GIS-Based Spatial Analysis for Optimizing Spare Parts Distribution of Combine Harvesters in Lampung, Indonesia

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Article Info	Abstract
	Rice harvesting machine in Lampung Province has been commonly used for both personal use and contracting system. This opens up business opportunities for the provision of spare parts and machine repair services, especially during the main harvest season. Determining office locations or business policies in a region requires an analysis of the internal and external factors of the business itself. The analytical method used in this study was Spatial Data Analysis (SDA) to determine the types of strategies and policies that must be carried out by dealers of Kubota brand harvesting machines in Lampung Province. This decision support system is based on the results of spatial data analysis at the sub-district level. The results of spatial data analysis that combines data on paddy field area, slope level, and machine acceptance level show that there are six groups of potential priority areas included the sub-district recommendation for placing part shop and comparing with the existing active dealer part shop. There are six areas group, and dealer has cover 4 of them. Dealer is suggested to add two more-part shop that located in Suoh and Sungkai Utara to cover all areas group that can cover all area within 2 hours by motorbike.

1. Introduction

The use of rice combine harvesters in Indonesia is becoming common and is supported by the government with a productive loan program with low interest (Ministry of Agriculture,2022). This program to minimize loss in rice production is equivalent to 100 to 130 kg of grain per 1 ton of rice harvested on the land. One of the efforts to minimize yield loss during the harvesting process is to use a rice combine harvester (CH), which has a yield loss rate (Indrayanti et. al, 2024).

The process of renting harvest services using a CH has good economic feasibility. This provides business potential for farmers to earn income by taking advantage of the demand for rice-harvesting

services (Saputra, 2021). The rice harvest service business uses a CH with an IRR value of 67% and a Net B/C ratio of 2.92 (Hari, 2017).

Lampung Province is one of the regions in Indonesia that is included in the category of potential areas for procuring rice combine harvester. The rice harvest area in Lampung Province is 490,000 ha, with an average land productivity of 5 tons/ha (BPS-Statistic Indonesia, 2021). This provides an opportunity for farmers and businessmen to start a rice-harvesting machine rental service business as their income. As the machine population grows, the opportunity to provide original spare parts during the harvest season is one of the keys to the smooth operation of the rental business and the consistency of good machine performance. Based on the economic analysis, the optimal replacement unit for agricultural tractors was 14 years, and that for combine harvesters was 7–8 years (Poozesh et. al, 2012) (Rodrigues et. al, 2024).

The availability and affordability of original spare parts greatly determine the quality and performance of harvesting machines during the harvest season, especially during the first harvest season, which occurs simultaneously. The loss potency if a CH was not operated for a day in peak season is 2-3 ha loss or equals to 4-6 Million IDR(Saputra, 2021). Obstacles to machine damage while operating can occur at any time and require speed in countermeasures to minimize the loss of time during harvest. Therefore, it is necessary to carry out geographic information system analysis at the sub-district level regarding the potential population of harvesting machine units to determine strategic location mapping of parts shops. The goal is to increase the supply of spare parts and mechanical service personnel in Lampung Province during the first harvest season. This research is expected to facilitate the dealer as a decision support system to choose the best sub-district location to minimize the downtime of machines in the first harvest season.

2. Material and Methods

This research was conducted from January to March 2023 and utilised the Q-GIS software to determine the suggestion sub district for setting up the part shop of Kubota authorised dealer. The following steps were used for the analysis based on spatial data. The chart flow of each stage of this research is shown in Figure 1.
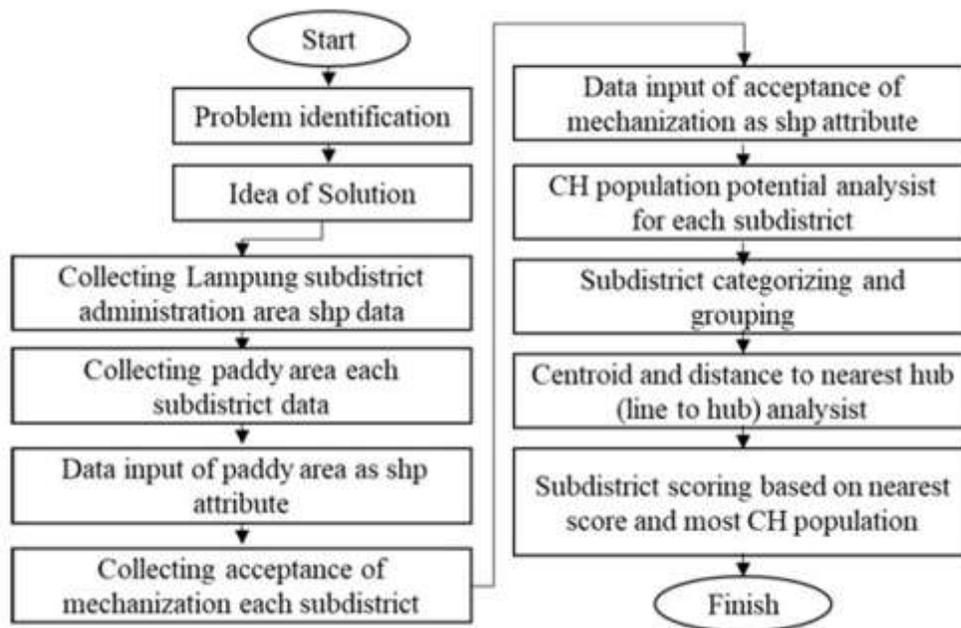
Figure 1. Flowchart of the study.

2.1 Assumption Materials, and Tools

This research used a case study of the Kubota brand combine harvester unit for Lampung Province. The assumption is that all of the total potency of units are from the Kubota Brand (there is no other brand population and government tender unit), the harvesting time of each area is simultaneous, there is no moving or cross-working of units from each subdistrict, and measurement for each subdistrict is assumed by the nearest line from the point to point, not using the road distance measurement (sea, river, and other obstacles are ignored). The working capacity of CH is 0,6 ha/hour with 8 hours/day and 20 days/month (Ministry of Agriculture, 2021). Statistical data and shape files (the polygon data that show the border of the sub-district coverage area) of each sub-district in Lampung Province were used in this research. The data were analyzed using Quantum GIS desktop version 3.16.16 software and Microsoft Excel.

2.2 Sub District Administration Area (Shape File)

Shapefile data of the sub-district administration were collected from the Indonesian Geospatial Organization. The basic data content of the shapefile contained no information about the paddy area in each sub-district. The next step was to combine the shapefile with the attribute data.

2.3 Attribute Data Collection

This study utilized paddy area data from each sub-district from BPS-Statistic Indonesia (2021). In total, there are 15 regencies in Lampung Province and 225 sub-districts that were analyzed for this research. Equation (1) for predicting the sub-district unit population uses a national standard of field-

testing procedure from   the Agri ministry. This equation is based on the 70 horse power crawler combine harvester model (Ministry of Agriculture, 2021).

$$A = C \frac{L}{T} P \cdot S \tag{1}$$

where A: Combine harvester unit population potency (unit), L: Total paddy area (ha), T: Harvesting time duration to finish (month), C: Working capacity for the 70 HP combine harvester (ha/unit/month), P: Acceptance level for the combine harvester, and S: Field slope factor.

There are three basic spatial data that are needed to predict the total CH potency, such as the total area of paddy, local rules for machine usage that show the acceptance level for CH, and field slope. The paddy area is in square kilometers (BPS-Statistic Indonesia of Lampung Province, 2019). The local rules for each sub-district were collected by asking the dealer staff (marketing staff) which areas refused to use the machine for harvesting. Acceptance was divided into three stages. Level 1 was highly accepted (CH can work without local PIC as a guarantor), acceptable (CH can work but needs local PIC as a guarantor), and not recommended (farmers prefer manual harvesting). The digital elevation model   for each sub-district was calculated using QGis software from the Shuttle Radar Topography Mission (SRTM), which has a 90 × 90 m image resolution. It was used to predict and categorize elevations. The area with more than 23° slope was categorized as a non-priority area, and the rest as a priority area because it is the maximum slope for the machine to work (Doungpueng, 2020). The slope level will impact the average plot size; a smaller plot size will reduce the CH working performance efficiency, which will affect the population of machines. Based on these three basic data, the potential population of the CH can be determined as the fourth attribute data for each sub-district.

2.4 Sub District Grouping Based on Centriod and Nearst Line to Point Analysis

Based on the CH population estimation data, each sub-district with less than 14 units is categorized as a non-priority area. The next step was to measure the buffer centroid function in QGIS software for 100 km, which was assumed to be the same as the total distance traveled by motorbike at 50-60 km/hours within 2 h. This step created a working group area for each sub-district. This will create the shortest transport distance as a suggested sub-district for opening a part shop. The ideal transport distance is a parameter for unit maintenance optimization (Zhang et al., 2022). Determining the suggested sub-district for setting up the part shop utilized the centroid function and the Nearest Line to Hub analysis to determine the total distance from one sub-district to all centroid of the sub-district.

3. Results and Discussion

3.1 Generating Map and Grouping Sub Districts

A base map of Lampung province CH population potency was determined after collecting the shape file and inserting the district data attributes of each sub-district. Based on figure 2, the sub-

districts were categorized into five types: red, orange, yellow, green, and blue. The data attributes shown above also include the subdistrict category that has local wisdom that makes the use of harvester machines not allowed. This data was collected by conducting a questionnaire survey of the dealer staff. The sub-districts with more than 14 units of potency (yellow, green, and blue) were clustered based on the radius.

This radius was assumed to be the maximum distance that can be reached one way by motorbike in 2 hours is 90-100 km. The method used the point and buffering radius from the Q-GIS software. The sub-districts covered by the circle become a working area. This range assumption was targeted to deliver the part to at least two customers, and the dealer staff can return to the shop during working hours.

There are six priority areas in the sub-district of Lampung, as shown in Figure 3. The areas were designated as Area 1 (North East), Area 2 (East), Area 3 (Central), Area 4 (Central), Area 5 (West), and Area 6 (North). Based on this result, the QGIS software was used to create the centroid point for each sub-district. The distance was calculated using the nearest line to the hub tools in this software (figure 4).
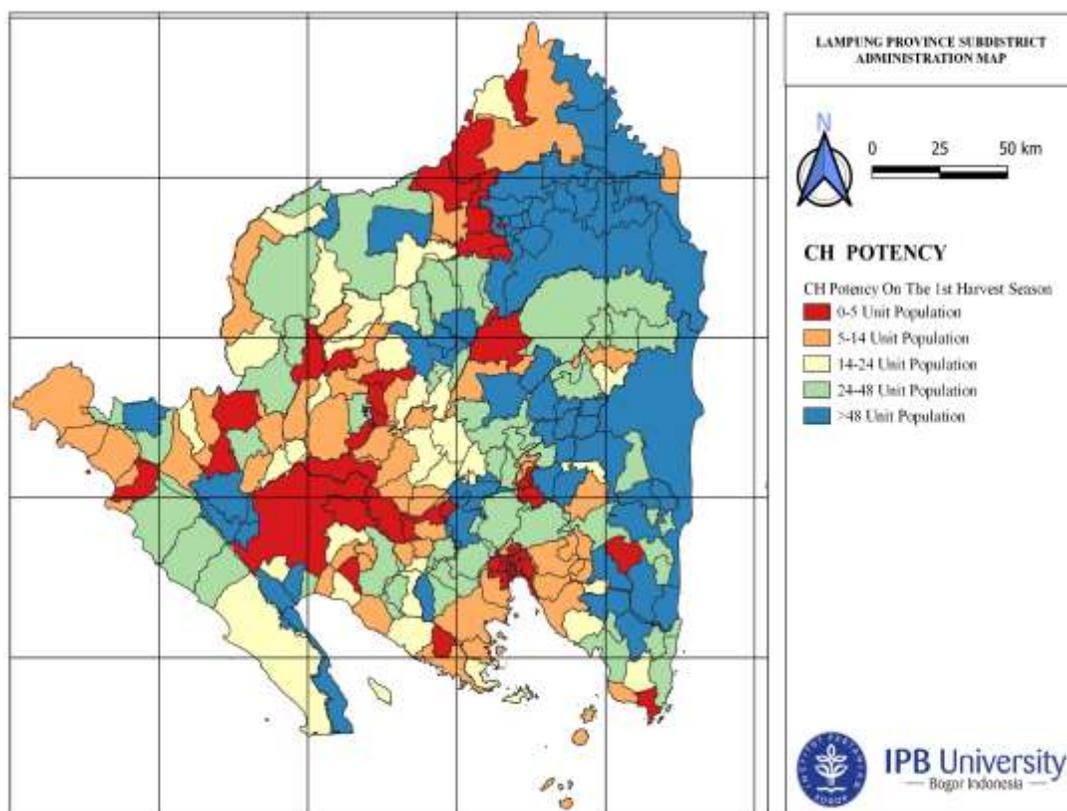
Figure 2. Base map of the population of CH potency units.
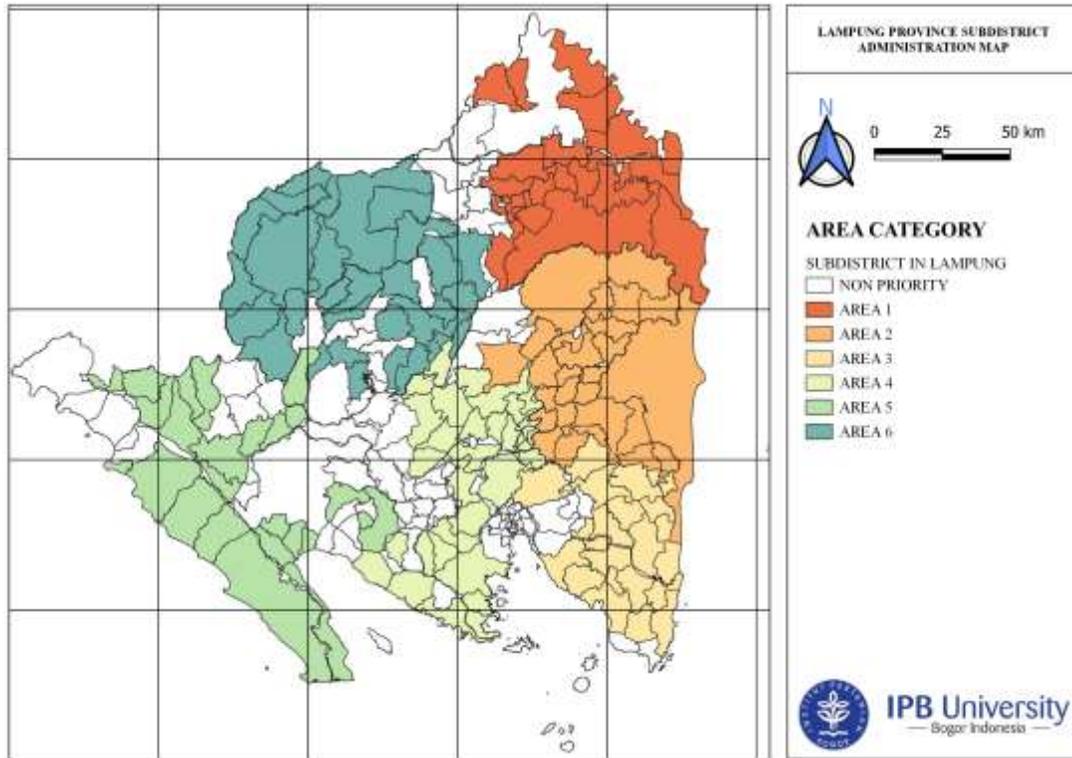
Figure 3. Sub-district working area.
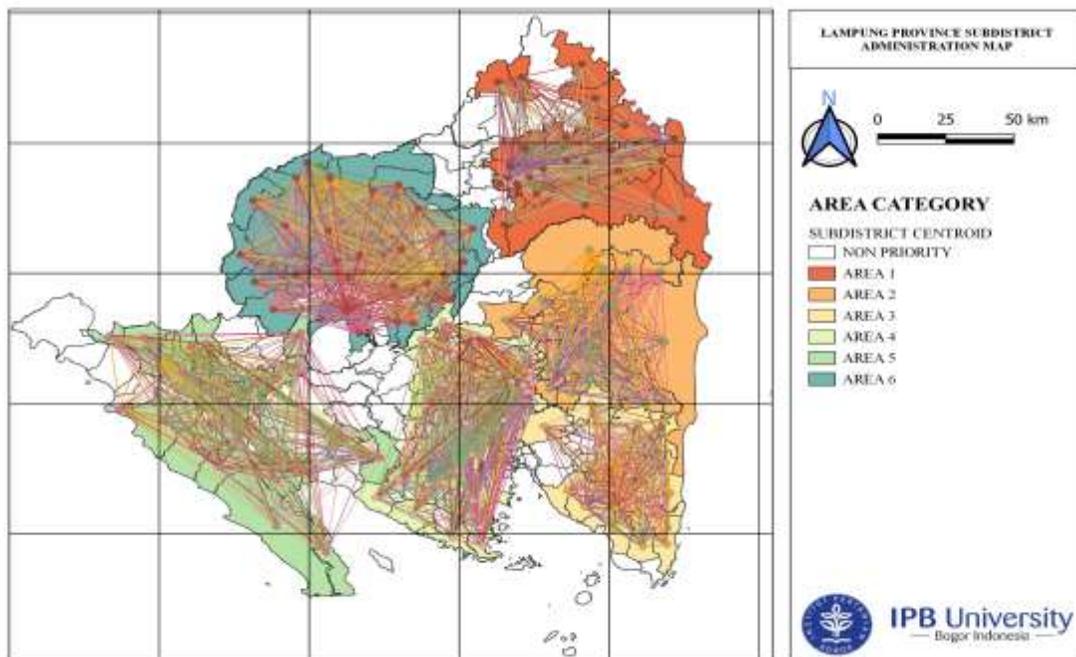
Figure 4. Nearest line to the hub for each area.

3.2 Distance Analysis and Sub District Recomendation

The attribute data collected by the nearest line to hub analysis were then inputted into Microsoft Excel to determine the rank for each sub-district. The data shown in Table 1 for the top five recommended sub-districts of each area group were then visualized as a map (figure 5) as a decision support system (DSS) for the dealer to select the best selection to set up a spare part shop.

Table 1. Recommendation sub districts dealer part shop

| No	Regency Name	Area	Total Distance (km)	Average (km)
1	Meraksa Aji	1	581.5	30.6
2	Gedung Aji	1	585.6	30.8
3	Penawar Aji	1	615.3	32.3
4	Penawartama	1	621.8	32.7
5	Banjar Margo	1	647.7	34.1
6	Way Bungur	2	550	23.9
7	Purbolinggo	2	552.5	24
8	Raman Utara	2	569.2	24.7
9	Seputih Banyak	2	578.2	25.1
10	Batanghari Nuban	2	631.5	27.5
11	Waway Karya	3	452.5	21.5
12	Waysulan	3	460.9	22
13	Jabung	3	466.5	22.2
14	Marga Sekampung	3	486.4	23.2
15	Waypanji	3	496.7	23.7
16	Tegineneng	4	925.7	21.8
17	Negeri Katon	4	961.2	24.4
18	Bekri	4	974.5	26.4
19	Bumi Ratu Nuban	4	984.4	27.5
20	Trimurjo	4	987.2	27.8
21	Suoh	5	872.8	37.9
22	Bandar Negeri Suoh	5	873.3	38
23	Air Hitam	5	914.5	39.8
24	Bandar Negeri Semong	5	959,6	41.7
25	Gedungsurian	5	970.5	42.2
26	Sungkai Utara	6	866.9	31
27	Hulu Sungkai	6	894.8	32
28	Sungkai Tengah	6	897	32
29	Bungamayang	6	938.4	33.5
30	Kotabumi Utara	6	953.4	34
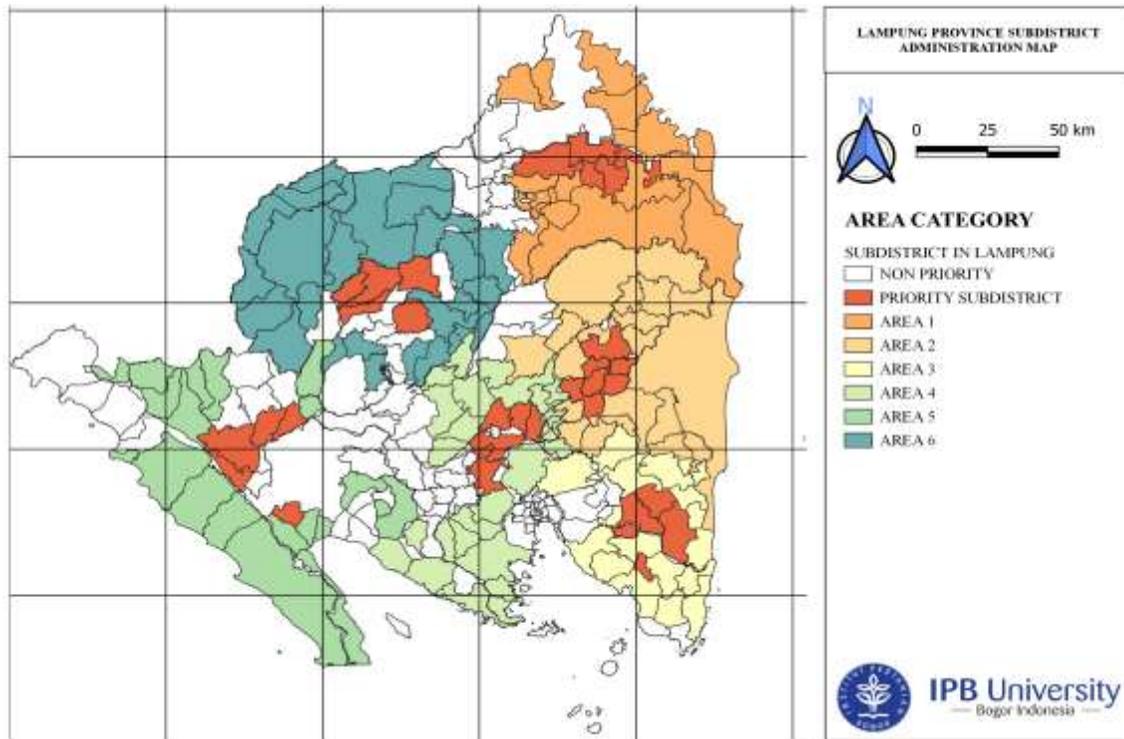
Figure 5. Recommendation of sub-districts for dealer part shops.

The data in Table 1 were then used to minimize the sub-districts option of each area. This total distance was generated from the point to point of each sub-district's centroid. The total distance was divided based on the number of sub-districts in each area as the average distance in one trip. This calculation is utilized for a rough estimation of whether the dealer will set up a part shop and try to reach all the units in each working area during the first harvest season. The result was to reach the target of less than 90 km if the average delivery time of a motorbike or car to the destination is 2 h. This assumption is based on the normal working hours of the dealer, which is 8 hours/day. The duration of mechanics repair in one task suggestion (based on the discussion) takes around 2-4 hours depending on the type of trouble, so the ideal time for dealers is 2 hours one way. In this study, the assumption is not only delivering the part but also replacing the broken part due to the regulation of Dealers Quality Assurance.

A map of the recommended sub-districts, as shown in figure 5, shows the most potential sub-districts for the dealer. This map was aimed at making it easier for dealer management to choose the best point for part sales by total linear distance analysis from the center point of the selected sub-district to the center point of the priority area. The recommendation also assumes that the unit population is harvested on the same day, so there is no unit movement from each subdistrict. Based on field surveys with the dealer staff, the first harvest season (January–February) is the most special

harvest season compared to the second (April–May) and third (August–September). The conditions in this season are mostly high grain prices, simultaneous harvest in all areas (irrigation and non-irrigation fields), a larger demand for harvest compared to machine population, and the highest rental fee for machines.

Compared to the actual condition, the dealer currently has five outlets located in Metro Timur, Way Seputih, Rawajitu Selatan, Banjaragung, and Way Panji (Rina, 2019). Based on the conditions shown in Figure 6, the coverage of the dealer has the shop located in Banjaragung and Rawajitu Selatan covering area 1. Area 2 was covered by a shop located in Way Seputih. The outlet for covering area 3 was located in the Way Panji sub-district. As the main logistic supply in Lampung Province, dealers set up their warehouses in the Metro Timur sub-district. This condition covers four of the six recommended areas. There are two remaining areas (areas 5 and 6) that need additional shops to cover the part needs. Based on the GIS results, Suoh and Sungkai Utara are the best locations for dealers to set up new part shops.
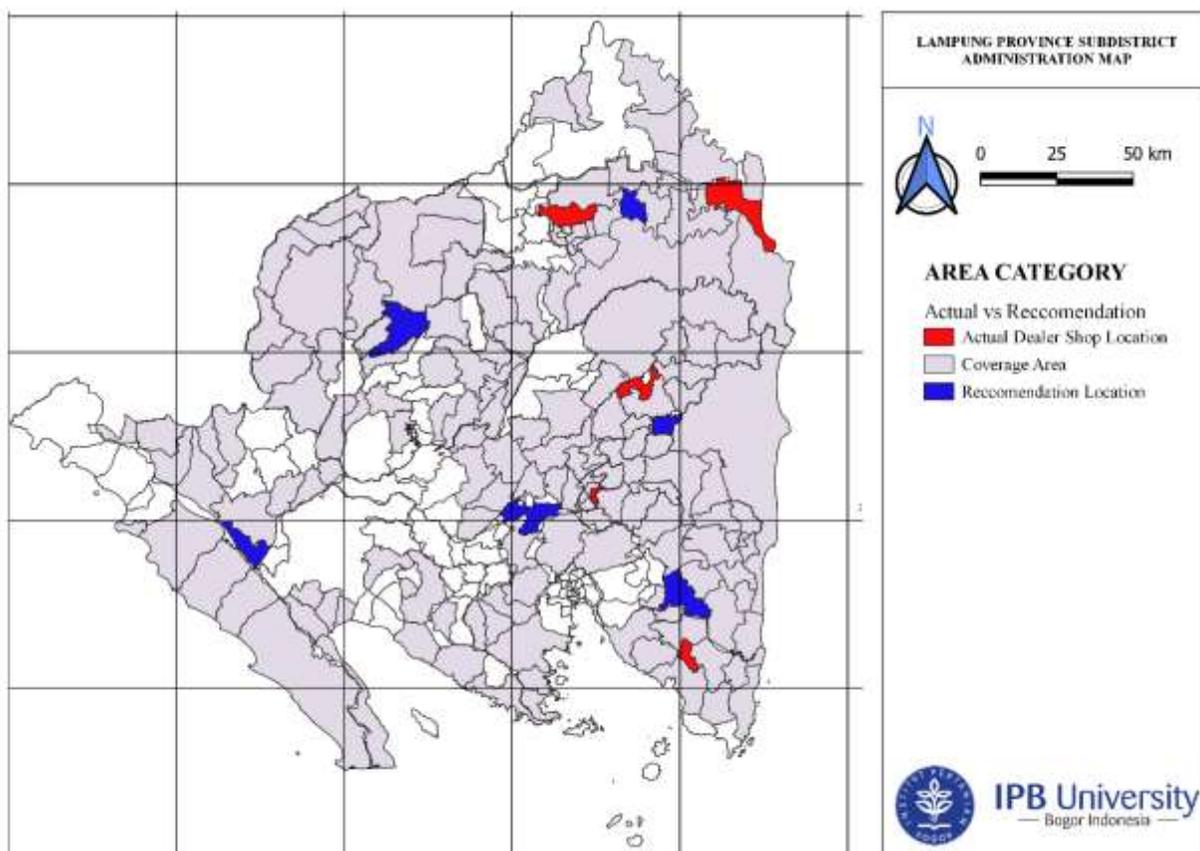
Figure 6. Actual vs recommendation sub-districts dealer part shop.

4. Conclusion

The use of GIS and spatial analysis created 30 recommended sub-districts from the total of 225 sub-districts in Lampung Province. Based on the comparison analysis between the existing and recommended shops, there are two sub-districts that are suggested for dealers to set up shop: Suoh and Sungkai Utara. The remaining four areas were already covered by existing part shops.

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