Effect of population pressure on land to Manggar watershed at East Belitung Regency, Bangka Belitung Island Province, Indonesia

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Abstract. Population pressure triggers farmers to expand their cultivation area due to population growth. East Belitung Regency, an expanded area of Belitung Regency, has developed into a new economic center on Belitung Island. The agricultural sector which has the largest contribution to the economy of east Belitung, but it has a negative impact due to the increasing demand for land by the community. This research examines the population pressure on agricultural land in each sub-district area as part of Manggar Watershed. The recent study presents the results of spatial analysis of land cover overlaying to the population of the Manggar watershed using ArcGIS 10.1 software. The results showed that three sub-districts intersect one another, namely Gantung sub-district (2.17%), Kelapa Kampit sub-district (12.49%), and Manggar sub-district (83.34%). In addition, there are ten types of land cover in the Manggar watershed, and the most prominent area is dominated by mining (8,709 Ha). Population pressure on agricultural land in the Manggar watershed is classified as moderate for the Gantung sub-district and low for the Kelapa Kampit and Gantung sub-districts. Furthermore, this study also revealed that land exploitation for the agricultural mean is still below it carrying capacity. Nevertheless, it is necessary to improve the better management of land-use systems in the Manggar watershed.

1. Introduction

Manggar watershed is located in the east of Belitung Island and the part of the East Belitung Regency, as a division of origin Belitung Regency, East Belitung Regency has developed into an economic center for Belitung Island. One of the potential economic sectors in the East Belitung Regency is the agricultural sector. Data from the Central Statistics Agency (BPS) shows that the agriculture, forestry, and fisheries sectors contributed 24.07% to the added value of the East Belitung economy [1]. The high contribution of the sector to the agricultural economy also risks and thus affects land cover changes [2]. The growth of population will lead to an increase in the communities’ demand for agricultural land. The higher demand for agricultural land that exceeds the availability of land triggers the population pressure on agricultural land. The ongoing conversion of land exacerbates this condition into mining activities as it occurs in the eastern Belitung area with the potential for mining materials [3]. Despite showing a
downward trend in the last five years from 2014 to 2018, the mining sector still contributed to the economy of East Belitung by 16.04% [1].

The development of the agricultural sector in the East Belitung Regency is carried out in order to meet the local communities’ demand for agricultural commodities and increase their income. So far, agricultural commodities are still mainly supplied from outside Belitung Island to become less economical. The agricultural sector is expected to absorb labor and become a promising alternative employment for the communities. Population pressure on land occurs because of extensive traditional land use patterns. Continuous expansion of agricultural land can disrupt the balance of the watershed ecosystem, impacting the health of the watershed [4]. This situation is indicated by the occurrence of flooding in the Manggar watershed [5]. The high demand for land causes excessive land exploitation so that the carrying capacity of the land is degraded.

Various studies on population pressure on land have been carried out, among others, such as those conducted by [6],[7],[4]. The studies related to watershed management aspects in the East Belitung Regency have also been carried out, such as those conducted by [8], [9], [10], [5],[11], but studies that specifically address the problem of population pressure on land in the Manggar watershed have not been carried out. For this reason, it is essential to elaborate the level of population pressure on agricultural land in each sub-district in the Manggar watershed.

2. Methods
The research method used in this research is descriptive quantitative. The research describes the results of the analysis and interpretation of land cover overlay with sub-district administrative maps and maps of the Manggar watershed and the results of processing the population in the Manggar watershed. The results are then processed and classified using the Soemarwoto formula type 1 (1985). This formula determined that community needs for living are highly dependent on the land sector. There is no other sector to support the community needs as explained in the following chart:

![Figure 1. Chart of Population pressure on land.](image)

2.1 Location and Time of Study
This research was conducted in the Manggar watershed, located in East Belitung Regency. The research was carried out from January to June 2020. Spatial analysis was carried out at the Center for Research and Development of Quality and Environmental Laboratory (P3KLL) Serpong.

2.2 Materials and Tools
The material used in this study is data population of the community. The population data used to determine the value of the population and the rate of population growth. The number of residents who work as farmers is used to determine the value of the farmer fraction [12]. The map of land use in the
Manggar 1:50,000 watershed used to determine the value of the minimum area of land for decent living per person and the area of productive land. This research use Arcgis 10.1 software and Microsoft Excel to process land cover data.

2.3 Data Analysis

1. The analytical method for determining Population Pressure (TP) used is the Soemarwoto method (1985). The formula for calculating population pressure on land (TP) is as follows:
\[
TP = Z \frac{FPo(1+i)t}{Lt}
\]

2. The Z value is calculated by the equation:
\[
Z = \frac{(0.25LSI_2) + (0.50LSI_1) + (0.50LST) + (0.76LLK)}{(LSI_2 + LSI_1 + LST + LLK)}
\]

3. The f value is obtained by the equation:
\[
f = \frac{Number \ of \ farmers \ and \ workers \ farm}{Number \ of \ population} \times 100\%
\]

4. The r value is obtained by the equation:
\[
r = \frac{1}{t} \ln \left( \frac{P_t}{P_0} \right)
\]

Information
TP : Population pressure on agricultural land
Z : Minimum area of land for decent living per person on flat land
Ft : Farmer fraction on subgrade
Po : The size of population at the point reference time t (person)
i : Rate of population growth
L : productive land area, which is consists of rice field, field, and yards.
t : calculation time period
LSI2 : harvested irrigation field rice area > twice per year
LSI1 : harvested irrigation field rice area once a year
LST : rainfed field rice area
LLK : dry land area
Pt : Total population at the year point t
Po : Total population at the base year
t : Time period

The results of data processing are classified into the following standards:
TP = <1 : Light pressure (Land demand is below the available land area)
TP = 1-2 : Medium pressure (Land demand can still be fulfilled by the existing land)
TP = > 2 : High pressure (Land demand is above of available land area)

3. Results and Discussion
3.1. Proportion of sub-district area in Manggar Watershed

Based on the spatial analysis results conducted in the Manggar watershed, three sub-districts intersect within the Manggar Watershed are Gantung, Kelapa kampit, and Manggar sub-districts. The most significant proportion is occupied by the Manggar sub-district (83.34%) followed by Kelapa Kampit (12.49%) and Gantung sub-districts (2.17%). The details are presented in Table 1.
Table 1. Area of each sub-district in the Manggar watershed.

| Sub-district | Sub-district Area (Ha) | Sub-district Area on Watershed (Ha) | Sub-district area on watershed per sub-district area (%) | Sub-district area on watershed per watershed area (%) |
|--------------|------------------------|------------------------------------|----------------------------------------------------------|--------------------------------------------------------|
| Gantung      | 101.218                | 605                                | 0.59                                                     | 2.17                                                   |
| Kelapa Kampit| 59.123                 | 3.488                              | 5.89                                                     | 12.49                                                  |
| Manggar      | 35.339                 | 23.531                             | 66.58                                                    | 85.34                                                  |
| Total        | 195.680                | 27.624                             | 100.00                                                   |                                                         |

Source: Spatial analysis processing (2020)

The proportions of Gantung and Kelapa Kampit sub-districts intersect within the Manggar watershed are only 2.17% and 12.49%. However, they are an integral part of the hydrological unit between one sub-district with other sub-districts. There is a close interaction between biotic and abiotic components in the Manggar watershed area. Activities and mobilization from one area to another in a watershed will affect the hydrological balance of the watershed. Gantung sub-district, located in the upstream area of the Manggar watershed, will affect the sub-district located in the downstream (Manggar sub-district). A change in hydrological input (precipitation) upstream, such as degradation of land conditions, will affect the discharge fluctuations and erosion (Q) downstream.

3.2. Land cover of each sub-district in the Manggar Watershed

There are ten types of land cover in the Manggar watershed, but not all land cover types are spread in the Manggar watershed area. The four most extensive types of land cover are mining (8,709 Ha), followed by plantation (7,262 Ha), dryland agriculture mix with bush (4,948 Ha), and secondary dryland forest (4,056 Ha). Meanwhile, the other six land cover types have a proportionate area, ranging from 299 Ha to 533 Ha. The details are presented in Table 2.

Table 2. Land Cover of Each District in the Manggar Watershed.

| Sub District | Secondary dryland Forest (Ha) | Secondary Mangrove Forest (Ha) | Dryland agriculture mix with Bush (Ha) | Plantation (Ha) | Bare Land (Ha) | Water (Ha) | Settlement (Ha) | Shrubs/ Bush (Ha) | Shrubs/ Swamp Bush (Ha) | Mining (Ha) |
|--------------|-------------------------------|-------------------------------|---------------------------------------|-----------------|---------------|------------|----------------|------------------|------------------------|-------------|
| Gantung      | 234                           | -                             | 355                                   | -               | 7             | -          | -              | -                | -                      | 9           |
| Kelapa Kampit| 262                           | -                             | 391                                   | 2.622           | 25            | 267        | 468            | 561              | 341                    | 188         |
| Manggar      | 3.560                         | 533                           | 4.202                                 | 4.640           | 267           | 468        | 561            | 341              | 447                    | 8.512       |
| Total        | 4.056                         | 533                           | 4.948                                 | 7.262           | 299           | 468        | 561            | 341              | 447                    | 8.709       |

Source: Spatial analysis processing (2020)

Mining is the most dominant sector in supporting the Manggar watershed economy. The community still considers the mining sector to provide promising income for household economy. The area of mining that still dominates in the Manggar watershed area. The four most extensive types of land cover are mining (31.53%); shows that the conversion of land to mining areas are still massive. Land conversion rate increases from 13% of total area in 2013 to 24% in 2018 in East Belitung [13]. This situation has shown that land degradation is still relatively high in the Manggar watershed. The areas have converted into mining areas would leave large holes, called “Kolong”.

This “kolong” generally has a low soil nutrient content resulting from very intensive nutrient leaching due to mining activities. Topographically, the “Kolong” area will cause cavity land areas. That cavity areas are deep enough and flooded with acidic water that has a low carrying capacity for living things to grow. The remnants of the exposed soil layer will become "tailing" around the ex-Mining land opening area.
3.3. Total Population of each District in Manggar Watershed

The total population in the three sub-districts in the Manggar watershed is presented in Table 3. Manggar sub-district still dominates the largest population in the last five years, starting from 22,642 persons at 2015 to 26,393 persons at 2019. While the other two sub-districts have a smaller proportion of the population, starting from 155 persons in 2015 to 166 persons in 2019 (Gantung sub-district) and 962 persons in 2015 to 1,111 persons in 2019 (Kelapa Kampit sub-district).

| Sub-district   | Total Population of each Sub-district (Person) | Total Population of each Sub-district in Watershed (Person) | g_i (%) |
|----------------|-----------------------------------------------|----------------------------------------------------------|--------|
|                | 2015  | 2016  | 2017  | 2018  | 2019  | 2015  | 2016  | 2017  | 2018  | 2019  |
| Gantung        | 25,814| 26,497| 27,194| 27,857| 27,700| 155   | 159   | 163   | 167   | 166   |
| Kelapa Kampit  | 16,271| 18,217| 18,554| 18,872| 18,800| 952   | 1,077 | 1,097 | 1,115 | 1,111 |
| Manggar        | 33,543| 38,279| 39,107| 39,889| 39,100| 22,642| 25,838| 26,397| 26,925| 26,393|
| Total          | 75,628| 82,993| 84,855| 86,618| 85,600| 23,759| 27,074| 27,657| 28,207| 27,670|

Source: Belitung Timur dalam angka (2020)

The highest population growth rate in the Manggar Watershed occurred in Manggar sub-district at 3.07%, and it is followed by Kelapa Kampit of 2.89% and Gantung sub-district of 1.41%. The values of population growth of the Manggar and Kelapa Kampit sub-districts were higher than the average value of population growth of East Belitung Regency of 1.94% [14]. This high-rate value of population growth can lead to an increase in population pressure on land [12]. Population growth will increase the productive workforce to be absorbed by the existing employment opportunities in East Belitung Regency, especially the Manggar Watershed. The existence of an imbalance in the absorption and distribution of the labor force can affect the imbalance in land use. The existence of population growth on limited land can lead to community pressure on land [6].

3.4. Population Pressure in each sub-district in Manggar Watershed

From the processing results carried out in each sub-district in the Manggar watershed only one area with population pressure on land that falls into the moderate criteria, namely Gantung sub-district. The other two sub-districts are categorized in the low criteria. In detail, it is presented as Table 4.

Table 4. Population pressure on land in each sub-district in the Manggar watershed.

| Sub-district | Σ Farmers and Farm workers (Person) | Σ Farmers and Farm workers on of Watershed (Person) | f | Z (Ha) | L (Ha) | TP | Criteria |
|--------------|-----------------------------------|---------------------------------------------------|---|---------|--------|----|----------|
| Gantung      | 495                               | 3                                                 | 0.019 | 0.757 | 355   | 1.10 | Moderate |
| Kelapa Kampit| 257                               | 15                                                | 0.015 | 0.759 | 391   | 0.55 | Low      |
| Manggar      | 226                               | 153                                               | 0.006 | 0.759 | 4202  | 0.04 | Low      |

Source: Primary data processing (2020)
Population pressure on land is classified as moderate in several areas of Manggar watershed (Gantung Sub-district). This condition indicated that the productive lands available for the agricultural sector are still in balance with the availability of farmers and communities. The capacity of the land for the agricultural sector in the Manggar watershed is still in balance with its capacity. The available land can still meet the needs and dependence of the community on the land. The low demand for land indicates that the available land for the agricultural sector is still vast enough; there is no pressure on the available land. The population pressure on agricultural land in the Manggar watershed is still considered ideal because the existing land can still meet the community's need for agricultural land. Increasing population pressure will reduce the carrying capacity of the watershed. These problems are the result of the conversion of land into built-up areas [15].

3.5. Land use strategy in Manggar Watershed
For areas with moderate population pressure (Gantung Sub-district), several control measures need to be taken, namely job diversification. This diversification is carried out so that the agricultural sector does not become the only livelihood sector. Livelihood diversification is a strategy to increase farmer income and to promote land management [16]. Mostly, agricultural is engine of economic growth [17]. With the job diversification, there are alternative job choices for the community to live.

In addition to job diversification, the agricultural systems need to be developed with an intensification and plant stratification. Intensification is strategy to overcome land use competition in the future [18]. The fallow period in intensification strategy will provide land recovered before being used for next planting [22]. It is necessary to regulate land tenure security in the form of agricultural intensification. Moreover, the guarantee of land ownership will increase the efficiency of land use by farmers [20]. While plant stratification will increase the land surface area covered so that the soil fertility will be high and productivity will increase [21]. Population pressure on land causes people to exploit land beyond their capabilities, and reducing land productivity [6]. Decreased land productivity will decrease the carrying capacity of the land to fulfill the communities’ needs. Similar to America, population pressure causing lost both of farmland and environmentally sensitive land (± 60,000 km²) [19].
4. Conclusion and Recommendation

4.1. Conclusion
Population pressure on land in the Manggar watershed area is moderate for the Gantung sub-district, while the Kelapa Kampit and Gantung sub-districts are low. The land exploitation carried out by the farmers and communities for the fulfillment of agricultural activity can still be balanced with the carrying capacity of the land. To keep this carrying capacity, it is necessary to regulate the land management system and job diversification in the Manggar watershed so that the land still has optimal and sustainable land productivity.

4.2. Recommendation
Local government intervention for the land use and the population growth intervention is needed in the Manggar watershed. Land use intervention (spatial plan) will maintain land use in line with its designation. Population growth intervention such as national family planning program will control the population growth of the Manggar watershed so that it is not exceeding the population growth of East Belitung Regency.

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