

# Analysis of agricultural land carrying capacity in North Sumatra Province in 2020

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**Abstract.** North Sumatra Province is an area with considerable agricultural potential in the Sumatra region. Analysis of the carrying capacity of agricultural land in North Sumatra in 2020 is very important to do in order to determine the carrying capacity of agricultural land in North Sumatra in meeting the food needs of its people. The purpose of this paper is to calculate and present the results of the analysis of the carrying capacity of agricultural land in North Sumatra Province. The data needed in this study is secondary data obtained from several journals and publications from related agencies, such as the Central Statistics Agency (BPS) of North Sumatra Province. The results showed that overall the carrying capacity of North Sumatra's land was classified as low. The low carrying capacity of rice farming land in North Sumatra is caused by increasing population growth and the quality of agricultural land which continues to decline so that the production of rice plants cannot meet the maximum food needs of the community. Therefore, it is necessary to make efforts to increase the carrying capacity of rice farming land in this area, for example by reducing the population and improving the quality of agricultural land resources.

## 1 Introduction

Indonesia is an agrarian country where the majority of its population relies on agriculture for their livelihoods. However, over time, agricultural land has been experiencing a decline in both quantity and quality. This is due to the increasing pressure of population on agricultural land [1]. The continuously growing population and the rampant development activities have led to the conversion of agricultural land, which should have been used for food production. Consequently, this has resulted in a diminishing availability of agricultural land to meet the food needs of the population.

The carrying capacity of agricultural land is defined as the ability of agricultural land to support the livelihoods of the community in a certain area, particularly in terms of food security [2], [3], [4]. The carrying capacity of agricultural land involves the calculation of the population that can be supported or sustained by a certain area of land resources in a prosperous state [5]. The analysis of agricultural land carrying capacity needs to be conducted to ensure adequate food availability for the population. Understanding the potential production of agricultural land becomes crucial in taking necessary measures to enhance agricultural productivity, optimize land use, and meet the increasing food demands in the future.

The province of North Sumatra is an area with significant agricultural potential and serves as a food barn in the Sumatra region. This is due to its favorable physical geographical conditions, such as agroclimatic conditions and abundant natural resources, as well as the cultural practices of its population, a large portion of whom work in the agricultural sector, particularly in food crops. Therefore, North Sumatra has become one of the prime markets for the best agricultural products, with some commodities even being exported abroad.

The agricultural sector, along with forestry and fisheries, plays a vital role in the economy of North Sumatra. In 2020, the economic structure of North Sumatra was still dominated by the agricultural, forestry, and fisheries sectors. These sectors contributed 21.34 percent to the total Gross Regional Domestic Product (GRDP) of North Sumatra [6]. This makes them one of the largest contributors to the formation of GRDP in the province of North Sumatra [7].

The food crops produced in North Sumatra consist of rice, corn, soybeans, peanuts, mung beans, sweet potatoes, and cassava. Among these food crops, rice had the highest production in 2020, reaching 2,040,500.19 tons with a productivity of 5,251 kg/ha. Based on productivity, there were three regencies/cities with the highest productivity values, namely Karo Regency, Deli Serdang Regency, and Pematang Siantar City [8].

The agricultural sector, which is essentially the economic backbone of North Sumatra province, is increasingly threatened by the growing population, which leads to an increased demand for residential land and infrastructure. According to data from the BPS (2020), the population of North Sumatra province reached 14,799,361 individuals, consisting of 7,422,046 males and 7,377,315 females. The population growth rate in North Sumatra, which was 1.22% during the period of 2000-2010, increased to 1.28% during the period of 2010-2020. This increase has led to changes in land use for housing and development facilities, which on the other

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hand, can threaten the availability of sustainable agricultural land.

Based on the above problems, the research entitled Analysis of the carrying capacity of agricultural land in North Sumatra in 2020 is very important to do in order to determine the carrying capacity of agricultural land in North Sumatra in meeting the food needs of its people. In addition, the purpose of this writing is to calculate and present the results of the analysis of the carrying capacity of agricultural land in North Sumatra Province. Knowing the capacity of agricultural land in each district/city in North Sumatra Province can provide an overview to the government and the local community regarding the availability of paddy agricultural land for food production. The pressure on agricultural land in North Sumatra is a concern for farming communities, so that if this situation is not controlled it will result in a decline in the demand for agricultural land for food production in the future.

## 2 Methodology

This research is a quantitative descriptive research with a spatial approach. Quantitative descriptive research is research that aims to describe, record, analyze, interpret, and classify a condition that occurs. While the spatial approach is an approach that puts forward the principles of distribution, interrelation, and description [9].

### 2.1 Location determination

This research was conducted in North Sumatra Province which has a total area of approximately 182,414.25 km<sup>2</sup> consisting of a land area of approximately 72,981.23 km<sup>2</sup> and an ocean area of approximately 109,433.02 km<sup>2</sup>. Administratively, the province of North Sumatra consists of 25 regencies and 8 cities with the capital city of Medan.

### 2.2 Data collection method and calculation

The data required for this research is secondary data obtained from several journals and publications of relevant institutions, such as the Central Statistics Agency (BPS). Agricultural land carrying capacity is one of the environmental carrying capacity analyses, which serves to calculate the availability of paddy agricultural land in supporting the population's needs. To determine the Land Carrying Capacity Status (DDL), it will be done by comparing the land availability (SL) with the land requirement (DL). The following is the interpretation of the analysis results, namely:

If  $SL > DL$ , it means that the land carrying capacity is surplus.

If  $SL < DL$ , it means that the land carrying capacity is deficit or exceeded.

The calculation is conducted to determine the region's capacity to achieve food self-sufficiency by comparing the optimum population with the food production output. The concept used to understand the

critical threshold of carrying capacity is the existence of a limited population that can be supported without compromising the natural environment and ensuring the preservation of the ecosystem [10]. The agricultural land carrying capacity can be calculated using a formula based on a combination of theories from Odum, Chirtaler, Ebenezer Howard, and Issard (Suhardjo & Tukiran, 1990).

$$\sigma = \frac{Lp/Pd}{KFM/Pr} \quad (1)$$

Explanation:

$\sigma$  = Agricultural land carrying capacity

$Lp$  = Harvested land area (Ha)

$Pd$  = Population

$Pr$  = Average rice production per hectare (Kg/Ha)

$KFM$  = Minimum Physical Needs (Kg/capita/year)

Regions capable of achieving food self-sufficiency are those that can meet the minimum physical needs of the population, which are 1600 calories/person/day or equivalent to 265 kg of rice/person/year. Regions capable of providing a decent standard of living for the population depend on the area of food crops that can meet the population's needs at an acceptable level, equivalent to 650 kg of rice/person/year or 2.46 times the minimum physical needs (KFM). Based on these values, the agricultural land carrying capacity is classified into three categories:

Class I ( $\sigma > 2.46$ ):

Regions capable of achieving food self-sufficiency and meeting the food needs of the population adequately.

Class II ( $1 \leq \sigma \leq 2.46$ ):

Regions capable of achieving food self-sufficiency but not yet able to meet the food needs of the population adequately.

Class III ( $\sigma < 1$ ):

Regions that are not able to achieve food self-sufficiency and cannot meet the food needs of the population adequately.

## 3 Results and discussion

Carrying Capacity research location Land (DDL) agriculture This conducted in North Sumatra Province. kindly geographical North Sumatra Province is located at 1° - 4° North Latitude and 98° - 100° East Longitude, with a land area of 72981.23 km<sup>2</sup>. Most of North Sumatra province is on the mainland Sumatra Island and parts small are on the Island Nias, Batu Islands, as well a number of island small, both in the west and part east beach Sumatra Island. North Sumatra Province consists of 25 districts and 8 municipalities of area the biggest is Regency Langkat with area of 6,262 km<sup>2</sup>, Regency Mandailing Natal with area of 6,134 km<sup>2</sup>, and Regency South Tapanuli with area of 6030.47 km<sup>2</sup>, meanwhile wide area smallest is Tebing Tinggi City with area of 31 km<sup>2</sup> [6].

Land area harvest paddy on North Sumatra Province in 2020 general is whole existing paddy fields, that is wide 388591,22 hectare. If seen from years previously wide land paddy the experience change decline wide harvest, so matter the influence to results production paddy from in 2019 amounted to 2,078,901.59 tons become of 2,040,500.19 tons with an average of 5,251 kg/ha. Production rice produced in North Sumatra obtained from production paddy and upland rice.

Need to food will Keep going experience enhancement along with a amount residents who will the more increase. North Sumatra is Province fourth with amount resident the biggest in Indonesia after West Java, East Java and Central Java. So that growth

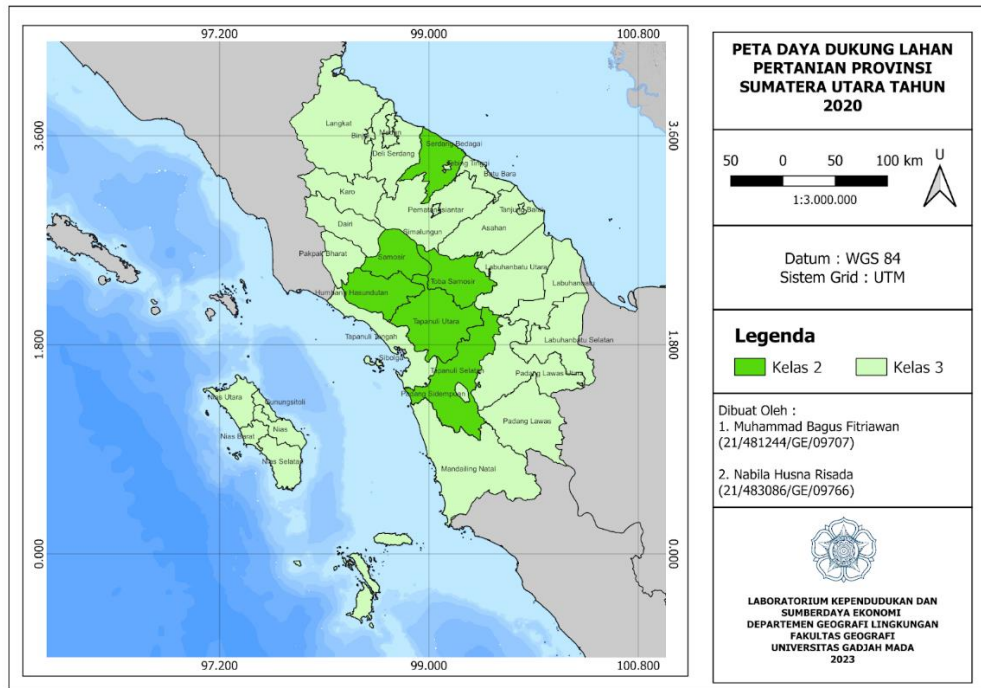
population in North Sumatra included high. In 2020 the population of North Sumatra Province is 14.703.532 people. Condition increase amount resident tend far more high, whereas for a vailability wide paddy fields as production food tend decreased. This is a factor triggering the low availability of land. The carrying capacity of the land in general can be influenced by the behavior of the community in an area itself, both rice fields that are converted to function, as well as an increasing population.

**Table 1.** The results of the carrying capacity of rice farming land in North Sumatra Province in 2020

No	Regency/City	Total population in 2020	Harvested area (Ha) in 2020	Average productivity (kg/Ha)	KFM	Carrying Capacity of Agricultural Land	Classification
1	Nias	143983	9513.49	3720	265	0.9275251913	Kelas 3
2	Mandailing Natal	451028	18198.88	4086	265	0.622147909	Kelas 3
3	Tapanuli Selatan	283389	17677.65	5140	265	1.209925939	Kelas 2
4	Tapanuli Tengah	382917	11903.68	3523	265	0.4132790257	Kelas 3
5	Tapanuli Utara	303688	21508.92	5126	265	1.370009885	Kelas 2
6	Toba Samosir	184493	17574.08	6041	265	2.171479171	Kelas 2
7	Labuhan Batu	501596	11594.12	5019	265	0.4377791244	Kelas 3
8	Asahan	735026	10737.39	5714	265	0.3149853739	Kelas 3
9	Simalungun	871678	33172.77	5270	265	0.7568161547	Kelas 3
10	Dairi	285481	6546.43	5394	265	0.4667586631	Kelas 3
11	Karo	421997	8601.24	6725	265	0.5172471628	Kelas 3
12	Deli Serdang	2234320	49658.5	6346	265	0.5322337589	Kelas 3
13	Langkat	1048100	27742.99	5040	265	0.5034254963	Kelas 3
14	Nias Selatan	322520	10803.5	4277	265	0.5406313196	Kelas 3
15	Humbang Hasundutan	191776	11968.69	4711	265	1.109480294	Kelas 2
16	Pakpak Bharat	49688	1064.93	3497	265	0.2828259821	Kelas 3
17	Samosir	126710	7927.89	4680	265	1.104960375	Kelas 2
18	Serdang Bedagai	617772	48862.29	6085	265	1.816185923	Kelas 2
19	Batu Bara	420103	12988.09	5693	265	0.6641785051	Kelas 3
20	Padang Lawas Utara	277423	8583.94	4018	265	0.4691462703	Kelas 3
21	Padang Lawas	286627	8374.84	3489	265	0.3846932057	Kelas 3
22	Labuhanbatu Selatan	344819	164.48	3796	265	0.006832855542	Kelas 3
23	Labuanbatu Utara	366603	12268.17	4575	265	0.5777354214	Kelas 3
24	Nias Utara	138800	7584.08	4183	265	0.862492704	Kelas 3
25	Nias Barat	82425	2691.48	3920	265	0.4830280976	Kelas 3
26	Sibolga	87791	0	0	265	0	0
27	Tanjungbalai	177005	75.45	5658	265	0.009101034882	Kelas 3
28	Pematangsiantar	257110	2055.44	6157	265	0.1857415713	Kelas 3
29	Tebing Tinggi	166100	484.97	5517	265	0.06078583009	Kelas 3
30	Medan	2295003	924.83	5435	265	0.008264799572	Kelas 3
31	Binjai	279302	1456.08	5405	265	0.1063312735	Kelas 3

32	Padangsidempuan	224483	3532.72	5551	265	0.3296485067	Kelas 3
33	Gunungsitoli	143776	2349.21	5684	265	0.3504641822	Kelas 3
Total	Sumatera Utara	14703532	388591.22	5251	265	0.5236817714	Kelas 3

Source: Department of Agriculture and Food Security, 2021 (processed)



**Fig. 1.** Map of the carrying capacity of rice farming land in North Sumatra in 2020

The carrying capacity of agricultural land in general can change, it depends on the factors that can influence it. Population pressure is the main factor in exceeding the carrying capacity of agriculture. The need for land for rice production is indeed important, because it supports the realization of regional independence in achieving self-sufficiency. By Odum et al., in [11], in general the minimum annual food requirement is 265 kg/person/year. This basic need is the minimum size a person can live normally with the fulfillment of the necessities of life. Based on Table 1, the results of the analysis of the carrying capacity of paddy fields in North Sumatra Province in 2020 were obtained. Districts that are capable of self-sufficiency in food are only found in South Tapanuli, North Tapanuli, Toba Samosir, Samosir, and Serdang Bedagai Regencies. Meanwhile, other Regencies/Cities have not been able to be self-sufficient in food. This district is capable of self-sufficiency in food, but has not been able to properly meet the food needs of its people.

The results of the analysis of the carrying capacity of paddy fields in North Sumatra Province in 2020 showed that the carrying capacity of agricultural land was low, so that it had not been able to achieve self-sufficiency in food and had not been able to meet the food needs of its people properly. The low carrying capacity of paddy fields in North Sumatra Province is due to the increase in population from year to year, while the area of agricultural land tends to decrease with decreasing land quality. The low carrying capacity of agricultural land is

also caused by agricultural production management factors that are not in accordance with conservation principles, resulting in low food production and crop failure.

The low carrying capacity of land in each of these regency indicates that the carrying capacity of agricultural land in North Sumatra needs to be increased either by reducing the population or by increasing the ability of agricultural land to provide maximum yields. Activities that can be carried out to increase the carrying capacity of land in order to fulfill self-sufficiency in food and provide a decent life is to increase agricultural yields by implementing agricultural intensification and extensification. Intensification activities that can be carried out are by selecting and using superior rice seeds, cultivating land in the right way, setting irrigation for rice fields, applying appropriate fertilizers and controlling pests. Meanwhile, an example of extensification that can be done is by opening or expanding new agricultural land.

## 4 Conclusion

The level of carrying capacity of agricultural land in North Sumatra in general is still relatively low, because the available agricultural land is lower than the available agricultural land needed. This shows that North Sumatra has not been able to achieve self-sufficiency in food and has not been able to meet the food needs of its people properly. The low carrying capacity of rice farming land in North Sumatra is due to the increasing population and

the quality of the land agriculture continues to decline so that the production of rice plants can not meet the food needs of the community to the maximum. Therefore, it is necessary to suppress or reduce the population by reducing the birth rate. Apart from that, the most important thing is that there is a need to improve the management of agricultural land so that it is hoped that later yields can increase both in quantity and quality.

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