# Spatial modeling for the potential location of a rubber processing factory in East Ogan Komering Ulu (OKU) Regency, South Sumatra Province

**Nyokro Mukti Wijaya\*[1], Lili Somantri\*, Iwan Setiawan\***

\* Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229 Bandung, Jawa Barat, 40154,
Indonesia
[1]Corresponding author, Surel: nyokromuktiwijaya@upi.edu

## Abstract

This study uses spatial modeling to determine the potential location of a rubber processing factory in East Ogan Komering Ulu (OKU), South Sumatra, Indonesia. This descriptive study used the map overlay method. Besides, this study also used six parameters, namely number of population, rubber plantation area, land slope, land suitability, river flow availability, and road network availability. Those six parameters were overlaid and scored to generate a map of the potential location for the rubber processing factory in East OKU, South Sumatra, Indonesia. Our analysis results suggest that the most potential location was 27.412 ha (9 percent), while the area with medium and low potential was 267.952 ha (86 percent) and 15.155 ha (5 percent), respectively. Generally, the pattern of the most potential area followed the road network pattern and river network in East OKU because both road and river facilitate the provision of water resources, as well as distribution of raw materials and produced products. These results can be used as a reference for the government of East OKU Regency in constructing the factory. Besides, this study can also be used as a Geography learning material in the course of map and mapping, as well as Geography Information System.

**Keywords:** spatial modeling; rubber factory; East OKU Regency

## 1. Introduction

Rubber is the second most superior export product from Indonesia in the plantation sub-sector, after palm oil (Soleh, 2016). Aside from Indonesia, the countries with the highest rubber export are Malaysia, Thailand, and Vietnam (Kurnia, Marimin, Haris, & Sudradjat, 2020). The results of rubber harvest become the mainstay for the farmers since they can harvest this commodity every week. In contrast, other agricultural commodities have a more extended harvest period. Therefore, rubber is an essential commodity to enhance the local and national economy.

The East Ogan Komering Ulu (OKU) Regency, South Sumatra, Indonesia, is one of the regencies with the highest rubber production in South Sumatra province. The rubber plantation area in this regency reached 77.144 hectares in 2020, with an annual production rate of 40.003 tons (BPS, 2021). It positions rubber as the greatest commodity in East OKU, with more than 50% of its population working on the rubber plantation (BPS, 2021).

The rubber produced by the people is common in the form of *slab* or people's rubber processing material (Christina & Pigawati, 2015) or called *balem* in East OKU. *Slab* is a collection of rubber frozen using freezing liquid, such as formic acid, in a bowl placed between

rubber plants (Malian & Djauhari, 2016). Meanwhile, *balem* is a group of slabs that is formed using a box by the farmers (Nefftalia, Daulay, & Surawan, 2015). The formed *balem* is later sold to the rubber collectors in every village. Later, those rubber collectors sell the *balem* to the rubber processing factory to be converted into crumb rubber. The results of crumb rubber processing are exported into a number of countries, such as the United States of America, China, and Japan, to be used as the materials for wheels, automotive, medical, children's toys, slippers, textile, and other industries (Ardanari & Mukiwihando, 2020).

The *balem* sales process to the factories requires relatively long processes since there is no rubber processing factory in East OKU. The rubber collectors have to go to Palembang, South Sumatra, Indonesia, to sell the *balems*. This lengthy process generates an excellent selling price margin between the farmers and the factories, with a maximum margin of 50% (Christina & Pigawati, 2015). Our observation results show that the price of *balem* (dry rubber content) is Rp. 20.000/kg, while the selling price from the farmers is only Rp. 13.000/kg. This margin inhibits farmers from obtaining maximum profit. One of the alternatives for that issue is the construction of a rubber processing factory in East OKU that ensures a maximum profit for the farmers. Besides, the construction of a rubber factory also improves the sale value as the exported rubber is in the form of semi-finished goods (Kurnia et al., 2020).

However, the construction of a rubber processing factory should follow a number of parameters, consisting of (1) water source, (2) great distance from residential area, (3) short distance toward the raw materials, (4) disaster-free area, (5) the presence of a river to discharge the processed waste, (6) the availability of facilities and infrastructure, and (7) availability of workforce (Christina & Pigawati, 2015). Those parameters should be considered in determining the proper location of the rubber processing factory.

The determination of the potential factory's location can be completed through the Geography System Information (SIG). SIG carries four primary functions, namely mapping, modeling, monitoring, dan measuring (Briggs et al., 1997; Foda & Osman, 2010; Jat, Garg, & Khare, 2008). This study used the modeling function of SIG to determine the proper rubber factory location. The modeling function was attained through the scoring process on each parameter. This study aims to investigate the potential rubber processing factory in East OKU Regency, South Sumatra, Indonesia.

## 2. Method

This descriptive quantitative study used several variables of plantation area, number of the working-age population, road network, land slope, land use, disaster threat, and river network. The data were obtained through secondary data sources, such as data from the Central Bureau of Statistic East OKU Regency 2021 (BPS, 2021), SRTM image, and RBI Map of East OKU. The data analysis was carried out using scoring on each of the parameters. For the scoring and weighting procedures, we followed the study from Christina and Pigawati (2015). The obtained scores for each research variable are presented in Table 1.

The data presented in Table 1 was used as the primary reference in weighting and scoring each variable. Each information within the map attained different scores, following the scoring criteria. The attained scores were multiplied by the weight of the variable. Further, the multiplication results were calculated. The final scores were converted to be the land status, using the criteria of determining the potential rubber factory location, as shown in Table 2.

**Table 1. The Scoring and Weighting Indicator for Variables in Determination of Rubber Factory's Location**

| No | Variables | Weight | Criteria | Score |
|----|-----------|--------|----------|-------|
| 1 | Rubber plantation area | 3 | Low (<5.000 ha) | 1 |
|   |   |   | Medium (5.000-10.000 ha) | 2 |
|   |   |   | High (>10.000 ha) | 3 |
| 2 | Number of populations | 1 | Low (<20.000 people) | 1 |
|   |   |   | Medium (20.000-50.000 people) | 2 |
|   |   |   | High (>50.000 ha) | 3 |
| 3 | Road network | 3 | Very far (>1.500 m) | 1 |
|   |   |   | Far (1.000-1500 m) | 2 |
|   |   |   | Close (500-999 m) | 3 |
|   |   |   | Very close (<500 m) | 4 |
| 4 | River network | 3 | Far (>3.000 m) | 1 |
|   |   |   | Close (1.000-3.000 m) | 2 |
|   |   |   | Very close (<1.000 m) | 3 |
| 5 | Land suitability | 2 | Not suitable | 1 |
|   |   |   | Fairly suitable | 2 |
|   |   |   | Suitable | 3 |
| 6 | Land slope | 2 | Very steep (>45%) | 1 |
|   |   |   | Steep (25-44%) | 2 |
|   |   |   | Fairly steep (15-24%) | 3 |
|   |   |   | Sloping (8-14%) | 4 |
|   |   |   | Flat (<8%) | 5 |

**Source: Christina and Pigawati (2015)**

**Table 2. Criteria of Rubber Factory's Potential Location**

| No | Criteria | Score |
|----|----------|-------|
| 1 | Less potential | 14-25 |
| 2 | Medium potential | 26-37 |
| 3 | Highly potential | 38-49 |

**Sources: Christina and Pigawati (2015)**

## 3. Results and Discussion

The East Ogan Komering Ulu (OKU) is located in the South Sumatra Province, with an area of 310.519 hectares. There are 20 districts established in this regency. In the north, East OKU adjoin with Ogan Komering Ilir (OKI) Regency and Ogan Ilir, while it borders South OKU Regency and Lampung Province in the west, OKU Regency in the west, and OKI Regency with Lampung Province in the east. The administrative area of East OKU is presented in Figure 1.
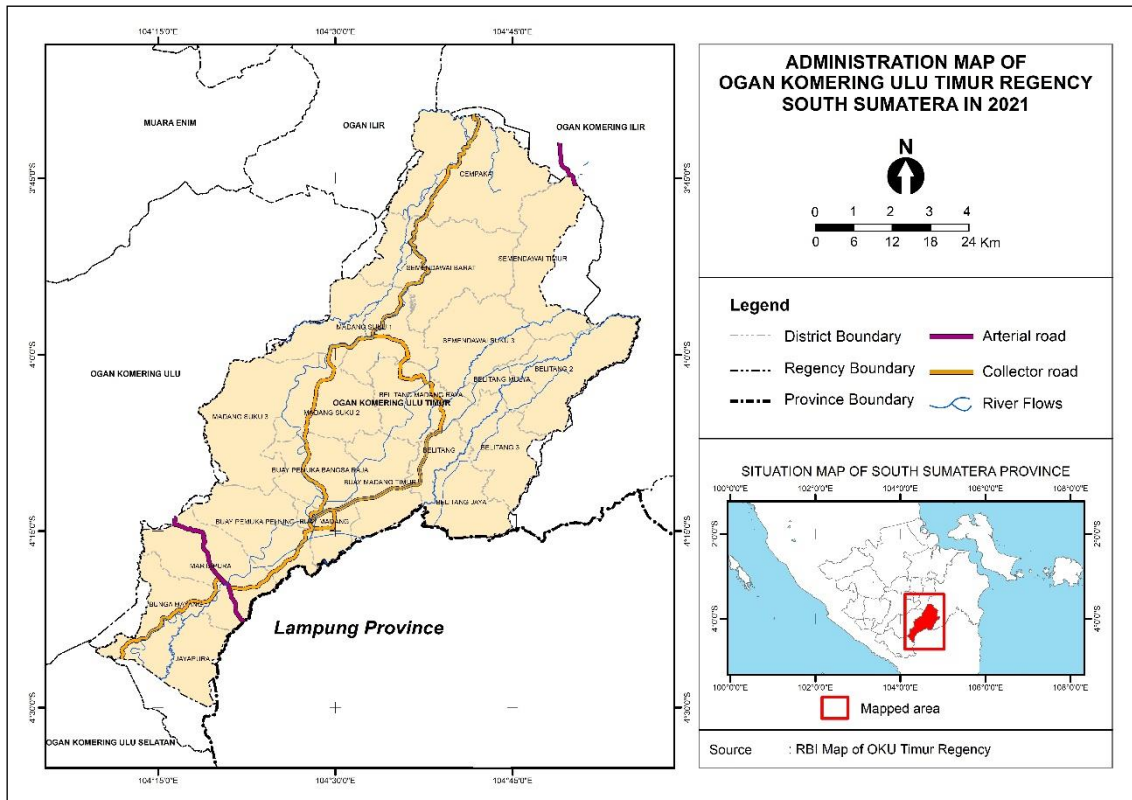
**Figure 1. Administrative Map of East Ogan Komering Ulu**

In addition, the determination of the rubber processing factory in East OKU is discussed below.

## 3.1. Rubber Plantation Area

The rubber plantation area is one of the factors being considered in selecting the location of the rubber plantation area as it is correlated with the availability of raw material. The raw material is a vital factor in establishing a factory because its availability and accessibility influence the production cost (Rianda, Kuncorisidi, & Sopiawadi, 2020). The closer distance to the raw material represents a higher potential for the factory. The raw material's availability also affects the production process (Drestalita & Rahmawati, 2016). Besides, a factory that is constructed near the raw material resources also increases the value-added for the farmers (Kurnia et al., 2020). Thus, the farmers can attain higher rubber selling prices since it has a relatively short distribution process.

The East OKU Districts own rubber plantations with distinctive areas. The total areas of rubber plantation in East OKU are 77,092 hectares, scattered in 20 districts, with the widest rubber plantation located in Belitang 2 and Madang Suku 3 Districts. From the raw material's availability, those two districts are the most potential location for the rubber factory construction. Figure 2 illustrates the distribution of rubber plantations in the East OKU Regency.
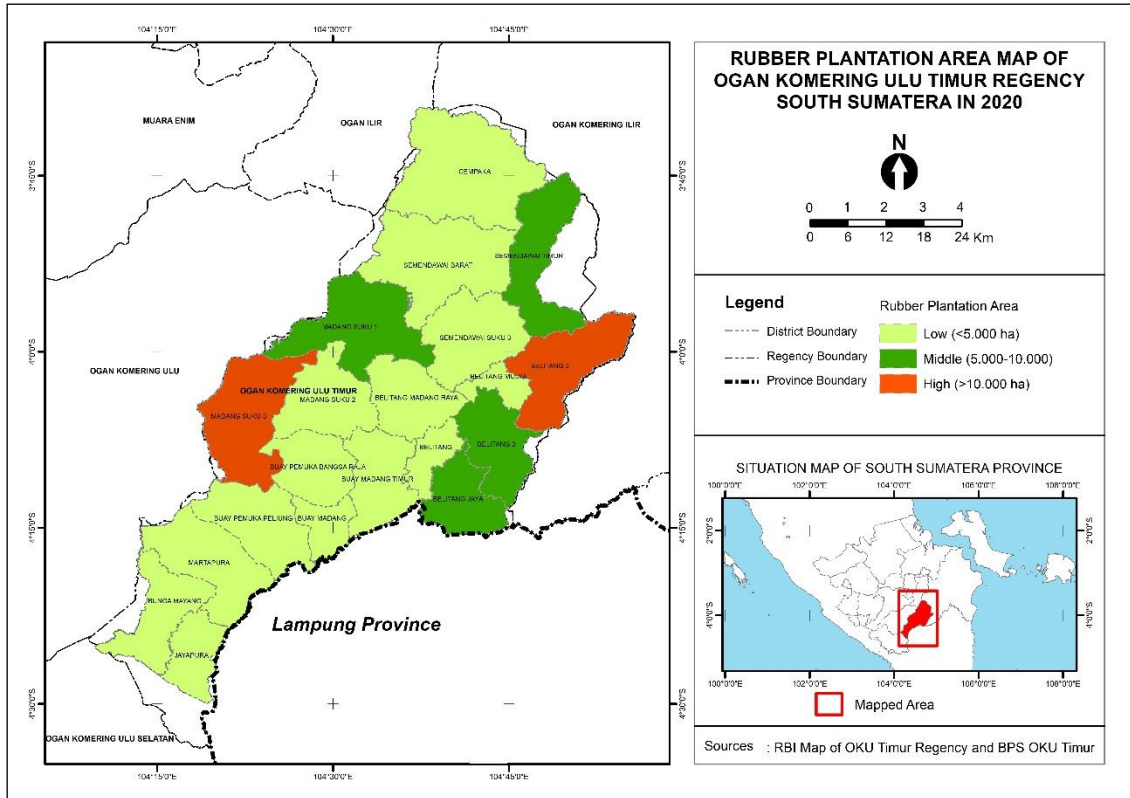
**Figure 2. Map of Rubber Plantation Distribution in East Ogan Komering Ulu Regency**

## 3.2. Number of Population

The production process in a factory relies on the surrounding workforce or the availability of human resources within the area. A higher population in a particular area shows the area's substantial potential for human resources (Fitrianingrum & Aulia, 2018). In 2020, the total number of populations in East OKU was 649,853 people. However, those populations are not equally distributed. The districts with the highest population are Martapura, East Buay Madang, and Belitang, with more than 50,000 people. From the workforce availability, the districts of Martapura, East Buay Madang, and Belitang are the most potential districts. The distribution of population in East OKU in 2020 is illustrated in Figure 3.

However, these abundant human resources should also have great quality. Therefore, investors are suggested to enhance the quality of their candidate of workers through the provision of education, training, evaluation, standardization, and encouragement to appreciate and respect their job (Kurnia et al., 2020) to ensure that their factories are managed by the highly qualified workforce.
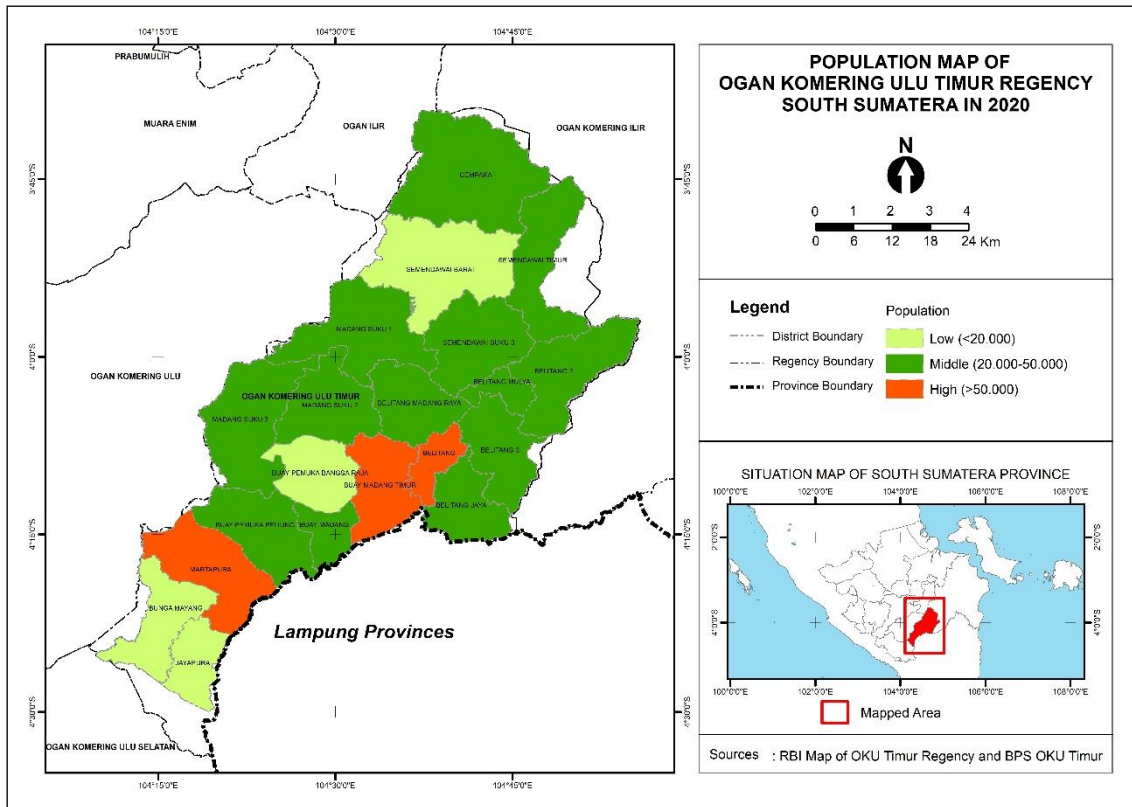
**Figure 3. Map of Population in East Peta Ogan Komering Ulu Regency**

### 3.3. Road Network

Another essential component of a factory location is the availability of a road network (Lukoko & Mundia, 2016). Road facilitates the distribution of produced products to the market or consumers (Nugraha, Subiyanto, & Wijaya, 2015). Besides, the road network also aids the mobility of raw material provision, human, and produced commodities (Purwanto & Iswandi, 2019). In this study, we used arterial, collector, and local primer roads to determine the potential location of the rubber processing factory (Christina & Pigawati, 2015). Areas with a closer distance to the road network have a more significant potential for rubber factory location.

We constructed a map of road networks in East OKU using the buffering technique. The constructed map showed the road network in three different areas grouped based on their distance to the arterial or collector road in East OKU, as illustrated in Figure 4. Our results suggested that only 7% (21.199 ha) of East OKU areas have 500 meters distance to the roadway. Those areas are the most potential area for the rubber factory construction. Meanwhile, the remaining 81% (251.045 ha) areas in the East OKU are categorized as non-potential areas for the rubber factory construction based on the road network criteria.
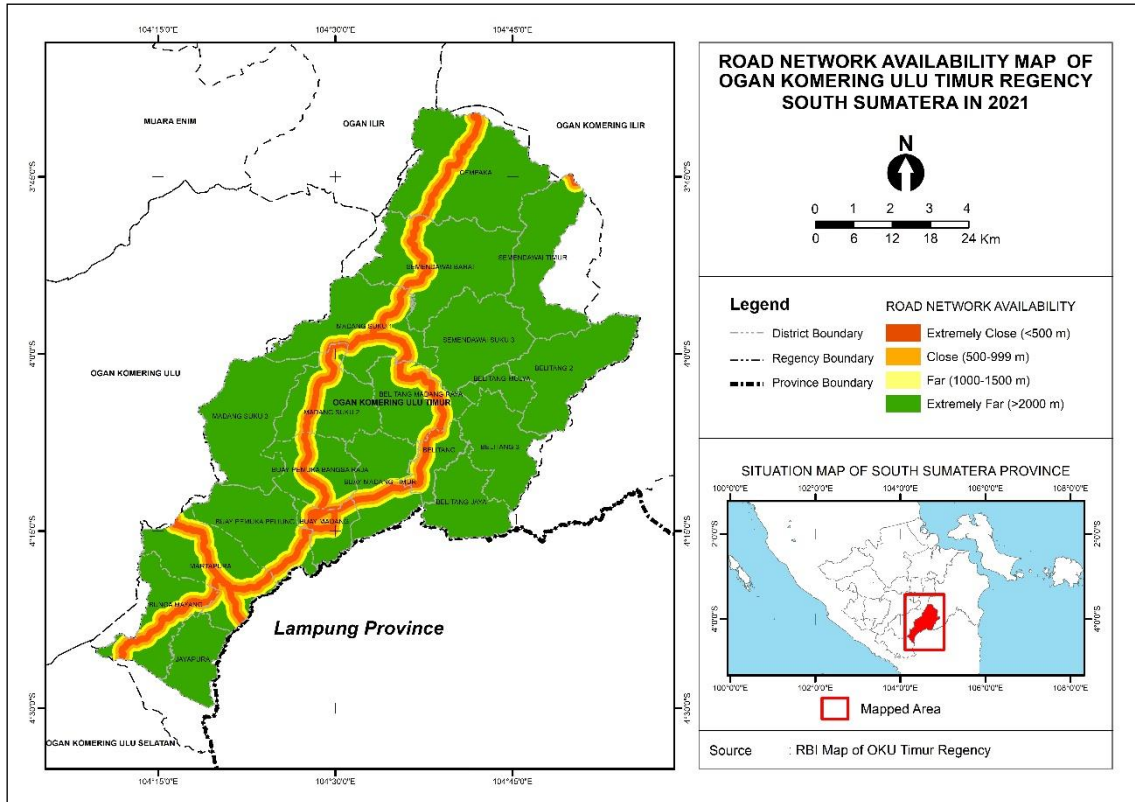
**Figure 4. Map of Road Network in East Ogan Komering Ulu**

## 3.4. River Network

The river is also one of the substantial aspects in the determination of the factory's potential location. The river carries two vital functions of being the water resource and disposal facility for processed waste (Nugraha et al., 2015). The factory's waste should not be thrown away into the river directly since it may pollute the river (Gong, Liu, & Chen, 2012). As the river's primary function is as a water resource required for the rubber processing, the most potential location for a rubber processing factory should be close to the river.

Buffering technique was carried out in the massive rivers in East OKU Regency, such as the Macak River, Balitang River, and Komering Dam irrigation. Our buffering analysis on those rivers resulted in a river flow map, showing three classifications of area's distance to the river, which consists of less than 1,000 meters, 1,000 to 3,000 meters, and more than 3,000 meters. The developed river flow map is illustrated in Figure 5.

Our analysis results suggest that 29% of the observed areas (89.616 ha) have the closest distance to the river, signifying the potential of those 29% areas to be used as the rubber processing factory location. Meanwhile, 39% of areas (89.616 ha) have the farthest location to the river, so they are categorized as the non-potential location for rubber processing factory location.
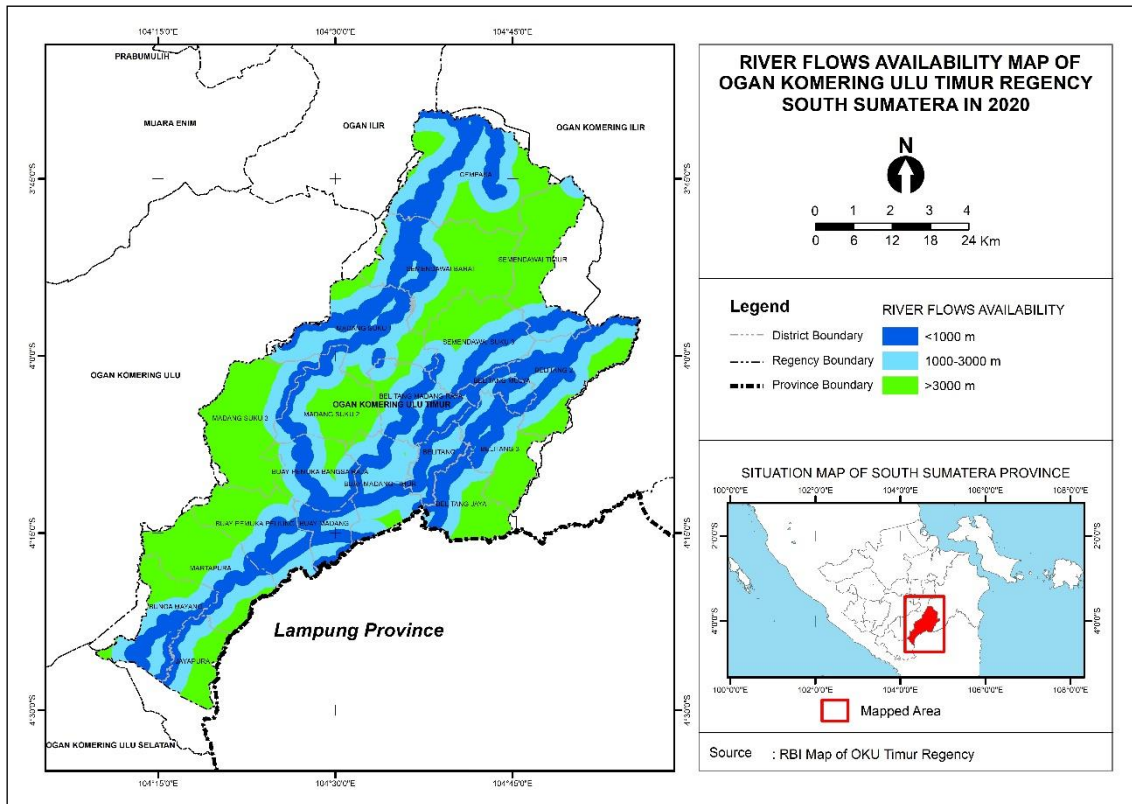
**Figure 5. Map of River Flow in East Ogan Komering Ulu Regency**
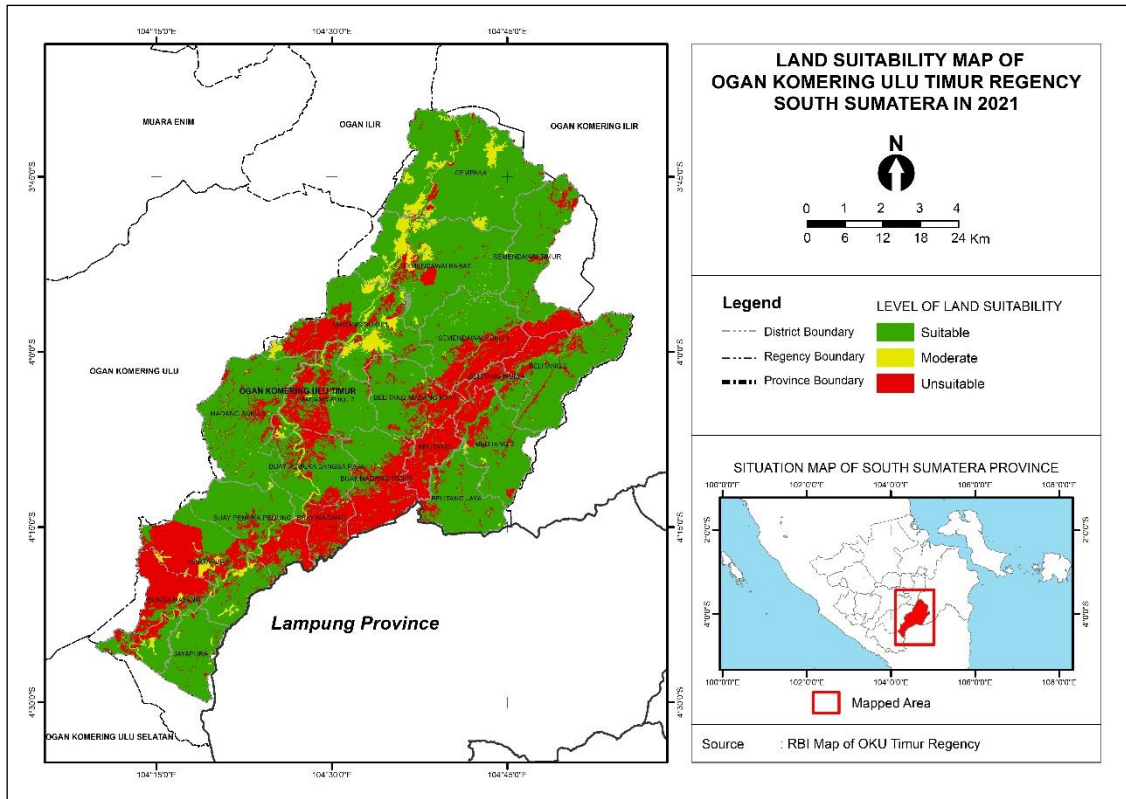
### 3.5. Land Suitability

Land suitability represents the suitability of a particular type of land to be used as a location for particular construction (Gong et al., 2012). This land suitability is frequently used in determining the location of industrial, residential, transportation, or public service construction (Burian, Stachova, & Vondrakova, 2018). In this study, land suitability was used as one of the variables to determine the potential location for a rubber processing factory in East OKU.

The land suitability level is required to protect living creatures, water resources, forests, and minerals around the factory (Burian et al., 2018) because the processed waste from the factory containing high nutrient levels, heavy metals, and other substances may harm the environment (Akporido, Emoyan, Ipeaiyeda, & Moderi, 2018) and generate disturbing pungent smell (Christina & Pigawati, 2015). The most potential area for the construction of a rubber processing factory is the land with scrub, and open land as the factory's waste will not obstruct the habitation and forest sustainability. Meanwhile, plantations and fields have medium suitability. Besides, the rubber processing factory should not be located near the residential areas due to the possible impacts of its waste.

In addition, the result of our spatial analysis showed the distribution of land suitability in East OKU, as illustrated in Figure 6. There are 81,561 ha, 13,672 ha, and 215,166 ha of areas categorized as non-suitable, relatively suitable, and suitable, respectively. The Cempaka Districts have the highest suitable land, with 88.6% (27,896 ha) and 9.4% (2,988 ha) of its areas classified as suitable and relatively suitable land, with only 2% (659 ha) non-suitable land. This

high land suitability in Cempaka District is caused by dominating scrub, open land, and rubber plantation in this area with a minimum residential area.



**Figure 6. Map of Land Suitability in East Ogan Komering Ulu**

### 3.6. Land Slope

The land slope of an area is related to the area's topography (Zhao & Chen, 2020). The determination of a factory or industry location should consider the land slope and select a relatively flat area (Nugraha et al., 2015). Relatively flat areas can be used maximumly, ease the construction process, and reduce the construction cost (Cahyadi, Suprayogi, & Amarrohman, 2018). Besides, this location also has a minimum risk of landslide, unlike the highly shole areas (Zhao & Chen, 2020). The sloping land expedites the land movement caused by the gravitation and enlarges the runoff that grinds the land, resulting in a landslide (Irawan, Roys, Rosyadi, & Siswanto, 2020). Therefore, the rubber factory should be constructed on flat land.

Most of the East OKU's areas are categorized as flat land, as our results show that 99.5% (309.066 ha) of East OKU's areas are flat land. Therefore, this 99.5% of areas have the potential to be the location of rubber processing factories. The map of East OKU's area land slope is presented in Figure 7.
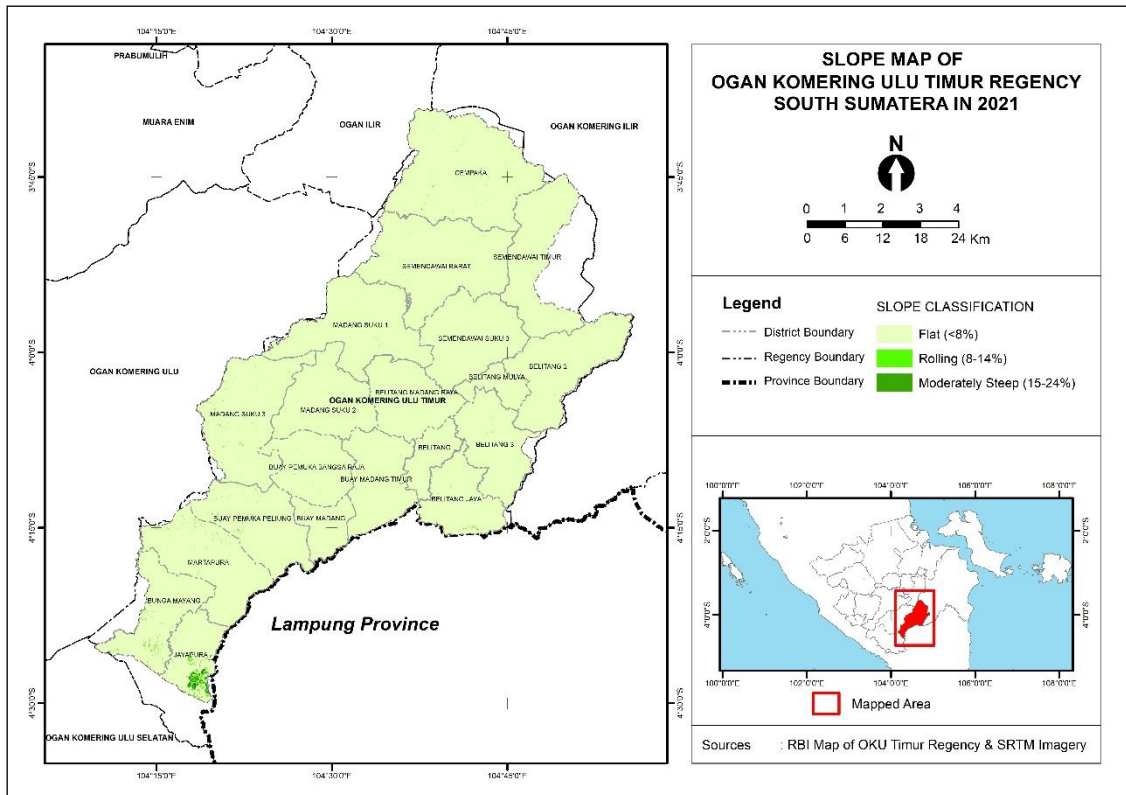
**Figure 7. Map of Land Slope in East Ogan Komering Ulu Regency**

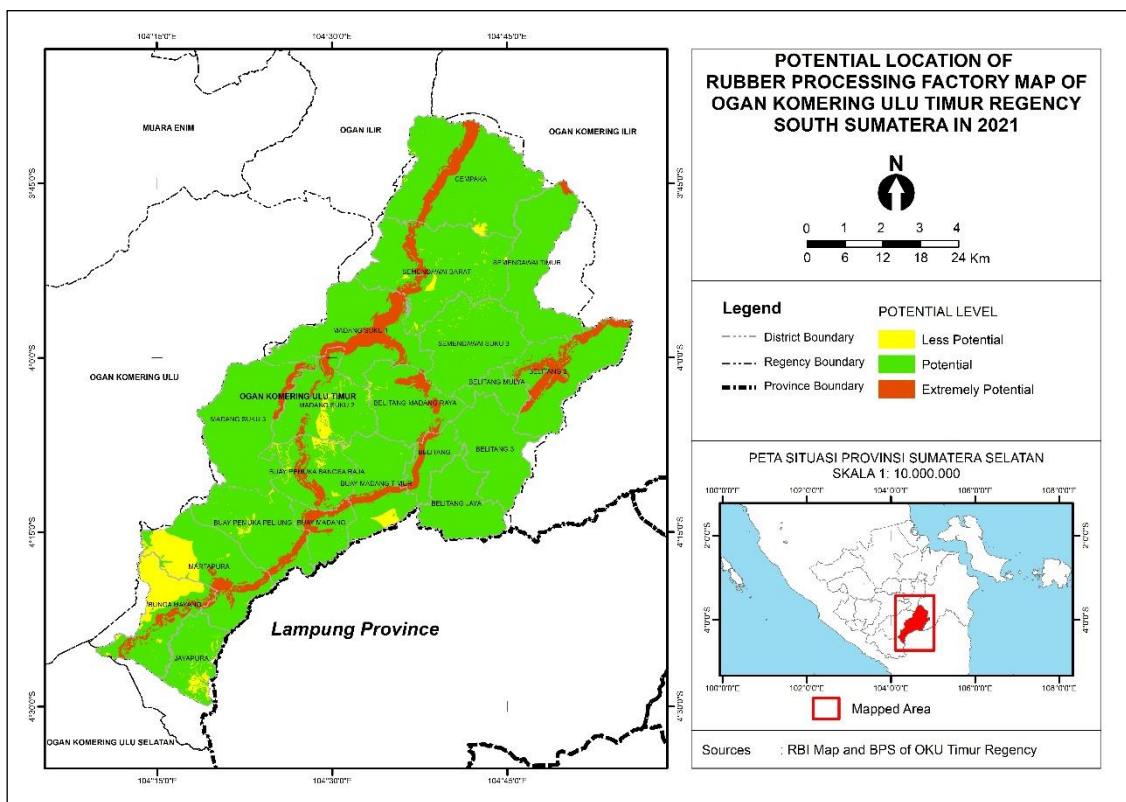### 3.7.  Potential Location of Rubber Processing Factory

As suggested by some developed maps, the potential location for the rubber processing factory has different references. The potential location based on the river network is different from the location based on the road network and so forth. Therefore, the generated maps should be overlaid, scored, weighted, and analyzed to attain new information on the level of a potential location for a rubber processing factory in East OKU. The result of the maps overlay is shown in Figure 8.

The scoring and weighting results on the six parameters show that 9% (27.412 ha), 86% (267.952 ha), and 5% (15.155 ha) of the areas in East OKU are classified as very potential, potential, and less potential. Thus, most of the areas in East OKU are potential for the rubber processing factory construction, but only 9% of them have the high potential.

Those highly potential areas are spread in almost all districts of East OKU Regency, such as Jaya Pura, Belitang Mulya, Belitang 3, and Belitang Jaya Districts. There are 16 districts with a high potential area, while Madang Suku District has the most potential of 4.448 ha. As seen from the pattern, the most potential area for rubber processing factory construction form a similar pattern as the pattern observed in the maps of road and river networks. Thus, the road and river availability are the essential parameter in determining the most potential location for a rubber factory in East OKU since many of East OKU's areas have no road access or river. Meanwhile, for the other parameters, such as the population, land slope, rubber plantation, and land suitability, the areas of East OKU have similar characteristics.

The areas with medium potential dominate the results (86% or 267.952 ha), observed in almost all districts of East OKU. An improvement should be carried out in these areas to enhance their potential for rubber factory's construction, through preparing new road and river flow. The construction of road and river flow is crucial since most of the potential medium locations have no arterial and collector road as well as river flow.

In addition, 5% of the area (15.155 ha) has a low potential for rubber factory construction. Even if 18 out of 20 districts have fewer potential areas, these areas are not equally distributed. The Mayang and Martapura districts have the highest less potential areas as these two areas are dense residential and rice field areas. The densely populated area is not suitable for rubber factory construction since the factory may disrupt the surrounding population and sanitation (Christina & Pigawati, 2015). Also, those districts have low rubber plantation areas.



**Figure 8. Map of Potential Areas for Rubber Processing Factory Construction in East Ogan Komering Ulu Timur Regency**

Spatial modeling using SIG and remote sensing helps the mapping, observation, and management of industrial areas (Johar, Jain, & Garg, 2013). The result of spatial modeling is shown in Figure 8, signifying that the pattern of most potential areas is linear with the map of the river flow (Figure 6) and road network (Figure 7). Accordingly, the road and river networks are the most influencing factors for rubber processing factories in East OKU.

### 3.8.   Use of Research Finding as Geography Learning Material

Geography teachers can use the maps developed in this study as Geography learning media. The eight generated maps in this study can be used in the delivery of learning materials, consisting of administrative, number of populations, river network, use of land, land slope, rubber plantation area, and potential rubber factory's location maps in East OKU. These maps are beneficial for Geography teachers, especially those teachers teaching in East OKU. By using the maps, the students can directly analyze the maps based on their residential area. Besides, the maps can help students understand different and new phenomena they are currently learning (Wijayanti, Astina, & Bachri, 2019).

The developed maps can be applied in some Geography learning materials in the 10th, 11th, and 12th grades of senior high school. First, the map can be used in the basic mapping materials in 10th grade. In this learning, the teachers can use the map as a media facilitating students to analyze and identifies components in maps and types of maps. Second, the maps can also be used in the population dynamics material in the 11th grade. In this material, the teachers can use the map of East OKU's number of populations. The maps facilitate students to analyze and interpret the demographic data, such as the population, population density, population growth, income per capita, and so forth (Rød, Larsen, & Nilsen, 2010). Third, the maps can be used in the concept of territory and territorial layout in the 12th. The teachers can use the land use maps as a media that facilitates the students to analyze types of land use in East OKU. The students can easily understand the use of lands and their spread using the maps. Fourth, the maps can also be used in the materials of maps use, remote sensing, and SIG in the 12th grade. The teachers can use the research results to demonstrate the use of SIG in territorial planning. The teachers can explain the use of SIG in determining the potential location for rubber processing factory construction in East OKU. The maps media can help the students to answer every geographical question, attain information related to the resources, explore geographical data, analyze geographical information, and enhance their Geographical knowledge in the future (Wijayanti et al., 2019).

## 4. Conclusion

The results of spatial modeling using SIG (Geography Information System) show the potential location for rubber processing factory construction in East OKU. Universally, the spatial modeling results in three groups of areas, namely the high potential, potential, and non-potential areas. The 9% (27,412 ha), 86% (267,952 ha), and 5% (15,155) areas of East OKU are classified as high potential, potential, and less potential areas, respectively. The pattern of the most potential area follows the pattern of the road and river network in East OKU since the road and river network moderate the water source provision, raw material distribution, and produced commodities distribution. Additionally, the eight developed thematic maps can be used as learning media by geography teachers. Future studies can develop another study that is more specific, in-depth, and applicative. Besides, our result findings can be used by the local government and investors in selecting the most potential location for rubber processing factory construction. Therefore, we also recommend the rubber processing factory in East OKU be constructed near the main road to minimize the cost of new road construction.

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