

Parameter	Criteria	Area (Ha)	%
Flood Hazard Map	Low	928.024	2.32
	Medium	31095.495	79.97
	High Enough	96186.208	15.52
	High	1669.175	4.19
Slop Map (%)	0-8 (Flat)	8658.899	22.03
	8-15 (Declivous)	12449.910	31.67
	15-25 (Wavy)	15106.700	38.43
	25-40 (Steep)	3019.623	7.68
	>40 (Very Steep)	75.559	0.19
Topography Map	0-12,5 (Very Low)	1952.899	4.95
	12,5-25 (Low)	773.933	1.96
	25-50 (Medium)	928.469	2.35
	50-75 (High Enough)	754.680	1.91
	75-100 (High)	731.632	1.85
	>100 (Very High)	34347.649	86.98
Soil Type Map	Latosol	37907.566	96
	Mediterranean	1580.896	4
Rainfall Map (mm/year)	2000-3000 (Medium)	4652.601	12
	3000-4000 (High)	14344.080	36
	>4000 (Very High)	20350.850	52
Land Use Map	Forest/Protected	27269.106	69,15
	Forest/Mangrove	248.629	0.63
	Settelement/Built-up Land	993.451	2.52
	Ricefield/Field	72.539	0.18
	Swamp/Pond	692.795	1.76
	Plantation	9894.248	25.09
	Empty Land/Bush	266.164	0.67

Source: Researcher analysis, 2021

Urbanization is considered as a spatio-social process that triggers land use change, causing changes in the urban landscape and surrounding areas (Dadras

et al., 2015; Pigawati et al., 2020). All forms of space/land use by the community will affect the availability (area) of land that can be used to support a relatively fixed and limited life.

The results of data analysis show that the existing land uses in Baolan District are; forest has the widest distribution of 27472.106 or 69.05%, while the smallest land use is the Ricefield/Field of 72.539 hectares or 0.18% of the total area of Baolan District. The development of flood-free residential areas is carried out by transferring the function/utilization of potential land for the adequacy of space/land to support community activities. Increased Land use change is influenced by the increase and rate of population growth (Budi et al., 2022).

Flood hazard can be defined as a threatening event, or a possible phenomenon of potential damage within a certain period of time and area (Baldassarre et al., 2010). Floodplain maps can be categorized into three and one of them is a flood hazard map (Merz et al., 2007; Baldassarre et al., 2010). An estimate of the flood risk area can be obtained by integrating the strong susceptibility to structural class and flood hazard (Risi et al., 2013). The results of processing and analysis show that the level of flood hazard in Baolan District is classified into 4 (four) classes or levels, namely not hazard, less hazard, hazard, and very hazard.

The not hazardous class is the class that has the narrowest (smallest) area with an area of only 928.024 Ha or 2.32% and the most widespread less hazard class which reaches 31095.495 Ha or 79.97% of the total area of Baolan District. The distribution area for the flood hazard class to very high in Baolan District is centered on two watershed outlets (Ogomalane and Dadakitan). Each area has a different flood height.

The flood hazard area will be evenly distributed bigger the closer the settlement is to the river (Perdana, Surya et al., 2019). This is triggered by high rainfall intensity, located in the downstream area of the river, and the transfer of excess river water from the upstream area. According to the nature of the river that moves from the highlands to the lowlands, the downstream areas are more dominantly affected by flooding than the upstream areas.

Distribution and Level of Suitability Land of Flood-Free Settlement

Determination of the level and distribution of land suitability for flood-

free settlements in Baolan District using the scoring and overlay methods. The parameters used are flood hazard, soil type, topography, slope, rainfall, and land use. The results of the map overlay, obtained a new land unit. Based on the results of the analysis of the six parameters used, it is known that the land allotted for flood-free settlements is divided into 3 (three) levels/classes, namely: S (Suitable), QS (Quite Suitable), and N (Not Suitable). The class division is intended to obtain areas that have the potential for flood-free residential land.

The results showed that the land allotted for flood-free settlements in Baolan District each category or land suitability has a different area and distribution. The distribution of land suitability classes for flood-free settlements can be visualized in the form of a map **(see Figure 3)**. The vailability of land for the development of settlement/residential designation areas, the ability factor or land capability land to support the construction of settlements must be considered as the basis potential value, future constraints, and artificial land or land that cannot be developed at all (Amir et al., 2020). The use of land for settlements is that the location of settlements must be based on applicable rules and does not interfere with existing protection functions (not in border areas of rivers/lakes/fountains/irrigation canals).

Land Suitability Class S (Suitable)

The area of land suitability class S (Suitable) is spread over an area of 538.892 hectares or 1.37% of the total area of Baolan District. This class S (Suitable) area is the smallest area and is only spread out in Sidoarjo Village, Baru Village, and Nalu Village. Most of these areas are located in areas far from the reach of river overflows, have a low-moderate topography, have a gentle-wavy slope, and the soil type is lithosol/mediterranean and the landforms are fluvial to structural.

The characteristics of the distribution area illustrate that the area can be a potential area to be developed as a flood-free settlement area. Even so, there are still some considerations that must be considered in building or developing the area into a flood-free settlement area. The things that must be considered are uncontrolled land use that is not suitable by the community, the carrying capacity and capacity of land, and other disasters (eg landslides).

Land Suitability Class QS (Quite Suitable)

The QS class (quite suitable) has the widest area distribution, which is 31570.148 Ha or 79.97% of the research area and compared to other classes. In general, this land suitability class area is located in an area that is quite close to the flow of rivers/water bodies, the soil type is Latosol, the topography is up to 40% (steep,) the altitude reaches 100 m above sea level, the rainfall is from quite high to high, and is usually found in formations. fluvial land, and can be used as plantation land or water cultivation land (ponds).

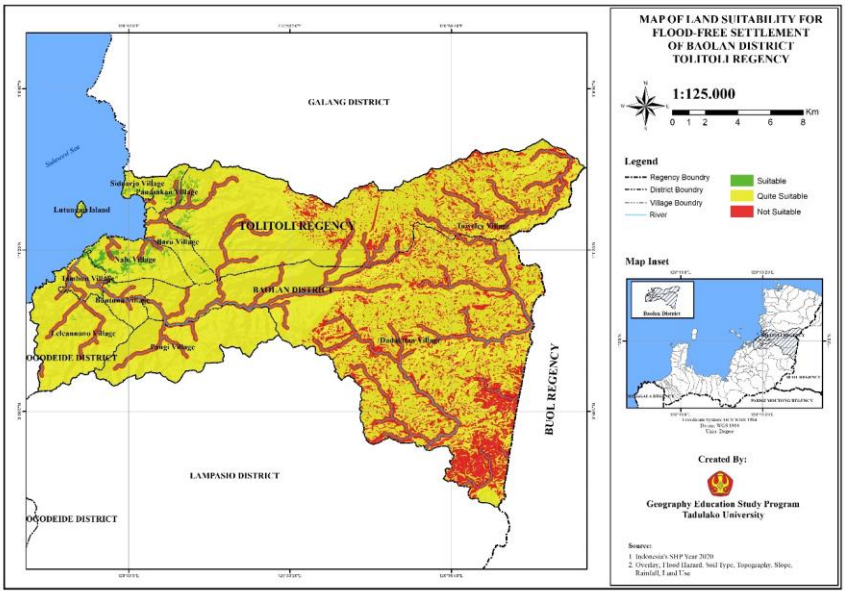

Figure 3. Map of Distribution Land Suitability For Flood-Free Settlemt

The QS class includes a fairly good level of suitability for the development of flood-free settlement designation areas, area development, but further analysis is needed. Things that need to be analyzed or considered are the geographical conditions of the area which are quite vulnerable to natural disasters (erosion and landslides). Another thing of concern is that the distribution area is located in a water catchment area which should function as a buffer zone.

Land Suitability Class N (Not Suitable)

This area covers an area of 7368.287 Ha or 18.66% of the total area of Baolan District. Administratively, this area is spread out in Tuweley Village, Dadakitan Village, etc. These areas are not good if used for the development of flood-free residential areas. This is due to several factors, including the very close distance to the river flow/water body, very steep slope conditions with very high topography, as well as being in

a buffer/protected area and denudational landforms. The settlement area is contained in the Tolitoli Regency City Spatial Plan which regulates the location and distribution based on the carrying capacity of the environment and the area that will not be converted (Pigawati et al., 2020). The factors described above make the class N area (not suitable) not very good or feasible to be developed as a flood-free settlement area. If in the future the area is attempted to clear land for conservation, it will certainly be very detrimental to the environment and especially to the surrounding community. Another bad impact that occurs is land degradation and a decrease in environmental quality both from the upstream to downstream areas of the river. This will certainly affect the lives and livelihoods of the community.

CONCLUSIONS

Baolan district has land units that are somewhat hazardous to flood hazard. This is supported by soil characteristics, topography, and slope. and distance from the river. Baolan district has a hazard level with a very hazardous class reaching 975.914 Ha or 2.2%, a hazard class 6713.534 Ha or 17.0%, a less hazard 31460.417 or 79.8%, and a non-hazard 263.261 0.7%. Land use that is not controlled and not in accordance with its designation can affect large, small, high, and the frequency of flood events. Floods in Baolan District have a dominant impact on the community.

In accordance with the allocation of allotted land that is used to depend freely outside the existing utilizing Baolan District, that the Baolan District Territory is divided into three adjustment classes, namely class S (Suitable), QS (Quite Suitable), and N (Not Suitable). The Class Suitable (S) covers a very small distribution area, namely 538 Ha or 1.37%. Class QS (Quite suitable) with a very wide distribution reaching 31570.148 Ha or 79.97%. Class Not suitable (N) has an area of 7368.287 Ha or 18.66%. Class S (Suitable) indicates that the class is very wide good if it is developed for a useful area and inversely proportional to class N (Not Suitable). While QS (Quite Suitable) is a class that is good enough to be developed into a useful area, but there are several things to consider. The condition of the area is quite steep and the topography is high, as a result it will cause natural hazards such as erosion and land slides. Another thing to consider is the area that covers the rain catchment area which should be

predominantly functioned as a buffer zone.

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