

Research Article

Analysis of the relationship of land carrying capacity and building area towards the development of Kualanamu International Airport in 2010 and 2017

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Abstract: Land resources availability has been declining due to the rapid development of the industrial, residential, and even tourism sectors in all regions, including Batang Kuis Subdistrict, Deli Serdang Regency of North Sumatra Province. The declining of land resources in Batang Kuis Subdistrict has a strong relationship with the factors causing rapid and dynamic development of Kualanamu Airport located at the east side of the sub-district. Regional development causes land conversion and urban development that impacts on carrying capacity of the land. Therefore, the objective of this study was to determine the relationship between land use and land carrying capacity of Batang Kuis Subdistrict in 2010 and 2017. Data used for this study consisted of primary data by Google Earth satellite imagery of Batang Kuis Subdistrict and secondary data of population and area per village in 2010 and 2017. The analysis used for this study was a quantitative analysis by calculating Land Carrying Capacity (LCC) and spatial analysis by mapping the land area that has been developed in two years with a unit of analysis at the village. Results obtained from this study were land carrying capacity table and the land area maps of Batang Kuis Subdistrict for 2010 and 2017. The highest value of land consumption per capita referring to Yeates dan Garner standard was observed at Sena, Sidodadi, and Mesjid Villages in 2010 and 2017. The main factor is easy accessibility since the development of Kualanamu Airport.

Keywords: *Batang Kuis, land conversion, land carrying capacity*

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Introduction

Land Carrying Capacity (LCC) is the ability of an environment to support life (Ariani and Harini, 2012). Because population activities become increasingly out of control, land conversion has been happening with no appropriate functions that resulted in a decrease of carrying capacity of the environment (Clark, 1992). The rapid development of new infrastructure and economic development in Batang Kuis Subdistrict due to industrial growth from Tanjung Morawa Subdistrict and its surrounding areas have triggered rapid growth and

population density. Those rapid developments have impacted on land acquisition to meet the life needs. Land resources availability has been declining due to the rapid development of the industrial, and residential sectors. Moreover, regional development of tourism and urban area sectors greatly influence the conversion of agricultural land to non-agricultural land which in turn decreased the carrying capacity of agricultural land and population capacity that exceeds optimal population limits (Sriartha and Giyarsih, 2015). According to Soemarwoto and Soerjani (1990), the high level of population density may boost land

demand. If land availability is insufficient, people will search for empty land regardless of paying attention to land suitability. For example, the land function at the top of a mountain should be available as land covers such as wood or empty land. Nonetheless, agricultural land conversion, land clearing and planting in susceptible erosion areas still happen. The higher population is proportionate to land demand for settlements; therefore, the LCC lessens fast (Ariani and Harini, 2012). The rapid and dynamic development in Batang Kuis Subdistrict is caused by the existence of Kualanamu Airport, which is located at the east side of sub-district, as shown in Figure 1.

The area around Kualanamu Airport is a buffer zone of Medan because of the construction of a new airport. Kualanamu Airport development project is assumed to be a driving force of economic sector on the surrounding regions, while the new airport plays a role as an accelerator of urban development to Kualanamu region and neighbourhood. Meanwhile, the airport function as an economic growth orientation on the surrounding areas has encouraged the community to gather and take benefit from consumers at Kualanamu Airport. The existence of merchants could create a trading area as economic activities centre around the airport. The airport construction has altered the physical function of the soils on the surrounding areas, including Batang Kuis Subdistrict, over time. Land conversion into built-up areas has been increasing for the years and impacts the land carrying capacity. Therefore, obtaining the value of land carrying capacity calculation based on capacity can be used as a reference to find out which areas are suitable for specific land use.

In order to generate the suitability, this study aimed to determine the relationship between land use and land carrying capacity in Batang Kuis Subdistrict in 2010 and 2017. Results of this study can be used as an additional reference in spatial planning and integrated space development on facing Kualanamu Airport development. Another benefit obtained is anticipating the penetration of economic activities from the Tanjung Morawa industrial area so as not to exceed the threshold of built-in land use.

Methodology

Location and time of study

The study location is in Batang Kuis Subdistrict, Deli Serdang Regency, North Sumatra Province, as presented in Figure 1. Batang Kuis Subdistrict is located at coordinates of 41° - 46° E and 3°35' - 3°41' N. Based on administrative boundaries, Batang Kuis Subdistrict borders of the mainland

are Pantai Labu Subdistrict (north), Banyan Subdistrict and Pantai Labu Subdistrict (east), Tanjung Morawa Subdistrict (south), and Percut Sei Tuan Subdistrict (west). Batang Kuis Subdistrict has an area of 4,034 hectares that consisted of eleven villages and 72 hamlets. It places Batang Kuis Pekan as subdistrict capital (BPS, 2016). Based on the physical geography, Batang Kuis Subdistrict has terrestrial geomorphology and the majority of land use are paddy fields. Meanwhile, the total population in Batang Kuis Subdistrict is 66,406 people with a growth rate of 2.71 percent from 2016 to 2017 (BPS, 2018). The sex ratio of population in Batang Kuis is almost balanced, which is seen by the number, 103. The number is composed of a high population of male. The sex ratio in Batang Kuis Subdistrict is 103, with a population density reaching 1424 people / km². Residents live in permanent, semi-permanent and wood buildings.

The study was conducted from March to April 2019. The period of study was quite short since it used secondary data to generate the output without conducting a field survey. Batang Kuis Subdistrict has been experiencing increment of population ss than ten years; thus it becomes the focus of study. The 2010 and 2017 were chosen since the data availability representing the condition of the Batang Kuis before and after the International Kualanamu Airport was built.

Method

The study in Batang Kuis Subdistrict was conducted with an analysis unit into villages, including other subdistricts surrounding Kualanamu Airport. Batang Kuis Subdistrict was chosen as a study location since its continuous development of the physical and socio-economic aspects. Furthermore, the location has the potential to influence its surrounding area, beside the existence of industrial estates in Tanjung Morawa Subdistrict as the southern boundary to Batang Kuis Subdistrict. Batang Kuis is one of the subdistricts that has been traversed to Kualanamu Airport area, especially by Medan people who access the airport. Data collection of the study was compiled by primary data and secondary data. Primary data stands from satellite images of Batang Kuis District in 2010 and 2017 adapted through Google Earth, whilst secondary data are collected from Batang Kuis Subdistrict in Figures 2010 and 2017. Batang Kuis Subdistrict in Figures obtained by Central Bureau of Statistics Deli Serdang. Data processing on the study began with collecting secondary data, such as population and area of each village in the subdistrict. LCC was calculated based on capacity (Muta'ali, 2012).

The land carrying capacity formula according to Yeates and Garner (1980) as follows:

$$A = L / P$$

where:

- A = Land carrying capacity
- L = Land area (hectare)
- P = Population (person)

The results of land carrying capacity calculation were compared to the table of land consumption per capita (Tabel 1). The value of LCC was classified good as long as it does not exceed the value of land consumption as the threshold, in accordance with Yeate and Garner standards (1980) and vice versa (Muta'ali, 2012). Satellite imagery was used to determine the distribution of built and non-built land on ArcGIS software. In general, the analytical techniques use quantitative and spatial analyses. The analyses were used to determine the distribution and the relationship between land use and capacity of LCC in Batang Kuis Subdistrict.

Flowchart

A flowchart is the steps taken in research. The steps in question include data collection up to the acquisition of research output. Meanwhile, flow diagrams are also interpreted as step by step progressive through a procedure or system using certain connecting lines or symbols (Merriam-Webster, 2019). The flowchart of this study is presented in Figure 2.

Table 1. Land consumption.

No.	Population	Land Consumption (hectare/person)
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 and Garner (1980).

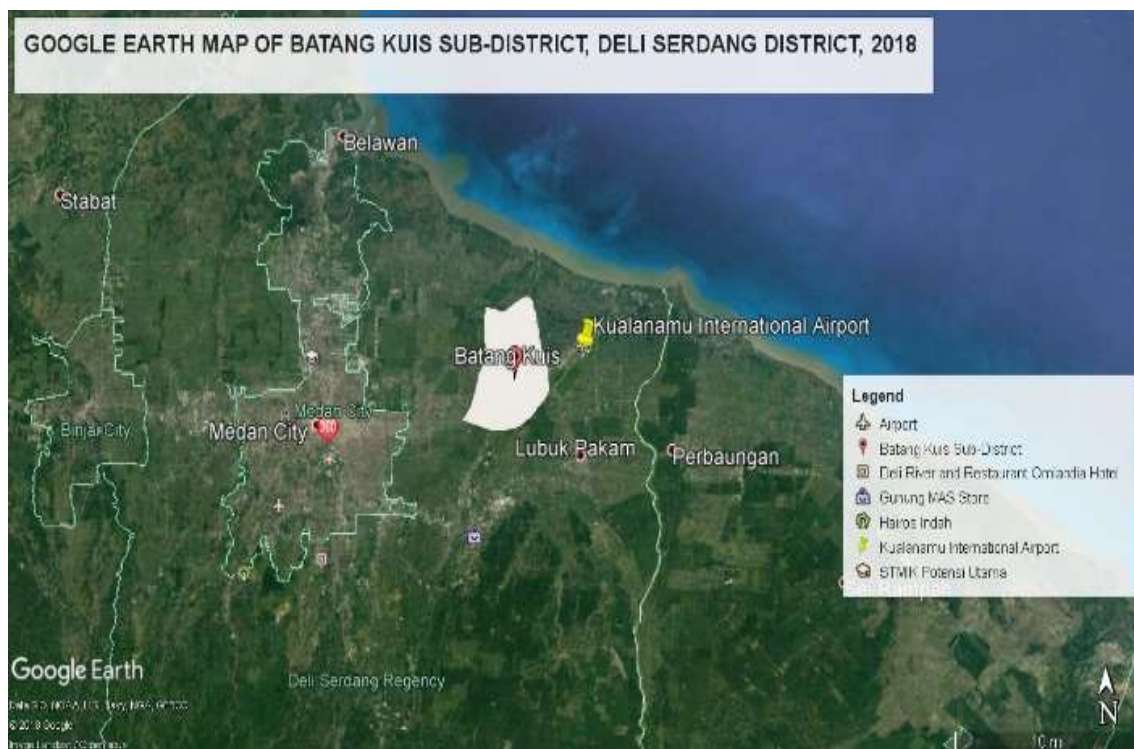


Figure 1. Google earth map of Batang Kuis Subdistrict, Deli Serdang Regency in 2018
Source: Data processing from Google Earth, 2018.

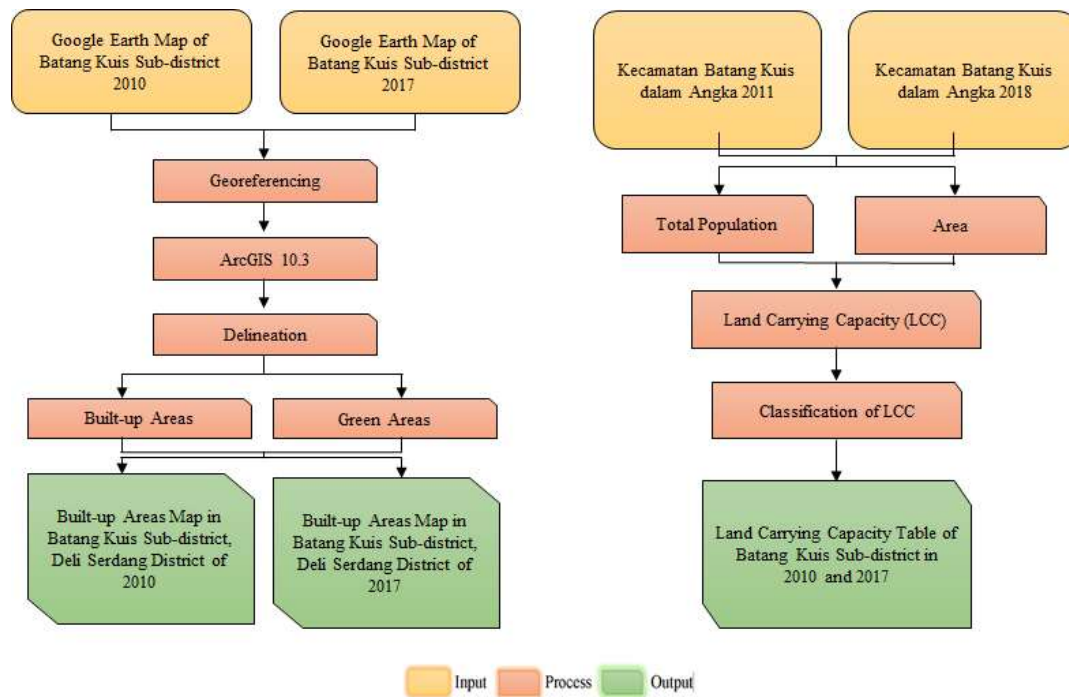


Figure 2. Research flowchart.

Results and Discussion

The capacity of the area is a study that is often discussed because it involves land use. The capacity of the region can uncover land conversion that occurs due to population growth that continues to increase. The study location of the capacity of the area, i.e. Batang Kuis District, Deli Serdang Regency, North Sumatra Province, consists of eleven villages. Sidodadi Village is the largest area (1,095 ha), followed by Sena Village (1,050 ha). The area in the "kelurahan" remains the same even though the population has increased. Although both areas have large areas, they do not have a high population. The highest population in 2010 and 2017 is observed in Tanjung Sari Village. This means that the largest area is not always occupied by the largest population. There are some internal and external factors that triggered the population increase in Batang Kuis Subdistrict. According to Thifaltanti (2019), the internal and external factors that increased population in Batang Kuis District were influenced by the presence of Kualanamu Airport, which has been operating since 2013. The increase was mainly due to a large number of newcomers which gave rise to a new economic centre in the surrounding areas. Residents often traverse this area. Many residents chose to live in Batang Kuis District because of their easy access to and from the airport. The land is an area that has natural wealth and it is used for various life and human activities, such as settlements, agriculture,

livestock, mining, road infrastructure, as well as facilities in the social, economic, etc. (Muta'ali, 2012). Various land-uses adjust the needs and objectives of human activities, so the largest area does not always have the largest population

Sidodadi Village has the largest land area with an increasing population from 3784 people to 4464 people (Table 2). This population growth has not made Sidodadi become a village with the highest number of population, even still ranked third lowest for the population in 2017 (Table 2). Therefore, the LCC of Sidodadi Village is ranked highest. The value of land carrying capacity in Sidodadi Village was also stated as surplus because the availability of land was still higher than the amount of land needed for human activities, such as settlements (Putra et al., 2016). Land carrying capacity in Sidodadi Village is similar to Mesjid Village, even though it has a different population and land area. Based on Table 2, the area of land in Mesjid Village is almost five times narrower than that of Sidodadi Village. Meanwhile, the number of population in Mesjid Village also increased slightly from 1323 in 2010 to 1564 in 2017. The population is also still below Sidodadi Village, which has tripled from the Mesjid Village. Surprisingly, the land carrying capacity in the two villages is almost the same, where the land carrying capacity in the Mesjid Village has indeed decreased from the range of 0.2 to 0.17. The decreasing land capacity in Mesjid Village was

caused by an increase in population that was not followed by increasing land area, and the area is always fixed. The fact that changes in land use patterns caused by lifestyles, such as urbanization, industrialization, human population, and welfare affect the land carrying capacity (Qian et al., 2015). Therefore, land carrying capacity in Mesjid Village has decreased, although it still occupies the second-highest position. The similarity of land carrying capacity of Sidodadi Village and Mesjid Village is also caused by different population ratios and land area, resulting in the same value. Overall, both villages have not yet experienced extensive urban processes, compared to Sena Village.

In Table 2, Sena Village has the second largest population in Batang Kuis Subdistrict. Although it has a high population it still has the high value of land carrying capacity has a high value too. It occurred because Sena Village has a large land area which supports the people inside the village to utilize the land more than the other villages. Sena Village is around at 1050 ha and the population in 2010 has reached 7.217 people and the population in 2017 was 8.517, where the population density in 2010 was only 7 people/ km² has increased to 8 people/ km² in 2017. The value of carrying capacity of land in Sena, Sidodadi, and Mesjid Villages is stated to be the highest value of per capita land consumption which refers to the Yeates and Garner's standard. Those villages still

have a huge potential for carrying human activities which requires a land existence. On the other hand, even though it is still relatively high, it can be observed that there is a decreasing value of carrying capacity of the land from the three regions. Efforts to maintain a good land carrying capacity are still needed. The area of Tanjung Sari Village is only 734 ha, but the population in 2010 has reached 10.280 people. Based on Table 2, the population of Tanjung Sari Village in 2017 was 12.175, where the population density in 2010 of 14 people / km² increased to 16 people/ km² in 2017. Population density is always increasing even though the capacity of the region remains the same in accordance with the theory of Thomas Robert Malthus which states that an increase in population growth occurs according to a series of measures and an increase in food production occurs according to arithmetical calculations. Land carrying capacity always inversely to the value of population density. Areas with a high value of land carrying capacity will have low population density values and vice versa. The theory of land carrying capacity according to Yeates and Garner (1980) has the disadvantage that the value of land carrying capacity is only limited to the extent of administration without taking briefly the phenomena of landforms, landforms and specific nature of land that can affect or inhibit land carrying capacity to be utilized in various needs.

Table. 2. Land carrying capacity of Batang Kuis Subdistrict in 2010 and 2017.

Village	Land Area (hectare)	2010		2017	
		Total Population	Land Carrying Capacity	Total Population	Land Carrying Capacity
Tanjung Sari	734	10280	0.071401	12175	0.060287
Sena	1050	7217	0.145490	8517	0.123283
Tumpatan Nibung	370	6945	0.053276	7667	0.048259
Baru	432	5774	0.074818	6802	0.063511
Bintang Meriah	65	5294	0.012278	6256	0.010390
Batang Kuis Pekan	75	4883	0.015359	5776	0.012985
Sugiharjo	159	4860	0.032716	5714	0.027826
Paya Gambar	301	4175	0.072096	4895	0.061491
Sidodadi	1095	3784	0.289376	4464	0.245296
Bakaran Batau	45	2185	0.020595	2576	0.017469
Mesjid	267	1323	0.201814	1564	0.170716

The development of the population in Batang Kuis Subdistrict is not very significant in 2017 but has experienced an increase in population evenly in all villages. Increased equitable population growth does not result in land carrying capacity having the same value. Based on data processing, the carrying capacity of land in Sena, Sidodadi, and Mesjid Villages in 2010 and 2017 was still decent in the

threshold of >0.1. Sena Village that has a high value of land carrying capacity also has a high number of population among the other villages just because Sena Village has a large land area. The growth of population and the built-up area in Sena Village is because its location is very strategic since it is close to the airport and passed by the toll road. Toll roads-provide developments in the

region's economic conditions (Sugianto, 2018). Another factor that resulted in the reduced carrying capacity of the Sena Village is that it is close to Tanjung Morawa Subdistrict, even limited by the toll road. Tanjung Morawa is an industrial area in Deli Serdang Regency, even one of the companies, namely PT. Mark Dynamics Indonesia built a factory in Tanjung Morawa (Hidayat, 2019). The assumption used is that the area near the plant will experience an urban sprawl process or even function as a buffer zone. Sena Village is assumed to be a buffer zone where factory workers live or waste capacity. This is in accordance with the

theory that higher economic growth results in the carrying capacity of the environment reaching its maximum point/threshold and then decreasing (Muta'ali, 2012). Therefore, economic activity affects the consumption of land capacity in Sena Village. Although Mesjid Village is located near Kualanamu International Airport, the conditions of land use are not too affected by the construction of the airport. Meanwhile, in Sidodadi Village, the effects of surrounding areas, such as Sei Rotan, Bintang Meriah or even Batang Kuis Pekan which is the subdistrict capital of Batang Kuis does not make the population overgrows.

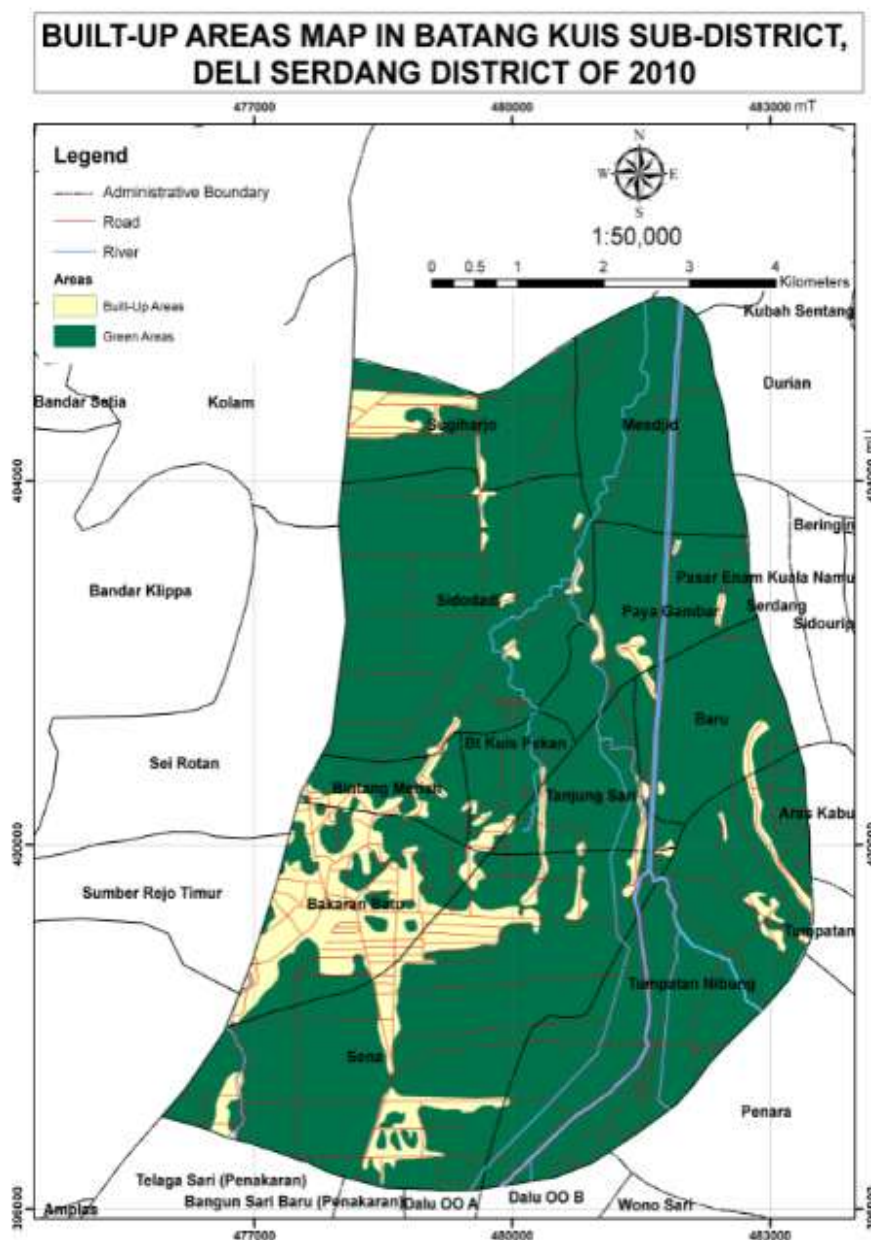


Figure 3. Map of Land area built in Batang Kuis Subdistrict, Deli Serdang in 2010.
Source: Data processing, 2019.

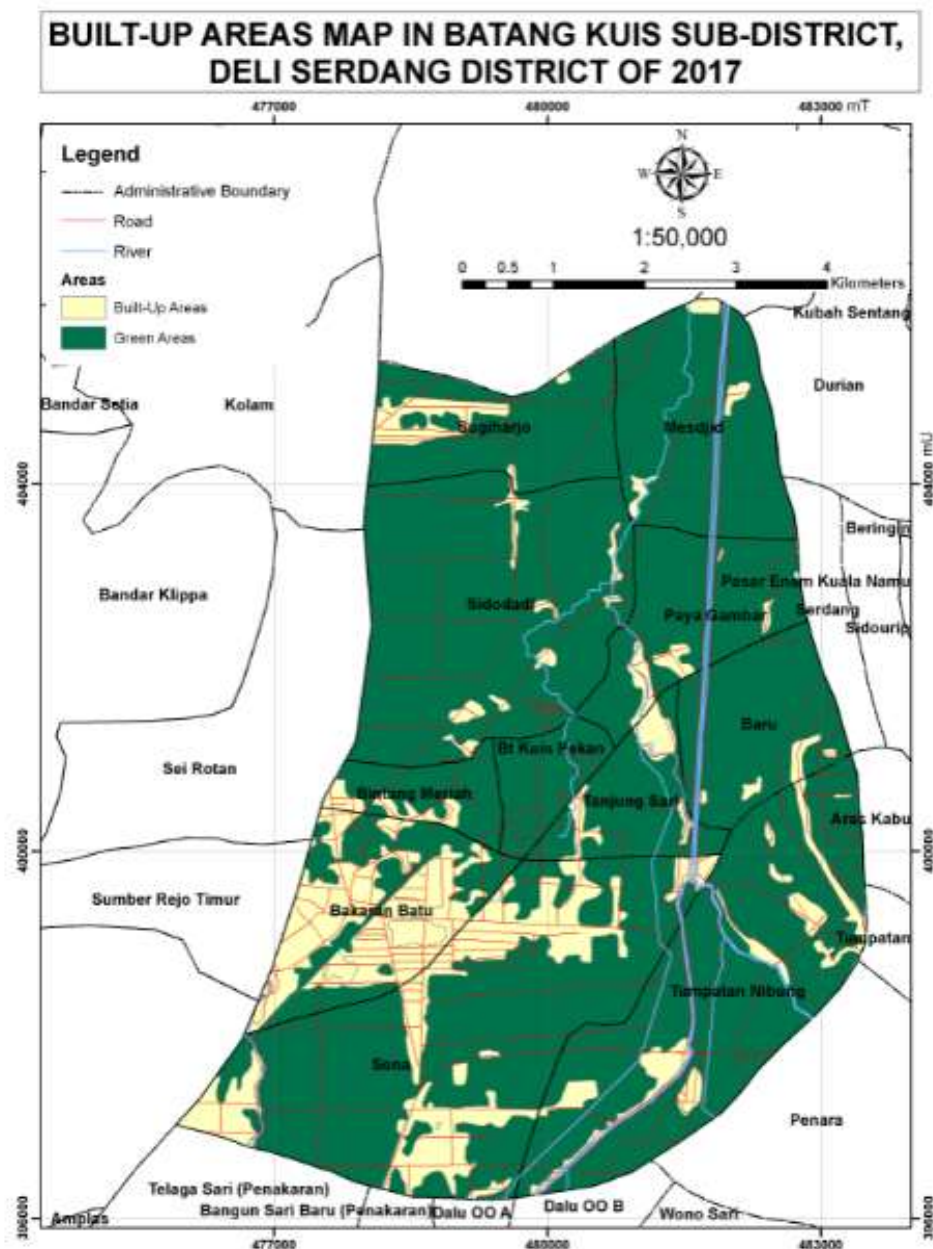


Figure 4. Map of the land area built in Batang Kuis Subdistrict, Deli Serdang in 2017.

Source: Data processing, 2019.

A land which is provided with a precious natural asset has experienced persistent pressure from a range of direct and indirect socio-economic driving forces (Teshome, 2018). An example of these various direct and indirect socio-economic driving forces is the increase in population in Batang Kuis Subdistrict each year. The persistent pressure is stated into the change of green area into a built-up area or from one form of green area to another form of the green area because of human needs. An increase in the number of population, meanwhile, the area of land which is constant will continue to

change the value of land carrying capacity every year in the future. Based on the results of this study, the land carrying capacity of each village decreased in 2017 compared to 2010, so there is a possibility in the future the value of land carrying capacity will continue to decrease because of land consumption per capita has also changed. Efforts are needed to restore the carrying capacity of land or to make the decreasing becomes slower because further decreasing will not only have an impact on the environment but also on humans. Adopting the results of research conducted by Rusli et al. (2009),

some efforts that can be done to overcome the decrease in carrying capacity of land are by making rules regarding restrictions on in-migration, increasing external carrying capacity, reforestation. Based on the results of data processing on the map (Figures 3 and 4), the map of built-up land in Batang Kuis in 2010 and 2017 has significant developments, especially in the Bakaran Batu Village and Sena Village. The assumption is that Bakaran Batu Village and Sena Village have experienced urban processes, resulting in a lot of land conversion. Sena Village located at the Batang Kuis border with Tanjung Morawa, where the border is crossed by the Medan-Kualanamu toll road. This toll road connects Medan City with Kualanamu Airport which shortens the trip to 45 minutes by passing Sena Village as a village at Batang Kuis which is close to Kualanamu International Airport (Sugianto, 2018). Bakaran Batu Village still has a low value of land carrying capacity than Sena Village because of the difference in the ratio of area to the population that showed in the built-up area (Figures 3 and 4).

The land conversion that occurs in the routes to Kualanamu Airport shows that urban appearance is beginning to be seen, especially in the Sena Village. Transformation of land functions from paddy fields to industrial estates, settlements, and industries, toll roads, and airports is evidence that there is a decrease in land carrying capacity (Hasibuan, 2017). Meanwhile, the industrial area of Deli Serdang Regency has reached approximately 365 hectares of the total dominant land; even the farming community tends to sell rice fields to other parties because of the construction of airports and highways (Hasibuan, 2017). Batang Kuis Subdistrict as an integral component, has a low value of land carrying capacity in 2010 and 2017. The value of land carrying capacity of less than one, meaning that Batang Kuis District has not been able to carry out food self-sufficiency (Matondang, 2017).

Conclusion

The land carrying capacity in Batang Kuis Subdistrict keeps decreasing, but the population keeps surging, while the land area remains similar. The main factor influencing the land carrying capacity is Kualanamu Airport development that impacts surrounding areas by urbanization, industrialization, human population, and welfare upgrading. Even so, the development of the population in Batang Kuis Subdistrict is not very significant from 2010 to 2017, while the population keeps increasing in all villages. The highest value

of land consumption per capita refers to Yeates and Garner standard stands from Sena, Sidodadi, and Mesjid Villages in 2010 and 2017. High land carrying capacity is not always caused by high land-use conversion and vice versa. The recommendation for the condition of the land in Batang Kuis Subdistrict is adopting research results of Rusli et al. (2009), some efforts should be made to overcome the decrease in land carrying capacity by making rules regarding restrictions on in-migration, increasing external carrying capacity, and reforestation.

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