

Conference Paper

Land Capability and Capacity Analysis of Marampit as a Border Island in Indonesia

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Abstract

Marampit Island is one of the outer islands that border on the Philippines. This island is dominated by lowland area with elevation no more than 100 m from the sea surfaces, composed of coral rocks. The surfaces consist of a thin layer of soil and dominated by forest and plantation. Marampit has good natural coastal system and high of diverse ecosystem. This study purposed to maping the land capability and capacity of Marampit Island. Based on the analysis, Marampit have three class of land capability, they are second class or high of land capability where spread over west and south edges of island, third class or medium of land capability where spread over middle of island and fourth capability where spread in the north of island. According to the developable area size and current built area population density, Marampit Island can withstand a population of 7 980 people. Mapping of land capability and capacity analysis can be used to equip the database and recommendation for Marampit development, as the outer and border island of Indonesia.

Keywords: Capability, Capacity, Land, Marampit Island, Mapping

1. Introduction

Marampit is one of the outer Island in North Sulawesi which bordered with Philipines in the north, Pacific Ocean in the east, Karatung Island in the west and Mangupung Island in the south. Marampit have about 1 273 people in five villages [1]. There are three prime villages, they are Marampit, Laluhe, and Dampulis and two sprawl villages are East Marampit and South Laluhe. Built up area growth higher but not so intensive. This island composed of coral rocks in all region and indigenous rock in some places. Marampit island is dominated by lowland area with elevation no more than 100 m from the sea surfaces. The lowland area is scattered in the middle and south, the hills area in the north. Marampit composed by coral rocks in all region. Indigenous rock scattered in the beach, result of volcanic process from others island. Elevation of this island no

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more than 100 m from the sea surfaces. This island dominated by lowland in the middle and south and hills in the north. Surfaces of this island consist of a thin layers of soils.

Land is a region in the earth surfaces, one of the natural resources that very useful for human [2]. Land consist of any aspects, such as soils, alongside vegetation, physiography, hydrology, climate, infrastructure, etc [3]. The important of land for human life made the land management need to support sustainable development of land in a region. Land use has relation with the human life because the existence is depend on human activities. The existings of land use will change in time and space lineary with the change of human necessary. This is cause the study about land need to accomodate the dinamic. Land use dominated by indigenou forest without owner, settlement and plantation. People plant coconut tree, nutmeg and clove in their farm land. Most of them also catch fish in the sea as the fisherman.

Land capacity has a relation about availability of land to support human life. This is useful for planners to inform about land supply and demad throughout the island. As a border island of Indonesia, the island's development sustainability hold key in keeping national border integrity. The development sustainability is closely related to land population capacity. By using land capability analysis and available population data, this study able to provide recommendation for the further development as well estimate the island population capacity.

2. Methods

This study was using primary and secondary data to arrange land capability and capacity of Marampit Island. Primary data was satellite imagery, Landsat 8 OLI with spatial resolution 30 m × 30 m in multispectral band and 15 m × 15 m in panchromatic band to produce terrain and hydrology map. Secondary data get from spatial and regional planning map, such as lithology, slope, topography, soil type and hazard. Field survey did to validate spatial and regional planning map, and collected information about terrain, hydrology and historical information by interviewing some respondents. Marampit geographically located between 4°45'12"LU and 127°47'02"BT. All of this data were used as an input to perform land capability and capacity analysis.

Land capability is a depiction of land capability level for agricultural or non-agricultural development, that measured by Land Potential Index (LPI) [4]. LPI is composed by certain parameter such as relief, lithology, soils and vulnerability of disaster. This score shows the relative potential of land for general land use and divided into four class (I to IV, very high to low), where high index score means

high suitability for agricultural use. Land capability analysis is made to knowing the potential function of a land for specific kind of development. This is useful for plan land best-use, mitigate hazards and arrange sustainable development strategy [5]. Land potential index measure by rational formula in Equation (1) [6],

$$LPI = (R + L + T + H) \times B \tag{1}$$

Information,

LPI = Land Potential Index

R = Relief/ topography

L = Lithology

T = Soil

H = Hidrology

B = Hazard vulnerability

Factors that influence the land potential index show in Table 1 until Tabel 7. Table 8 shows the class of land potential index. Table 9 show the soil depth. This study conducted based on the methods in Fig. 1.

TABLE 1: Value of slope [6, 7].

Class	Slope	Value
I	0 % to 5 %	5
II	5 % to 15 %	4
III	15 % to 25 %	3
IV	25 % to 45 %	2
I	0 % to 5 %	5

TABLE 2: Value of topography [6, 7].

Class	Topography	Value
I	Flat-slighty	5
II	Wavy-bumpy	4
III	Low hill	3
IV	Hill	2
V	Mount	1

TABLE 3: Value of soil type [6, 7].

Class	Value	Soil type	Value
I	Coarse	Regosol, Litosol, Organosol	1
II	Little coarse	Podsolik, Andosol	4
III	Medium	Brown alluvium, Mediteran	5
IV	Little smooth	Topsoil gley, Rensia, Podsol	3
V	Smooth	Grumusol, Latosol, Grey alluvium	2
		Regosol, Litosol, Organosol	

TABLE 4: Value of lithology [6, 7].

Class	Lithology	Value
Lb	Indigenous rock	5
Lp	Piroclastic	8
Lk	Coarse sediment	5
Lh	Smooth sediment	2
Lg	Limestone and metamorf sediment	3
Li	Limestone	5
La	Alluvium/colluvium	10

TABLE 5: Value of hidrology (surface water) [6, 7].

Class	Hidrology	Value
P1	Very high potential for irrigation	5
P2	High potential for irrigation	4
P3	Medium potential for local irrigation,	3
P4	Low potential/local	2
P5	Lack of surface water	0

To perform land capacity analysis, this study used total population data that collected from the database and current settlement size or built size area that measured using GIS, which these two information were used to find the current population density. Using these findings, land capacity was predicted through linking land-use recommendation and the current population density. By knowing the land capacity, the ideal population size based on developable land can be found.

TABLE 6: Value of hidrology (soil water) [6, 7].

Class	Soil water	Value
A1	High productivity, wide spread	5
A2	Medium productivity, wide spread	4
A3	Local medium-high productivity	3
A4	Local low-medium productivity	2
A5	Lack of soil water	0

TABLE 7: Value of hazard vulnerability [6, 7].

Class	Haard vulnerabilitu (tsunami-earthquack-flood)	Value
E1	Very high	0.5
E2	High	0.6
E3	Medium	0.7
E4	Low	0.8
E5	Without erosion	1.0

TABLE 8: Land Potential Index Class [6, 7].

Class	Land Potential	Value of land potential index
I	Very high	32 to 40
II	High	24 to 31.9
III	Medium	16 to 23.9
IV	Low	8 to 15.9
V	Very low	0 to 7.9

3. Result and Discussion

Marampit island is dominated by lowland area. Elevation of this island is no more than 100 m from the sea surfaces. This island composed of coral rocks in all region. Indigenous rock is scattered in the beach, result of volcanic process from the other island. Surfaces of this island consist of a thin layer of soils. Marampit size 14.63 ha based on the field tracking survey. Currently, land use in marampit consists of mixing plantation, then dry land forest, open field and settlement (Fig. 2). The settlement spreads line in every village, following the transportation line. Built up area increases

TABLE 9: Value of soil depth [6, 7].

Class	Soil depth	Soil Type	Value
S1	Very depth (> 100 cm)	Alluvium, mediteran, podzol, grey regosol and sand volcan, intermedier volcan, brown regosol, grey-brown regosol, complec grey-regosol, sediment of sandy clay, sandy dust, complex of sand and dust regosol, tuff volcan and intermedier volcan rock, complex grey regosol and sandy volcan and tuff intermedier	5
S2	Depth (75 to 100) cm	Grumusol	4
S3	Medium (50 to 75) cm	Andosol, podsol	3
S4	Shallow (30 to 50) cm	Renzina, planosol	2
S5	Very shallow	Glays, topsoil, complex grey regosol and sandy tuff volcan and volcano cone intermedier volcan rock, litosol	1

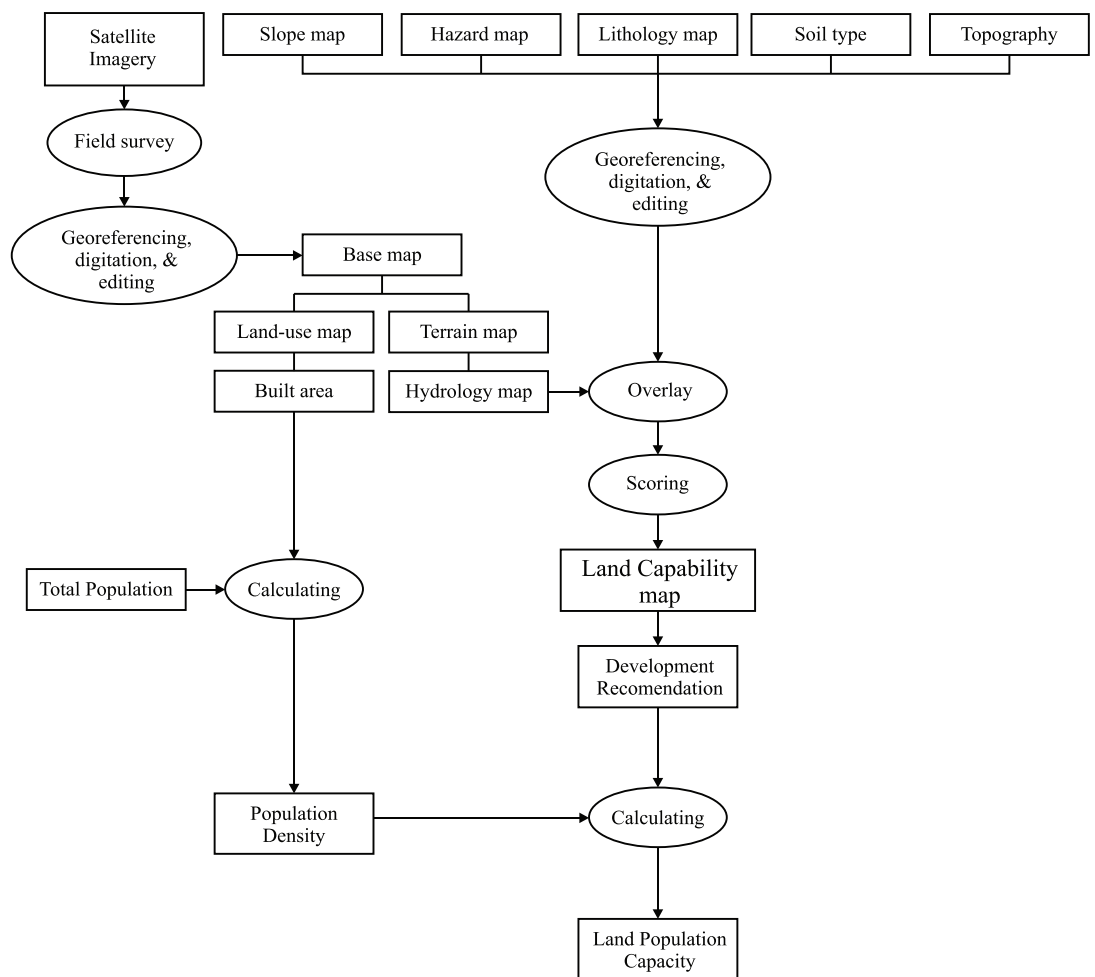


Figure 1: Research flowchart of this study.

every year, but not so intensive. Marampit Island consists of five villages that consist about 357 families based on a survey census of population in 2016.

Land use dominated by indigenous forest without the owner and free to be loaded by everyone. The thin layers and poor of organic matters make the forest can't open to plantation directly so the society made treatment the land forest. The indigenous forest spread over in the center part of island. Plantation alongside the coast dominated by coconut trees. Cloves and nutmegs planted towards the center of the island. Indigenous forest soils in the middle of island dominated by clay and sand that have variation color, such as brown red, pink and chocolate. These soils spread unevenly. Ferns and weeds growth spread in this area. But, coconut trees can not well growth. This area is a meeting border between the three villages, Marampit, Laluhe and Dampulis.

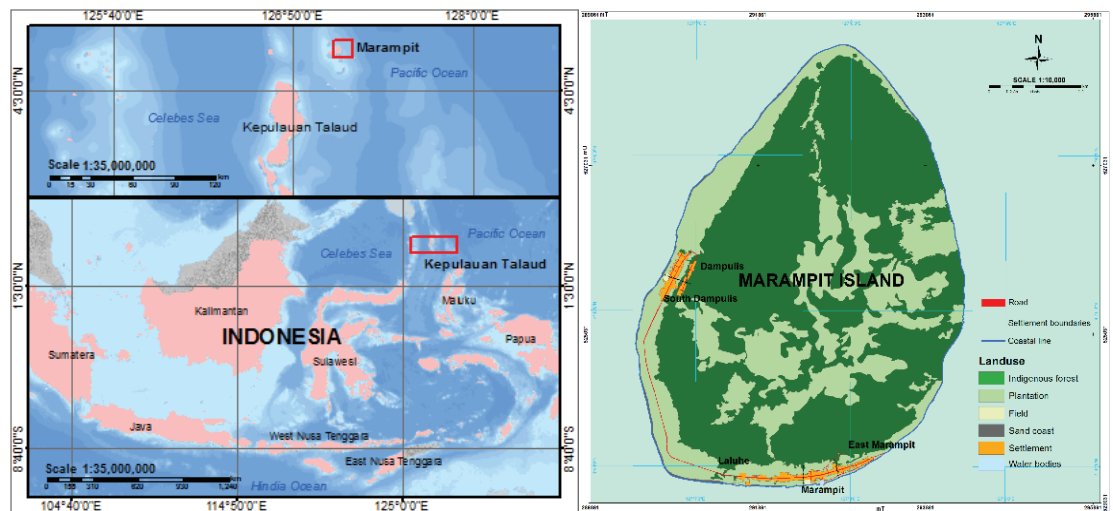


Figure 2: Land use map of Marampit Island.

Not all species of vegetation well growth in this Marampit island. Just vegetation that can hold out in high temperatures and does not require nutrients and water too much. Rice can not grow, but others cereals such as maize and sorghum can. Taro and sago are also growing well. The type of flower that can growing well are orchid. There is one endemic plants in Marampit Island, namely Gedi. This plants usually used for animal feed and vegetable. There is no surface rivers flowing in Marampit Island. They are just a flowing water in the rainy season, the rivers call perennial river. The resources of clean water are springs that come from groundwater. Length of dry season in last years made the clean water resources scarce. Water flowed at certain times. Beside the El Nino impact, drying up of springs estimate caused by decreasing of many forest as buffer zone. They change to be individual plantation.

The settlement spreads linear in every village, following the transportation line. Built up area increases every years, but not so significant. The island has no enough clay to

make roof top. Almost people at there use roofing (zinc) to their roof top to decrease high risk of accident and loss when move clay roof using ship. Marampit is the highest of settlement density. The distance between buildings are closed. The coast classified based on main physical characteristics, such as coastal morphology, geomorphological process and human activities [6]. Marampit coast can be classified to sandy coast, rocky coast and cliff coast. Sandy coast spread over in the south west until north of Island. Commonly, the material of sand composition by sand and soft of coral and foraminifera fractions. Coral coast spreads over in north and some area around the island. Sand composition consist of molusca eggshell fragments and soft of coral and foraminifera fractions. Cliff coast spread over in the northeast and east of island. Morphology of the coast are steep hills with high relief. The hills composed by hard rocks (lava) and coral limestone. Commonly, in this coast not form beaches or very tight of beaches. Hard rocks from lava make the abrasion not so high in this area.

People who live on the island Marampit mostly original from Marampit. Some of them come from Karatung, Manado, Makassar and the others islands in North Sulawesi, also two people from Java. The language that used in Marampit are Talaud and *bahasa* (Indonesian language). Population growth in Dampulis, South Dampulis, Marampit and East Marampit higher than Laluhe. In the four villages, the population are dominated by children until youth. But, in Laluhe dominated by elderly (old). Plantation crops, such as cloves, nutmeg and coconut sold in Tahuna or Manado. In addition, they also plant vegetables such as tomatoes, peppers and eggplant on the home. They usually sold their sea crops to fellow citizens in Marampit. They live a simple life with not too high of economic income.

Development in many sectors due to increasing the quality and quantity of Marampit development. In the physical aspect, public services facilities such as senior high school, optimizing of *puskemas* function and program to provide fences. In the marine aspect, TNI (army of Republic Indonesia) helps the community give exercise and tools for fishing. In the human resources aspect, there are more of physicians that conduct the public health community in Marampit and teachers. Community has high enthusiasm to accept new lesson, such as about entrepreneur, skill, agriculture and fishing. Development all of the aspects support by environmental and land condition that has very important roles in life. As the small and outer island, Marampit very depend on the ocean, hazard, natural resources and geographic condition. So, knowing the land capability and capacity of Marampit is important for creating sustainable development. Especially, Marampit is the border island that plays roles for defence and security of Indonesia.

3.1. Land capability

Land capability shows that not all species of vegetation will grow in this area. Just vegetation that can hold out in high temperatures and does not require nutrients and water too much. Each region in Marampit has different land capability depend on many parameters, such as relief, slope, soil depth, soil texture, lithology, hydrology and hazards. Land capability is an imagine the level of land for certain land use, such as agriculture, non-agriculture and settlement. The assessment of land capability helped to in managing the land so the risk of soil damage can decrease and prevented [8].

Most of Marampit Island have flat until bumpy slope with 0 % to 15 %. Hills with a slope more than 15 % located in the north of the island. Wavy and bumpy relief with 2 % to 15 % in the middle of island. According to potential land index, the flat slightly slope have high potential than the others. Based on lithology map, Marampit composed by rough of clastic sediment and alluvium/colluvium. The rough of clastic sediment composed the north and east of this island. The south and west of this island composed by alluvium/colluvium that depend of volcanic process from other island.

Marampit island consists of a thin till medium soil depth. Soil depth has relation with effective depth for root development [8]. The thin soils spread most of the Marampit surfaces with less than 30 cm depth. Vegetation that growth in this region are a mix plantation and dry land forest. The medium depth of soils to 30 cm to 60 cm spreads in the west and south edges of the island. In this region soil from more intensive because the high of human activities and management. Soil texture in the thin is rough. But, there is region in the thin layers that have medium soft texture that located in the middle of the island. Medium soils layers texture spread in the west also south and west edges of island.

Hydrology parameters that used to calculate the potential land index are groundwater. The surface water assumed same in all region, because there is no surface water in the Marampit. Marampit Island has the potential hazard of tsunami, flood, erosion and rock. West of Marampit has high potential of flood and the east has high potential of tsunami. In the north, middle and south of Marampit composed by coral rock with low potential of erosion. Land potential index measured by scoring of seven parameters using rational formula from [6] to classified to be land capability class (Table 10).

Map of land capability (Fig. 2) produced based on the potential land index. South and west of Marampit have high potential, it is caused by flat-slightly slope, medium groundwater potential, medium soil depth, medium soil texture and low hazard potential. The medium class in the middle of Marampit with wavy and bumpy slope, rare

TABLE 10: Scoring of Land Capability Class.

No	Topography	Slope	Lithology	Soil depth	Soil texture	Hidrology	Hazard	Total	Class	Class
1	4	4	10	2	4	2	0.8	21	II	High
2	4	4	10	2	4	2	0.8	21	II	High
3	2	2	5	1	1	2	0.7	9	III	Medium
4	3	3	10	1	3	0	0.7	14	III	Medium
5	3	3	5	1	4	0	0.7	11	III	Medium
6	3	3	5	1	1	0	0.7	9	III	Medium
7	3	3	5	1	4	0	0.7	11	III	Medium
8	3	3	10	1	3	0	0.7	14	III	Medium
9	2	2	10	1	4	0	0.7	13	III	Medium
10	2	2	5	1	1	2	0.8	10	III	Medium
11	2	2	5	1	1	0	0.7	8	IV	Low

groundwater, thin soil depth, medium-soft texture and medium hazard potential. North of Marampit is the lowest potential land class with hills slope, rare groundwater, thin soil depth rough texture and medium hazard potential. Land capability the potential land for certain land use, management and productivity [9].

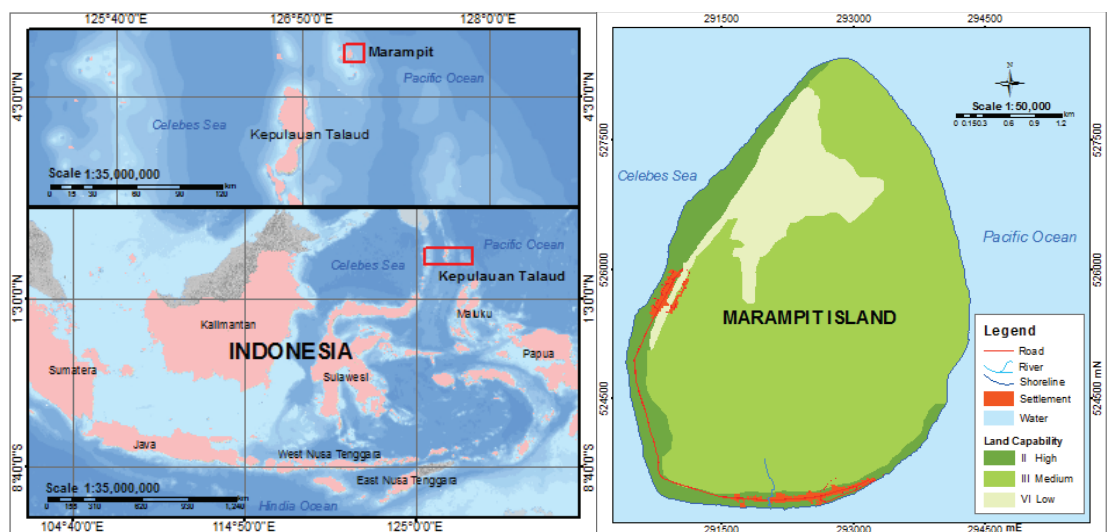


Figure 3: Land capability class of Marampit Island.

Second class land capability suitable for settlement and any kind of plantation, such as vegetable, fruits and annual production trees. The soil in this area more fertile with medium depth and texture. The groundwaters easy to access so the human

water necessary easy to fulfill. This class spreads in the south and west of Marampit with flat and slight slope. West of Marampit has high potential of flood, so mitigation management needs to decrease the risk damage. Besides that, made the evacuation track of the tsunami need as the mitigation of Marampit from tsunami.

Third class land capability has higher land resistance to develop. These lands are not suitable for settlement because has wavy and bumpy slope. Soil depth is thin and has medium until soft texture. The soft texture located in the middle of the island contains Mg and Fe minerals. It caused coconut and production trees can't growth well. Medium texture spread over the other region. Fourth class capability or low class spread in the north of the island. The soil depth is thin with a rough texture. Hills and steep slope made this area not suitable for settlement and plantation. Land in this area is used as dry land forest.

First class in this Marampit Island is not found. It is because there is no line suitable for agriculture land with alluvial land and good in drainage and hydrology system. The agricultural potential of the outer islands is very difficult. Climate and soil are the crucial indicators in judging the production potential of agriculture [10]. Marampit can be developed as dry land agriculture and plantation. Corn and sorghum can growth well, besides coconuts, cloves and nutmegs. Marampit land is suitable to develop as dry cultivation in agriculture. Dry agriculture produce more benefit for Marampit's society because they must sell their agriculture product to an outer island. This distribution needs much time to across the sea using a boat or ship. The quality of dry product more durable than wet product.

3.2. Land capacity

Related to the findings, most of developable land are located in the northern and western edge of the island. This plain land is plain and relatively safe from certain hazard, suitable for plantation and settlement development. The developable area size is 1.4 km², counts for 10.1 % of the island size (14.63 ha). In 2013, Marampit Island has population of 1 273 people, which live in a 22 ha size settlement. By calculating the total population and settlement size (built area), this study found that the average of built area population density in Marampit Island is around 57.8 people/ha and categorized as low density according to *Standar Nasional Indonesia - SNI* [11].

From these findings, the land capacity found by times the developable area size (1.4 km² or 140 ha) and the average built area population density (57.8 people/ha). The result is 7 980 people. It means Marampit Island can withstand a population of 7

980 people, according to the developable area size and currently built area population density. In another density scenario according to SNI, the land population capacity is:

TABLE 11: Population density scenario according to [11].

Density Category	Density	Land Population Capacity (average)
Current density	57.8 people/ha	7 980 people
Low density	< 150 people/ha	21 000 people
Medium density	151 to 200 people/ha	24 500 people
High density	201 to 400 people/ha	42 000 people
Very high density	> 400 people/ha	56 000 people

This projection made based on population so the others factors that influence the land capacity, such as availability of resources didn't considered. Marampit has potential to more developed because has so many natural resouces.

4. Conclusion

Marampit Island are the lowland area that use to settlement and plantation. The hills area located in the center toward to the north. The area of Marampit Island based on field survey are 14.63 ha. Marampit have three class of land capability, they are second class or high of land capability where spread over west and south edges of island, third class or medium of land capability where spread over middle of island and fourth capability where spread in the north of island. High class suitable for settlement, plantation and human activities. Medium class is suitable for mix plantation. Low class suitable for dry land forest. High class of land capability suitable used for settlement and plantation. According to the developable area size and current built area population density, Marampit Island can withstand a population of 7 980 people.

5. Limitation

Although this study was clearly prepared, there were some unavoidable limitation and shortcoming. This study was conducted to classify land capability and measure the land capacity of Marampit Island, based on six parameters of land capability and two parameters of land capacity. First, this studies not include the type of climate because all region assumed has the same type. Then, also not used the specific factors, such as salinity, tide and soil elasticity beside soil depth and texture, slope, relief, hydrology

and hazard. Second, maximum of land capacity measure just from available land and population, is not considering the resources.

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