Land capability and carrying capacity analysis against land use change in the Motaain Border Region (Indonesia-Timor Leste)

by Murshal Manaf

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M Manaf[1], U R Irfan[2]*, R A de Fretes[3]

[1]City and Regional Planning Study Program, Engineering Faculty, Bosowa University, Makassar, South Sulawesi, Indonesia
[2]Geological Engineering Department, Faculty of Engineering, Universitas Hasanuddin, Gowa 92119, Indonesia
[3]KOTAKU Individual Consultant, Kupang, Indonesia

*Corresponding author: ulvairfan@unhas.ac.id

Abstract. Changes in land use in the border regions of the Motaain state (Indonesia-Timor Leste) are caused by population growth and a variety of activities of the population. Thus, changes in land use that are not controlled affect the ability and carrying capacity of the land. Moreover, the research objective is to assess the characteristics of the region from the physical aspects of the environment to spatial changes, as a reference for controlling spatial use. The analytical methods are used population density and activity density (Kernel density); analysis of activity patterns (cluster and outlier analysis and spatial auto-correlation Moran's I); class analysis of land capability and carrying capacity (overlay); and quantitative statistical quantitative analysis. The results of the analysis explain that from the year 2013 until 2017 the border area of the Motaain state experienced population growth and activities, these affected spatial patterns that change in land use from non-developed land to build-up land. It is also explained that overlay analysis results are more dominant land capability classes are very low as well as the carrying capacity to land that is predominantly a potential and protected development area. The difference in capability and carrying capacity to land is a product of social activities that cannot be controlled.

1. Introduction

Motaain is one of the border areas of the Republic of Indonesia and the Democratic Republic of Timor-Leste (RI-RDTL). Spatial planning in border areas is a priority and is part of the National Strategic Region because it has a very important influence on national sovereignty and defense [1]. Interaction of two contiguous areas is divided into border areas on land and at sea [2]. The development of the Motaain area in the past decade has shown rapid growth, particularly in social and general activities, housing, education, government, trade and services, infrastructure and local industrial activities. This also influence changes in trading activities related to the trafficker, trade flow, type of trade and number of

facilities that have an impact on costs, intensity, income per person and economic growth on a micro, moderate and macro-scale [3].

Overall development activities require extensive land [4], but on the other hand, it is constrained by the basic physical condition of the region [5], carrying capacity and land capacity according to its purpose in spatial planning especially at the national border region. This condition is very susceptible to land conversion from protected functions to uncontrolled cultivated land [6][7]. Changes in function can also lead to reduced land for development that will reduce the function of the area [8]. To prevent and minimize change in the function of an area, the aim of this study is to examine the ability and carrying capacity of the land to land-use change and minimize the environmental and physical degradation of land.

2. Method

The research location is in Silawan Village, Tasifeto Timur District, Belu Regency which is located at coordinates 08 ° 09'00 '- '09 ° 12'00' 'LS and 124 ° 54'00' '- 125 ° 03'00' 'East Longitude (Figure 1). Belu Regency is one of the districts in East Nusa Tenggara Province which shares a direct border with the Democratic Republic of Timor-Leste (RDTL). Primary data obtained through field observations to land-use changes. The distribution of population, residence, and patterns of activities, utilize land use and the results of the interpretation of high-resolution satellite imagery secondary data in 2013 and 2017.

The most recent base map of the area is from Geospatial Information Agency, while the population and characteristics of its activities are sourced from Statistics Indonesia Belu Regency and the Silawan Village Office in 2108 [9]. Quantitative analysis methods, spatial analysis (map overlays) is used to describe the basic physical characteristics of the area, social and economic as well as the distribution and spatial allocation patterns which are then discussed descriptively. Identifying changes in land use in 2013, using high-resolution satellite imagery data in 2013 and 2017 then interpreting it using Geographic Information System.

Figure 1. Location of research in the State Border Area

The results of the interpretation of high-resolution satellite imagery are given a value on each land use then a spatial analysis is done using the Kernel Density method [5]. Identify population characteristics and activity patterns that affect land-use change using Cluster and Outlier Analysis and Auto-correlation Moran's I [10]. Meanwhile, to identify the ability of land and carrying capacity of land using GIS (Geographic Information System).

3. Result and Discussion

3.1 Land-Use

Utilization of space requires the potential to develop and a review is needed so that it can be directed according to the function of the space [11]. The distribution of land use in the Motaain State border region is based on interpretations of High-Resolution Satellite Imagery in 2013 and 2017 (Figure 2). In 2013, land use was dominated by shrubs by 52.09%, forest areas by 13.294%, fields by 10.642% and mangrove forests by 9.591%. The remaining by 14,381% is the use of built land and open areas or yards. The type of land use in 2017, in part of non-built land-use types, has changed into a built space, shrubs reduced to 51.44%, forest area 13.281%, fields reduced to 0.004% and for the area of land use types built began to increase as settlements by 0.97%, Motaain PLBN 0.34%, road network by 0.78%, trade and services by 0.070%, health 1by 0.54%, industry by 0.006%, offices by 0.019%.

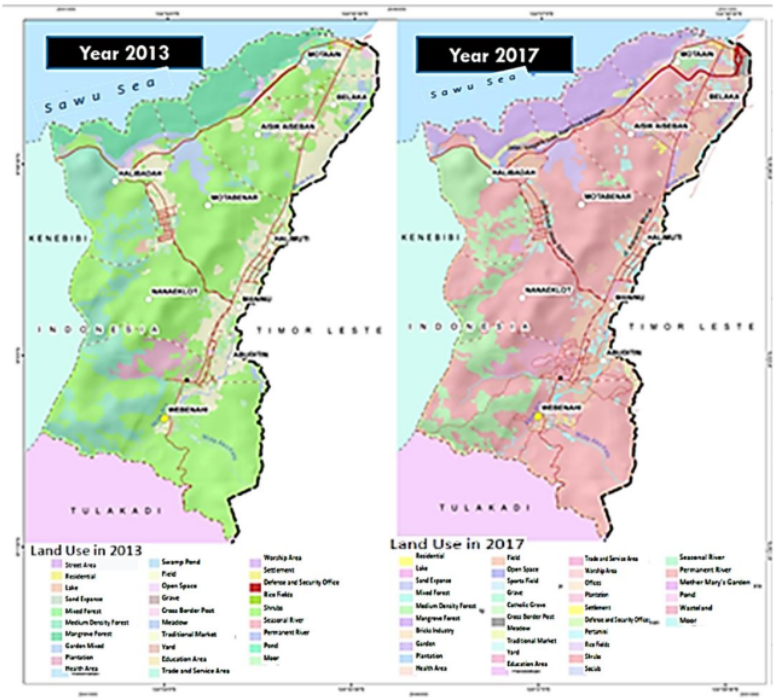

Figure 2. Map on Land-Use in 2013 and 2017

3.2 Population Growth

Population growth based on the Motaain Border Area Population Map from 2013 to 2017 (Figure 3). The total population of Silawan Village in 2013 was 3.534 people spread over 10 hamlets. The center of the village capital is in the village of Webenahi, which has the most population compared to other hamlets, namely 578 people. In 2017 it increased to 3.787 people and the population in the village capital was 620 people with a moderate category of population density.

The results of Kernel Density analysis in 2013, several regions that have high activity density values between 0 – 3.470. Whereas in 2017 the activity density increased from 0 – 3.600. This proves that in the period of 2013 - 2017 the state border area in Motaain experienced a change in land use from non-developed land to built-up land with relatively rapid settlement activity (Figure 4).

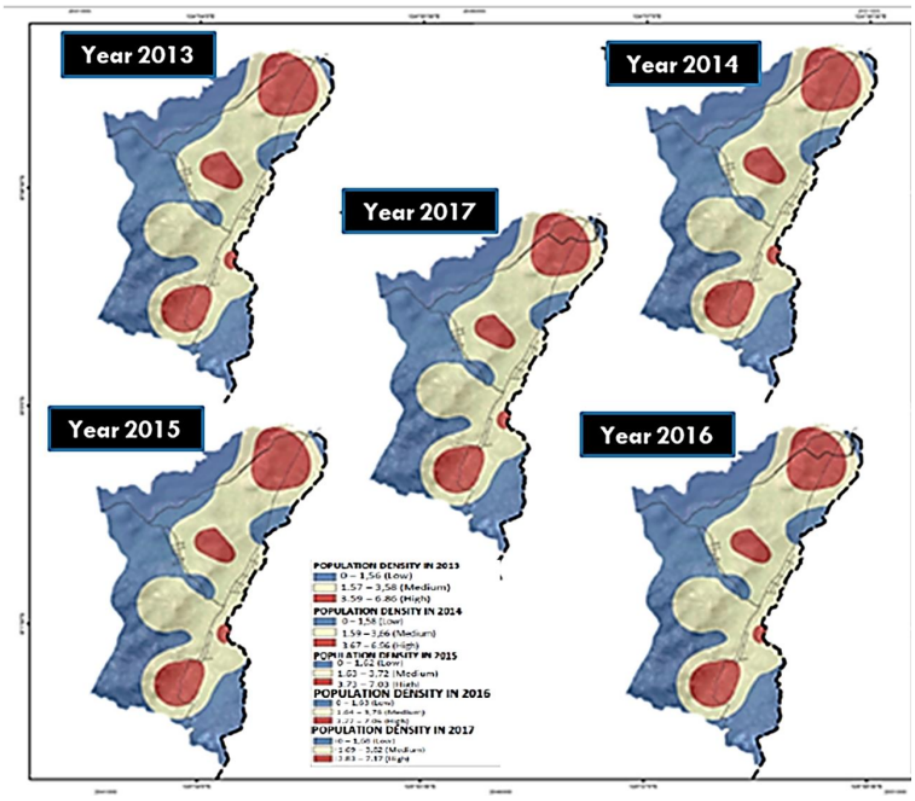

Figure 3. Map of Population Density of 2013 - 2017

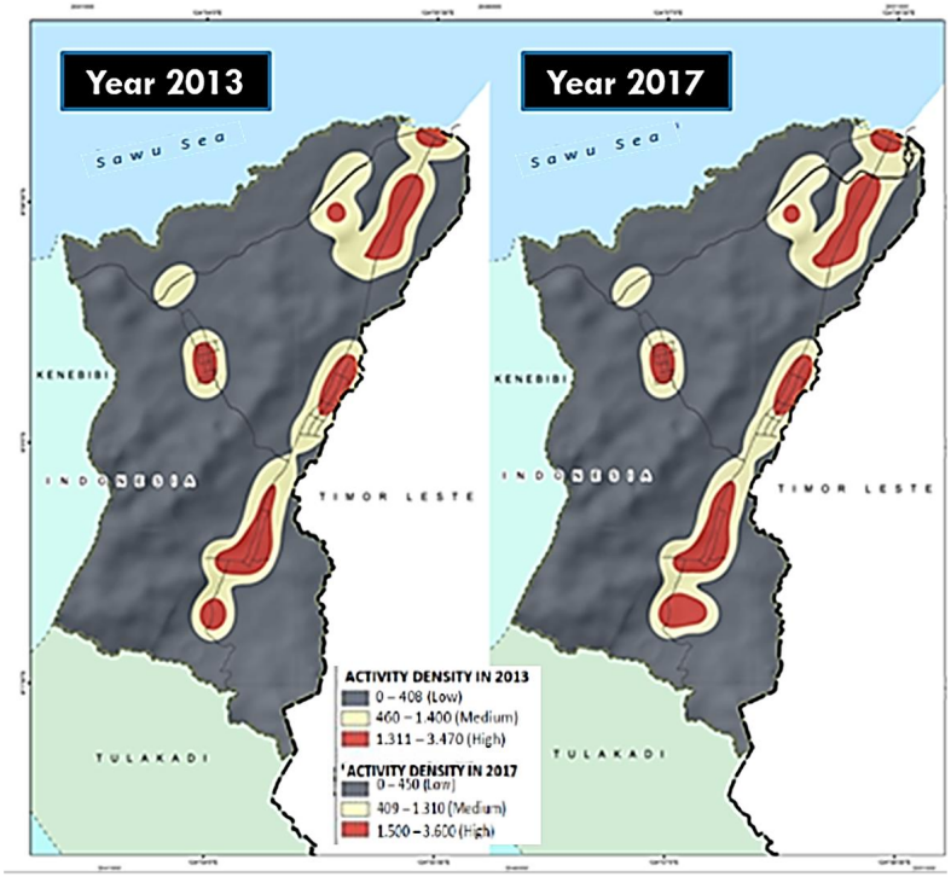

Figure 4. Map of Density of Activities in 2013 and 2017

3.3 Activity Patterns and Changes in Land Use

Based on the results of CSRT interpretations in 2013 and 2017, the dynamics of land-use change range from 80.66 Ha from the Motaain border area. Changes in the use of non-built land to the use of built land have increased around -73.33 Ha. The pattern of land-use change in the Motaain border region in that period was relatively developed and was dominated by the conversion of agricultural land into built land with the designation of settlement activities, social education and worship facilities, home industry, trade and services, office and public facilities (Table 1).

Residential settlements affect the building densification process, as well as the diffusion of socio-economic infrastructure buildings towards the periphery, will affect building density [12]. For example, a socio-economic infrastructure building is an educational facility building, namely a school. The acceleration of the reduction of rice fields indicates the process of converting agricultural land to non-agriculture in the form of buildings. Changing agricultural land to this building will practically cause the process of building or settlement densification.

Table 1. Change in Land Use in the Motaain Area

No.	Land Use 2013	Area (Ha)	Land Use 2017	Area (Ha)	Area Change (Ha)	Percentage Change	Activity Value
1	Road	11	Road	14,88	3.88	4.81	2
2	Residential	12.93	Residential	18,69	5.76	7.14	3
3	Lake	3.02	Lake	3.02	0	0.00	1
4	Stretch of sand	8.56	Stretch of sand	9.73	0	0.00	1
5	Forest	253.42	Forest	253.42	0	0.00	1
6	Mangrove	182.84	Mangrove	183.28	0	0.00	1
7	Brick Industry	0,00	Brick Industry	011	0.11	0.14	3
8	Healt	0.09	Healt	0.18	0.09	0.11	2
9	Pond	0.08	Pond	0.08	0	0.00	1
10	Plantation	202.87	Plantation	188.57	0	0.00	1
11	Open field	12.32	Open field	12.54	0.22	0.27	1
12	Playing Field	2.41	Playing Field	2.35	0	0.00	2
13	Cemetery	0.98	Cemetery	0.35	0.63	0.78	1
14	meadow	26.8	meadow	20.52	0	0.00	1
15	Traditional Market	0.07	Traditional Market	0.07	0	0.00	2
16	Housing	29.59	Housing	95.22	65.63	81.37	1
17	Education	0.97	Education	1.33	0.36	0.45	2
18	Trade and service	0.2	Trade and service	0.36	0.16	0.20	3
19	Worship	0.14	Worship	0.16	0.02	0.02	2
20	Farm	65.04	Farm	29.49	0	0.00	1
21	Office	0.04	Office	0.37	0.37	0.46	2
22	Defence/security	0.31	Defence/security	0.33	0.02	0.02	2
23	Oil and gas	0,00	Oil and gas	0.01	0.01	0.01	2
24	PLBN	3.42	PLBN	6.63	3.21	3.98	3
25	Rice paddy	1.09	Rice paddy	1.09	0	0.00	1
26	Thicket	993.03	Thicket	981.58	0	0.00	1
27	Social	0.04	Social	0.05	0.01	0.01	2
28	River	20.49	River	18,29	0	0.00	1
29	Bunda Maria Garden	0,00	Bunda Maria Garden	0,18	0.18	0.22	2
30	Fishpond	7.37	Fishpond	7.33	0	0.00	1
31	Wasteland	2.36	Wasteland	2.38	0	0.00	1
32	Moor	65.05	Moor	55.57	0	0.00	1
	Total	1.908		1.908			

Furthermore, activities in 2017 have a broader pattern of High-High Cluster and Low-High Outlier activities than in 2013 (Table 2). This condition shows changes in land use and high activity patterns that lead to land use in a clustered and centralized manner. The closer to the center of activity the higher the intensity and diversity of activities emerge. Thus, this perspective confirms that the development of the state border region in Motaain begins with an area with little activity and forms an area with a centralized pattern of activity (Figure 5).

Table 2. Results of Analysis of Activity Patterns for 2013 and 2017

No	Activity Pattern	Area of Activity Pattern (Ha)	
		2013	2017
1	Not Significant	1233.67	685.97
2	High-High Cluster	11.31	19.64
3	High-Low Outlier	0.76	0.81
4	Low-High Outlier	220.76	295.88
5	Low-Low Cluster	439.93	905.1

Description of Analysis:

Not Significant	:	Does not show a pattern of activity or there is no change in land use in the area.
High-High Cluster	:	1. Shows the pattern of high activity or changes in land use in the area.
High-Low Outlier	:	2. Shows the change in the pattern of high activity to the pattern of low activity in the region
Low-High Outlier	:	Shows a change in the pattern of low activity into a pattern of high activity or an increase in changes in land use
Low-Low Cluster	:	Shows the pattern of low activity or low land use changes in the area

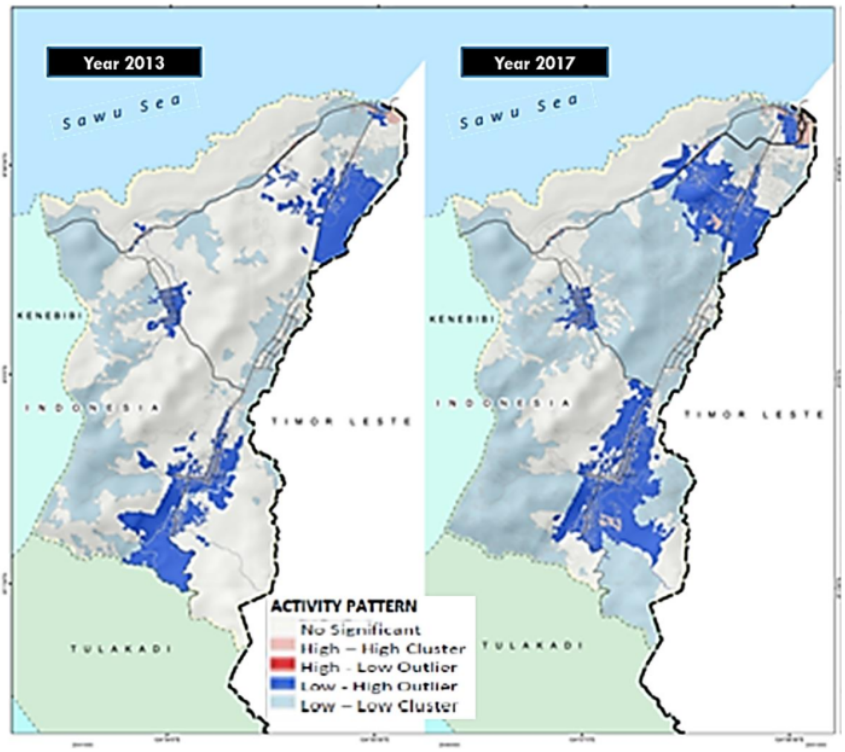

Figure 5. Map of Activity Patterns for 2013 and 2017

Furthermore, based on the results of the Moran's Index show in 2017 (Z-Score: 34.96) higher than in 2013 (Z-Score: 31.94), where a variety of activities clustered patterned and centered on trade and services, offices, education, and settlements (Table 3).

Table 3. Results of 2013 and 2017 Moran's I Spatial Autocorreclation Analysis

No	Year	Moran's Index	Z-Score
1	2013	0,127248	31,942152
2	2017	0,118285	34,964321

3.4 Land Capability

Kernel Density analysis results explain that the growth of the Motaain state border region affects the configuration of spatial use and the occurrence of land-use changes. As a result of land changes that occur continuously and uncontrollably can cause damage to the environmental ecosystem of the Motaain region. The results of the land capability score consist of four classes, namely very low, low, medium and rather high (Table 4).

Tabel 4. Result of Land Capability Analysis

No	Ability Value	Ability Class	Classification	Area (Ha)
1	32	Class a	Very Low Development Capability	950,23
2	64	Class b	Low Development Capability	51,43
3	96	Class c	Medium Development Capability	371,88
4	128	Class d	Rather High Development Capability	532,66

From the results of the total assessment of all these variables, it can be seen that the range of values obtained is from 32 to 128. Based on these values, the ability of land development in Motaain can be divided into 4 (Figure 6), as follow:

a) the ability is rather high, value 128, area of 532.66 Ha (27.91%).
b) medium ability, value 96, area of 371.88 Ha (19.49%).
c) low ability, value 64, area of 51.43 Ha (2.69%).
d) very low capability, value 32, area of 950.23 Ha (49.80%).

3.5 Land Carrying Capacity

Land carrying the capacity analysis is carried out to assess the ability of land to support activities in the Motaain state border region. Analysis of the carrying capacity of the land is also useful for identifying the potential and problems of regional development based on the suitability of the land in the development of border areas. This land carrying the capacity analysis is used to produce recommendations for the designation of the cultivation and protection zones.

The results of the analysis of the carrying capacity of the land obtained 3 (three) carrying capacity classifications, namely the carrying capacity of the potential land area of 885.08 Ha, carrying capacity of constrained land with an area of 156.41 ha, and carrying capacity of protected land with an area of 866.54 Ha. Of this area, approximately 1041.49 Ha is the potential carrying capacity of the land to be developed as a cultivation and settlement area (Table 5). Potential land at the morphology of the undulating to sloping hills which are composed of fine-sized rocks in the form of claystone in the Bobonaro Complex [13]. The carrying capacity of the land that includes the area constraints is composed of a mixture of rocks from clay up to chunks in the Bobonaro complex and basaltic rocks of the Maubisse Formation [14] in the moderate hill morphology. Claystone has the potential to become a land of expansion which can cause stability to decrease and carrying the capacity to accept the burden is low. The carrying capacity of protected land function is in the steep hill morphology composed of ultramafic rocks. Furthermore, the results of the carrying capacity of the land were found to be the use of land and the activities of settlements were in areas with carrying capacity of the protected and non-functioning land functions (Figure 6).

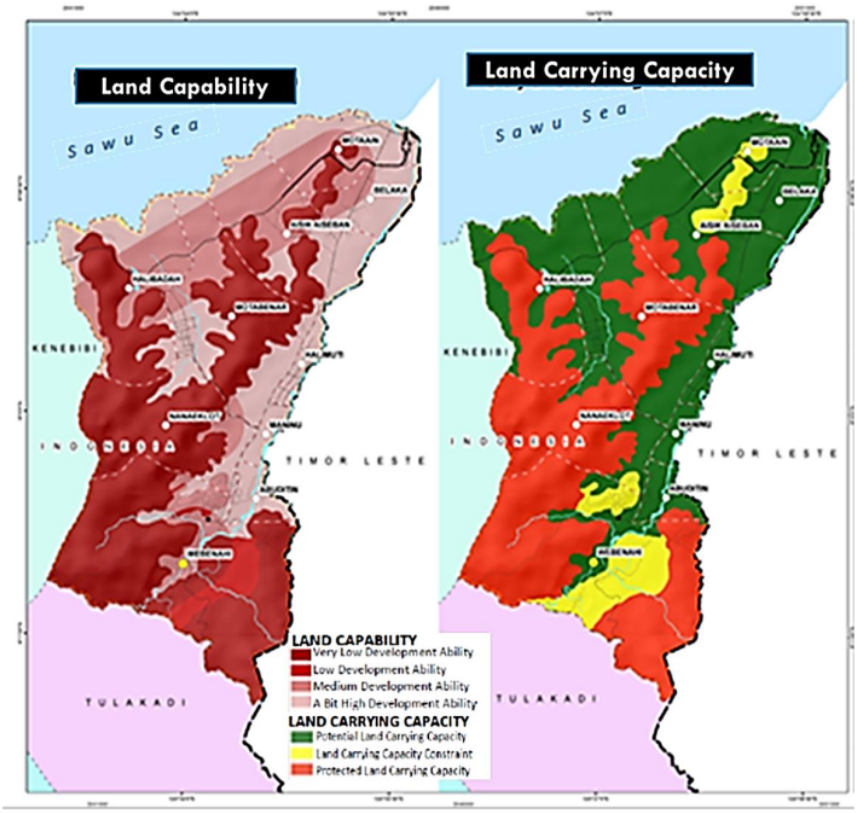

Figure 6. Map of Land Capability and Carrying Capacity Land

Table 5. Result of Carrying Capacity Analysis

Morphology	Slope Map	Topography Map	Geology Map	Rainfall Map	Land Use	Land Capability	Land Carrying Capacity	Broad (Ha)
Steep hills	>40 %	>40 Mdpl	Ultrabasic Rocks, Bobonaro Complex, Maubisse Formation, Pillow Lava, Aluvium		Roads, Lakes, Forests, Gardens, Fields, Open Grounds, Meadows, Yard, Settlements, Moor, Shrubs, Rivers	Class a	protection	866.54
Mild hills	15 – 40 %	15 - 40 Mdpl	Bobonaro Complex, Formasi Maubisse Formation, Pillow Lava, Aluvium	69 - 120 mm/year	Roads, Lakes, Forests, Gardens, Fields, Open Land, Meadows, Yard, Settlements, Ponds, Moor, Shrubs, Rivers	Class b	constraints	156.41
Gentle hills	5 – 15 %	8 - 15 Mdpl			Roads, fields, forests, worship, open land, settlements, yards, rivers	Class c		
Undulating	2 – 5 %	0 - 8 Mdpl	Bobonaro Complex, Aluvium		Roads, Forests, Industry, Gardens, Fields, Open Land, Meadows, Yard, Settlement, Education, Offices, Worship, Ponds, Moor, Shrubs, Rivers	Class d	Potential	885.08

4. Conclusion

Changes in land use in the state border region in Motaain in the last four years 2013-2017 are quite rapid from the use of non-developed land to built-up land. There is a tendency to centered and clustered following the trend of concentration of social and economic activities before, especially in the zone of housing, trade, and services, offices, as well as defense and security.

Furthermore, the ability of land in this area is generally very low but has a good potential land carrying capacity as a developed cultivation area and the carrying capacity of the land serves to protect the built area. The difference in land capability and carrying capacity of border area land is a product of social activities that must be controlled for the sustainable development of the Motaain state border region.

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