Analysis of Population Pressure and Environmental Carrying Capacity on Agricultural Land in Lampung Province

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ABSTRACT
Population growth is a problem that can lead to the conservation of agricultural land. This can result in increasing population pressure on agricultural land. The purpose of this study was to determine the condition of population pressure and environmental carrying capacity (ECC) on agricultural land in Lampung Province 2020. This province was chosen because it has the highest urbanization rate on Sumatera Island at 6.5% in 2015. Lampung also has the highest population density on Sumatera Island at 244 people/km in 2019. Data were collected through secondary sources and calculated using environmental carrying capacity (ECC) calculations. Then the resulting data were analyzed using quantitative descriptive methods. The results showed that the area with the highest agricultural land area was Lampung Barat at 14685.71 Ha and the lowest area was Metro at 2895.28 Ha. The minimum land area for decent living or the widest z value is in Metro Regency with a value of 0.448 and the narrowest is 0.178 Lampung Barat Regency. The results of the population pressure (Pp) model I show that the areas of Lampung Barat, Mesuji, Tulang Bawang Barat, and the Pesisir Barat are suitable for agriculture. Model II has two additional regions, namely Tulang Bawang and Way Kanan. However, on the assumption of model III with sharecropping of sharecroppers and the non-agricultural sector, the area that is friendly to the agricultural sector is only in Bandar Lampung and Pesisir Barat. The results of the calculation show that the area with the highest environmental carrying capacity (ECC) is the Pesisir Barat and the lowest is the Lampung Tengah region.

Keywords: *Agricultural, Land, Environmental Carrying Capacity, Population Pressure, Population Growth, Land Conversion.*

1. INTRODUCTION

Population growth is one of the problems that can threaten agricultural land. To meet the sufficient area of residential land, agricultural land is often the main target of land conversion. Land conversion is a process of changing land use from certain forms to other forms [1]. Changes in land use from agricultural land to nonagricultural is dynamic phenomena involving aspects of human life [2]. Conversion of agricultural land will have an impact on reducing agricultural production both regionally and nationally.

In 2020, the total population in Lampung Province is 9.01 million. This province also experiences an increase in population of around 140 thousand people per year [3]. Even based on Central Statistics Agency of Lampung Province in the period 2010-2020, the population growth rate in Lampung Province reached 1.65 percent per year. This figure has increased by 0.41 percent compared to the previous period.

In 2015 the urbanization rate in Lampung Province was the highest on the island of Sumatera, which was 6.5% [4]. In addition, according to BPS data, Lampung Province also has the highest population density on the island of Sumatera, which is 244 people/km in 2019. The more population there is, the more massive the development and causes of the urban process [5]. The high rate of growth in Lampung Province which then

affects the increase in the rate of population pressure on agricultural land. Therefore, Lampung Province is a suitable province for further analysis related to population pressure conditions and environmental carrying capacity (ECC).

Population pressure according to [6] is a term that describes the symptoms of overpopulation in an area. According to [7] population pressure is the ratio of the total population and land area to live well. According to [8] population pressure can trigger the conversion of agricultural land into built-up land and use that is not in accordance with the land capability class which causes land resource degradation.

Land degradation is a decrease in land quality either temporarily or permanently with the characteristics of decreasing physical, chemical, and biological properties [9]. This can occur due to activities carried out beyond the ability or carrying capacity of the environment (ECC). This research is expected to provide an overview of the conditions of population pressure and environmental carrying capacity (ECC) in Lampung Province in 2020 so that future development can be carried out optimally in accordance with the capacity of the available land. ECC analysis is important as a reference for allocating the natural resources and spatial planning of the environment [10].

2. METHODS

2.1. Location

Lampung Province is the southernmost province on the island of Sumatera. This region is divided into 15 districts/cities. Astronomically, Lampung Province is located at 103° 40' - 105° 50' East Longitude and 6° 45' - 3° 45' South Latitude. The following is an administrative map of Lampung Province.

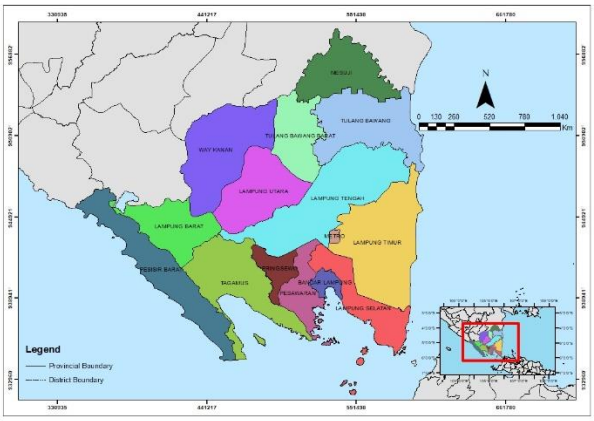

Figure 1 Lampung Province Administrative Boundary Map

2.2. Data

This study uses secondary data obtained from the Central Statistics Agency of Lampung Province. The data used are land use data, number of farmers, and population. Based on the available data, land use and the number of farmers used data in 2018. This is still relevant because, within two years, land-use changes and the number of farmers usually does not change significantly. Population data uses data in 2020 to determine population pressure and environmental carrying capacity in that year.

2.3. Research Design

Research data processing is taken by the following steps:

1. Collect and prepare Lampung Province data needed in calculating population pressure.

2. Determine the value of α, β, and the value of the minimum land area for decent living (z). Alpha (α) value is the percentage of non-agricultural income (0.35) [11]. Beta (β) value is the share of land benefits owned by smallholders (0.4) whose value is obtained through the following formula:

$$\beta = \frac{Total\ area - area\ of\ nonagricultural\ land}{Total\ area} \quad (1)$$

The value of z is the minimum land area for decent living (ha/person/year) which is known through the formula:

$$Z = \frac{(0.25 \times LSI2)+(0.5\times LSI1)+(0.5\times LST)+(0.16\times LLK)}{(LSI2+LSI1+LST+LLK)} \quad (2)$$

3. To calculate population pressure, three models are used, namely model I, model II, and model III. The formula used in calculating population pressure refers to [7].

Population Pressure Model I

$$Pp = Z\frac{fPo(1+r)^t}{L} \quad (3)$$

Population Pressure Model II

$$Pp = Z(1-\alpha)\frac{fPo(1+r)^t}{L} \quad (4)$$

Population Pressure Model III

$$Pp = Z(1-\alpha)\frac{fPo(1+r)^t}{\beta\times L} \quad (5)$$

in which Pp represents population pressure on agricultural land, Z is minimum land area for decent living (Ha/person/year), f is percentage of farmers in the population (%), Po is initial year population (person), r is current population growth rate (% year), t is time period, L is agricultural land area (Ha), and Pt is final year population (person) or Po(1+r)t [11].

4. Calculating the value of environmental carrying capacity (ECC) using the following formula [11].

$$iECC = \frac{1}{Pp} \quad (6)$$

in which iECC symbolized environmental carrying capacity (ECC) index with the following classification ECC < 1 means low ECC, ECC> 1 means high ECC, and ECC = 1 means optimum ECC.

5. Analyzing the results of calculations descriptively quantitatively and comparing and adjusting to secondary data, literature, or other sources in the form of theories that support research.

3. RESULTS AND DISCUSSIONS

Table 1 shows that in general all regencies/cities in Lampung Province experienced an increase in population from 2018 to 2020. This basis becomes the assumption of an increase in farmers in general in the regencies/cities in Lampung Province. The largest population is in Lampung Tengah with 1290407 inhabitants. While the smallest population is in the Pesisir Barat with 155883 inhabitants.

The number of farmers in an area will affect the z value, or the minimum land area for a decent living. The higher the number of farmers in an area, the smaller the z-value. This is in line with the results of the z value which is inversely proportional to the largest number of farmers, namely in Lampung Tengah with 280474 farmers, as well as the lowest number of farmers in Lampung Province, namely in Metro City with 9679 farmers. The condition of the small number of farmers is due to the relatively narrow area of Metro City and an urban area so that the agricultural area is small [12].

The area with the highest agricultural land area is Lampung Barat with 14685.71 ha (SUTAS, 2018). While the area with the narrowest agricultural land area is the Metro City area with 2895.28 ha (SUTAS, 2018). The highest area in the district/city in Lampung Province is Lampung Tengah Regency and the lowest is Metro City.

The area with the widest minimum area of land for decent living is the Metro area with 0.45 and the narrowest is 0.18, namely Lampung Barat and Tulang Bawang Barat. The greater the value of z, the wider the area of land used as non-agricultural land. This is because the value of z is very influential on the value of population pressure. The value of population pressure on land is the ratio between the total population and the minimum land area to be able to live properly.

Metro City is one of two cities in Lampung with a population of 168,676 people with an area of 68.74 km and a population density of 2,454 people/km2 in 2020 [13]. Because of its narrow area with a high population, Metro City has a high need for land, resulting in a high z-value. In contrast to Lampung Barat and Tulang Bawang

Table 1. Land Area, Number of Farmers, and Total Population in Lampung Province

Districts	Land Area 2018 (Ha)				Area of The Dictrict (Ha)	Number of Farmers 2018	Total Population 2018	Total Population 2020
	Irrigation	Non-irrigation	Moor	Total Area of Agricultural Land				
Lampung Barat	283.65	488.01	13914.08	14685.74	211876	67466	300703	304874
Tanggamus	925.53	255.2	8921.74	10102.47	290029	112189	592603	603706
Lampung Selatan	140.54	2131.33	4614.18	6886.05	221946	142689	1002285	1019789
Lampung Timur	921.6	900.39	4837.42	6659.41	386469	196946	1036193	1051994
Lampung Tengah	1200.53	772.07	4511.92	6484.52	454000	280474	1271566	1290407
Lampung Utara	534.96	327.02	10826.63	11688.61	252954	104838	614701	618818
Way Kanan	343.97	722.79	12979.5	14046.26	365749	87723	446113	453921
Tulang Bawang	12.66	2561.47	10498.67	13072.8	309108	70299	445797	455891
Pesawaran	609.42	831.73	5727.1	7168.25	127821	73230	440192	448410
Pringsewu	816.65	933.06	2990.01	4739.72	61448	61150	397219	403115
Mesuji	4.31	3868.93	9768.68	13641.92	220527	42670	199168	200999
Tulang Bawang Barat	558.94	213.33	10632.89	11405.16	128574	54479	271206	274905
Pesisir Barat	736.62	1312.76	11249.82	13299.2	298807	25645	153743	155883
Bandar Lampung	128.18	518.56	3648.49	4295.23	18331	10808	1033803	1068982
Metro	2346.32	105.74	443.22	2895.28	7315	9679	165193	169507
Lampung Province	9563.88	15942.39	115564.35	141070.62	3355354	1340285	8370485	8521201

regencies, which have relatively less land requirements, they produce a low z value.

The results of the calculation of population pressure show that the area with the lowest level is the Pesisir Barat and the highest is the Lampung Tengah region. Lampung Barat has the lowest score in either model I or II. This shows that this area is still capable of farmers obtaining good welfare. In addition, the areas of West Lampung, Mesuji, Tulang Bawang Barat, and Bandar Lampung are also still quite good for the welfare of farmers. For areas with a Pp>1 value such as Lampung Tengah and others, it shows that farmers' lives in general cannot be fulfilled through agricultural activities. The greater the percentage of land that can be used as agricultural land, the greater the carrying capacity of the area's land [14].

The calculation of Pp model II uses the percentage value of agricultural dependence of 65% and 35% in the non-agricultural sector. The calculation results show that the areas of Tanggamus, Lampung Selatan, Lampung Timur, Lampung Tengah, Lampung Utara, Pesawaran, Pringsewu, and Metro are experiencing population pressure on agricultural land. In addition, with the Pp model II, the Way Kanan and Tulang Bawang areas become areas that do not experience population pressure on agricultural land.

The calculation of model III uses the addition of yield indicators received by smallholders by 40%. This means that the higher the value of land productivity, the higher the income received by small holdersThe greater the income of the population working in the non-agricultural sector and high land productivity, the lower the population pressure on agricultural land in the region [15].

The results of the calculation produce areas that do not experience population pressure on agricultural land, namely the Pesisir Barat and Bandar Lampung. So that most areas in Lampung Province are included in the category of pressure on agricultural land.

This shows that the ability of farmers to live properly is not good in Lampung Province. Overall, Lampung Tengah Regency is the area with the highest population pressure. This is due to the high population and low land area value. Meanwhile, the area with the lowest population pressure is Pesisir Barat Regency. This is due to the large area of agricultural land and the relatively low population compared to other districts/cities.

The results of population pressure models I, II, and III will have the same lowest and highest values show in Table 2. Because models II and III are the development of model I with the addition of indicators for the non-agricultural sector and the yield of smallholders. However, the results of population pressure can be classified differently in each model. For example, the districts of Lampung Barat and Tulang Bawang Barat with the results of models I and II are not depressed, but become depressed in model III.

Table 2. Population Pressure and Environmental Carrying Capacity (ECC)

District	Population Pressure (Pp)			Environmental Carrying Capacity (ECC)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Lampung Barat	0.86	0.56	1.40	1.16	1.78	0.71
Tanggamus	2.39	1.55	3.88	0.42	0.64	0.26
Lampung Selatan	6.04	3.93	9.82	0.17	0.25	0.10
Lampung Timur	7.95	5.17	12.92	0.13	0.19	0.08
Lampung Tengah	12.08	7.85	19.64	0.08	0.13	0.05
Lampung Utara	1.70	1.11	2.77	0.59	0.90	0.36
Way Kanan	1.24	0.81	2.02	0.80	1.24	0.49
Tulang Bawang	1.33	0.87	2.17	0.75	1.15	0.46
Pesawaran	2.51	1.63	4.08	0.40	0.61	0.24
Pringsewu	3.91	2.54	6.35	0.26	0.39	0.16
Mesuji	0.83	0.54	1.35	1.20	1.85	0.74
Tulang Bawang Barat	0.92	0.60	1.50	1.08	1.67	0.67
Pesisir Barat	0.43	0.28	0.70	2.31	3.55	1.42
Bandar Lampung	0.61	0.39	0.99	1.65	2.53	1.01
Metro	1.66	1.08	2.70	0.60	0.93	0.37
Lampung Province	2.26	1.47	3.67	0.44	0.68	0.27

The results of the calculation of environmental carrying capacity (ECC) show that the area with the highest carrying capacity is the Pesisir Barat region and the lowest in the Lampung Tengah region. This ECC value is obtained from the calculation of 1/Pp which shows a value that is the opposite of Pp [16]. The result

is that ECC is inversely proportional to the value of Pp. so that the area with a low ECC value is an area that has a high population pressure value. So that the ability of the environment to support agricultural activities in the region will be low and vice versa.

This also applies when the level of productivity is high, but the results will not be able to meet the needs of farmers and cannot be maximized compared to areas without population pressure. This relates to the area of land and farmers that can be supported, the ratio of the population, and the exponential land area that is not a function of the square. As a result, it will be difficult for farmers to prosper with low regional carrying capacity.

Regions with ECC models I and II that can support agricultural activities are Lampung Barat, Mesuji, Tulang Bawang, Pesisir Barat, and Bandar Lampung. The Bandar Lampung area is an interesting case with sufficient environmental carrying capacity to support farmers even though the area is the capital city of Lampung Province which tends to be urban. The influencing factor is the sufficient number of farmers for the amount of agricultural land and the productivity of agricultural products which is still quite high.

The ECC value generated from the Pp Model III value also has the same value, which is reversed from the existing Pp value. The Pp value of model III shows that the area with the highest population pressure is Central Lampung with the lowest value being the Pesisir Barat. So that when the values are compared inversely, the highest ECC value is in Pesisir Barat Regency and the lowest value is Lampung Tengah, as is the same as the ECC result through the calculation of the Pp I and II models. It can be said from these results that the Pesisir Barat region is the area with the highest agricultural land area compared to other districts in Lampung Province.

Figure 2 shows the distribution of areas with high ECC and low Pp values in light green. Meanwhile, areas with low ECC and high Pp are colored dark green. In general, there is no specific pattern for the distribution of ECC and Pp in districts/cities in Lampung Province. However, it can be observed the distribution of ECC and Pp in the area.

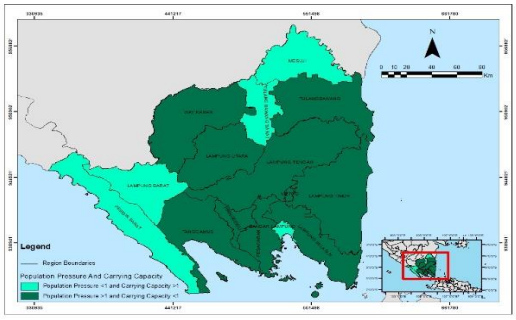

Figure 2 Map of Population Pressure and ECC with Model I.

Figure 3 shows the distribution of areas with high ECC and low Pp values in light green. Meanwhile, areas with low ECC and high Pp are colored dark green. In this map, there are differences with model I, namely the addition of the number of areas with high ECC and low Pp.

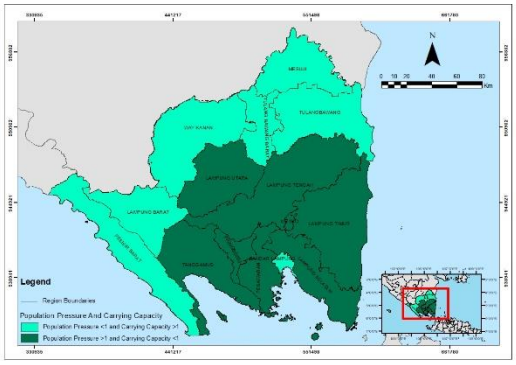

Figure 3 Map of Population Pressure and ECC with Model II.

Then on Figure 4 shows the distribution of areas with low ECC and high Pp. Regions that have good Pp and ECC are Lampung Barat and Bandar Lampung.

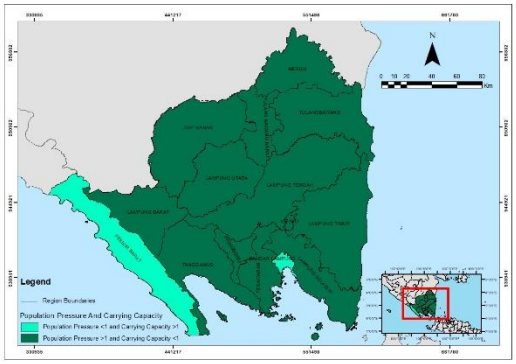

Figure 4 Map of Population Pressure and ECC with Model III.

4. CONCLUSIONS

The results of the calculation of population pressure on agricultural land have a value that is inversely proportional to the value of the carrying capacity of the environment. The results of model I show that the areas of West Lampung, Mesuji, Tulang Bawang Barat, and Pesisir Barat are suitable for agriculture. Meanwhile, model II has two additional regions, namely Tulang Bawang and Way Kanan. However, the assumption of model III with sharecropping of sharecroppers and the non-agricultural sector shows that areas that are friendly to the agricultural sector are only in Bandar Lampung and the West Coast. The results of the calculation of environmental carrying capacity (ECC) show that the

area with the highest carrying capacity is the West Coast region and the lowest is the Central Lampung region.

AUTHORS' CONTRIBUTIONS

All authors contributed to discuss the results and the writing of the final manuscript.

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