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GIS-Based Analysis Of Location And Environmental Impact Of The Rice Distribution Network In Tasikmalaya

Dicky Surya Kurnia Putra [1], Darda Efendi[1], Dan Eny Widajati[1]
[1]Program Studi Logistik Agro-Maritim, Sekolah Pascasarjana IPB, Kampus IPB Dramaga Bogor, Indonesia 16680

*__E-mail__: suryadicky@apps.ipb.ac.id
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ABSTRAK

Beras adalah komoditas makanan pokok yang paling vital bagi lebih dari 90% penduduk Indonesia, tetapi terjadinya penurunan produksi beras karena beberapa faktor, termasuk ketidakefisienan dalam rantai pasokan beras sehingga efisiensi distribusi menjadi sangat penting. Penelitian ini bertujuan untuk: 1) mengukur lokasi optimal dari pusat distribusi dan emisi dari jaringan distribusi beras di Tasikmalaya, dan 2) merumuskan strategi untuk meningkatkan efisiensi jaringan distribusi dan mengurangi emisi. Metode analisis spasial menggunakan bantuan QGIS untuk mengidentifikasi Pasar Cikurubuk sebagai pusat distribusi beras di Tasikmalaya, dan berdasarkan analisis lokasi menggunakan teknik Load-Distance Technique, Location factor rating dan Weighted Multi Criteria Overlay Analysis (WMCA). Hasil dietahui jika Pasar Cikurubuk sudah berada pada daerah yang opimal sebagai pusat distribusi. Emisi gas buang yang dihitung dengan membandingkan jarak tempuh total kendaraan (VKT), konsumsi bahan bakar, dan faktor emisi yang dihasilkan dari aktivitas pengantaran beras dari 22 unit penggilingan padi ke Pasar Cikurubuk dihasilkan emisi tahunan sebesar CO 1,2 ton, HC 0,26 ton, NOx 2,54 ton, PM10 0,20 ton, CO2 41,99 ton, SO2 0,12 ton. Membangun Pasar Induk Singaparna sebagai pusat distribusi baru, berdasarkan simulasi analisis jaringan, terbukti dapat meningkatkan efisiensi jaringan distribusi beras, mengurangi total jarak tempuh dan emisi sebesar 6,16% dan pengurangan konsumsi bahan bakar sebesar 5,45%.

Kata Kunci: *Analisis Spasial, Emisi, QGIS, Keoptimalan*

ABSTRACT

Rice is the most vital staple food commodity for more than 90% of Indonesia's population, but the decline in rice production is due to several factors, including inefficiencies in the rice supply chain, making distribution efficiency very important. This study aims to: 1) measure the optimal location of the distribution center and the emission from the rice distribution network in Tasikmalaya, and 2) formulate strategies to enhance distribution network efficiency and reduce emissions. The spatial analysis using QGIS identifies Cikurubuk Market as the rice distribution centre in Tasikmalaya and based on location analysis using the Load-Distance, Location Factor Rating, and Weighted Multi-Criteria Overlay Analysis (WMCA) technique. The result confirmed that Cikurubuk market is already in an optimal location as a distribution center. The exhaust emissions, calculated by comparing the total vehicle kilometers traveled (VKT), fuel consumption, and emission factors resulting from rice delivery activities from 22 rice mills to Pasar Cikurubuk, yielded the following annual emissions: CO 1,2 tons, HC 0,26 tons, NOx 2,54 tons, PM10 0,20 tons, CO2 41,99 tons, SO2 0,12 tons. Establishing Singaparna Main Market as a new distribution center, according to network analysis simulations, has been proven to enhance the efficiency of the rice distribution network, reducing the total travel distance and emission by 6,16% and 5,45% fuel consumption reduction.

Keywords: Spatial Analysis, emissions, QGIS, Optimality

INTRODUCTION

Rice is the most important staple food commodity for over 90% of Indonesia's population (Sabarella, 2019). Demand for rice is increasing, but this is not followed by an increase in rice production. Provisional figures from the Ministry of Agriculture from 2022 to 2023 recorded a decrease in rice production by 2.05%, followed by a price increase of around 22% at the mill level for medium rice (Pusat Data dan Sistem Informasi Pertanian, 2023).

The imbalance between rice demand and supply is caused by, among others, a decrease in the area of paddy fields and land productivity, changes in harvest patterns due to climate change, and an inefficient rice supply chain (Hervani, 2020; Kumawat & Yadav, 2021; Octania, 2021). Therefore, planning the rice distribution network, transportation, and routing will be important (Chopra, 2003; Dacholfany et al., 2023). Particularly the location of distribution centers, will affect the efficiency of the rice supply chain, prices and customer satisfaction (Fonseca & Vergara, 2015; Mangiaracina et al., 2015). In addition, the efficiency of the distribution network has an impact on the environment by reducing the load of exhaust emissions released from distribution network transportation (Bosona et al., 2013; Fauzi et al., 2021).

Distribution centers are facilities that serve to accumulate and consolidate products from various distribution channel points before being delivered to customers (Ballou, 2006). Rice distribution centers can be markets, warehouses, or other facilities.

Spatial analysis, a set of techniques for describing, analyzing, simulating, and predicting a spatial pattern or geographic phenomenon (ESRI, 2000; Gao, 2022) can be used to identify the location of distribution centers, which in turn can be used to measure the optimality of the location. Rice distribution is carried out using oil-fueled transportation, which produces exhaust emissions that have an impact on the environment (Crippa et al., 2022). Six pollutants from exhaust emissions are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter 10 microns (PM10), carbon dioxide (CO2), and sulfur dioxide (SO2) (Peraturan Menteri Negara Lingkungan Hidup Nomor 12 Tahun 2010 Tentang Pelaksanaan Pengendalian Pencemaran Udara Di Daerah, 2010)

Geographic Information System (GIS) technology, which in this study uses Quantum Geographic Information System (QGIS) version 3, can assist spatial analysis, location analysis and in the calculation of exhaust emission loads (Lee & Hong, 2021; Teniwut et al., 2019). GIS-based spatial analysis in the form of overlay, buffering, patern analysis, and network analysis techniques were carried out to identify distribution centers and calculate distances. Location analysis used load distance, location factor rating and weighted multi-criteria overlay analysis (WMCA) techniques. GIS was chosen because it provides functions to capture, store, analyze and display geographic information. The power of GIS can aid the simultaneous analysis of geographic space and related information that would be more difficult without the use of GIS (Rikalovic et al., 2018).

At the local level of a region, the efficiency of the food distribution network is expected to increase the affordability of food and reduce emissions in the region. Therefore, this study analyzes the efficiency of the rice distribution network for the Tasikmalaya area, which includes Tasikmalaya City and Regency, one of the areas with the lowest food security index (FSI) in West Java Province (Bapanas, 2023). The current condition is that there is one wholesale market in Tasikmalaya, Cikurubuk Market, which is the center of trade including for rice. The analysis was conducted to verify whether Pasar Cikurubuk is the center of rice distribution in Tasikmalaya, and to measure its optimality. This research is expected to produce a strategy that can improve the efficiency of the rice distribution network and reduce the exhaust emissions generated.

The above description shows the important role of the efficiency of GIS-based food distribution networks in efforts to achieve food security and mitigate climate change. However, research examining the role of distribution network efficiency in achieving food security and reducing emission is still limited. One of the related studies was conducted by Bosona et al. (2013), Lee (2021) and Teniwut et al. (2019) who evaluated the local food distribution network in Sweden. However, above research did not focus on one particular food commodity or only focus on one aspect. In contrast, this study focuses on analyzing the optimality of distribution center locations and the emission load of the rice distribution network. This aligns with research findings that highlight the limited number of studies focusing on food logistics, particularly those related to rice commodities (Munialo et al., 2023). This study examines the rice distribution system with the following objectives: 1) to measure the optimality of distribution center locations and the emission of the rice distribution network in Tasikmalaya, and 2) to formulate improvement strategies that can increase the efficiency of the distribution network and reduce the emissions.

RESEARCH METHOD

The research was conducted in Tasikmalaya, a region in West Java Province consisting of two areas: Tasikmalaya Regency and Tasikmalaya City. Although these two areas are administratively separate, they are interconnected in terms of economic and social activities. This location was chosen not only because it is among the regions with the lowest food security index but also because it serves as an economic hub in the East Priangan region, functioning as the epicentre of socio-economic activities for several surrounding regencies, therefore, improving the efficiency of rice distribution in this area is expected to have a positive impact on other regencies in the region.

The research was conducted from April to October 2023, a period during which most rice fields in Tasikmalaya were undergoing the 2023 harvest season. This period also coincided with peak rice milling activities, enabling easier and real-time observation of rice distribution flows.The data collected in this study consisted of primary data and secondary data. Primary data in the form of distribution channel data such as location, sales data, and shipping data. As well as the weight of the distribution center location selection criteria. Primary data is collected by field surveys, interviews with distribution channels and experts to obtain the weight and rating of distribution center location selection criteria. As for secondary data in the form of a list of distribution channels, geospatial data, road networks, and related demographic data. Data is obtained by taking data from credible sources. In rice distribution, the distribution channels include rice mills as producers, rice distributors, rice sub-distributors, and retailers. This study took one rice mill for each sub-district in Tasikmalaya as respondents. Location analysis was conducted on rice mills that supply rice to distribution centers. In addition, the study only analyzed rice distribution channels in the traditional market channel.

Analysis Technique

Spatial analysis was conducted with the help of QGIS version 3. The analysis techniques used in this research are overlay, buffering, and pattern analysis. Furthermore, Network Analysis was conducted to analyze the distance between distribution channels. Location Analysis, to determine the optimality of distribution center locations using three location analysis techniques. *Load-Distance Technique*. In this analysis, various candidate locations must be selected and evaluated using the multiplication of load (the number of sales from the rice mill to the distribution center) and distance as the measuring value. The mathematical formulation is given in the following equation 1:

$$LD = \sum_{i=1}^{n} w_i d_i \quad (1)$$

Where:
LD = measured value of load and distance
wi = request to delivery point i
di = distance between distribution channel to delivery point i
n= number of distribution points

Location Factor Rating. This technique evaluates the selected location factors based on the conditions of the area under consideration. Each factor is weighted in percentage terms, according to its importance and then a rating is assigned to each factor based on the attractiveness of the location. A location with a higher total rating is more optimal. *Weighted Multi Criteria Overlay Analysis (WMCA) technique*. This analysis uses raster data so that the resulting location suitability is a continuous area. WMCA analysis is carried out by first converting vector data in QGIS into raster data, then proximity analysis is carried out on the raster data layer, finally the overlay process is carried out on the results of proximity analysis. *Analysis of exhaust emission load* calculation is obtained by comparing activity data with emission factors(Peraturan Menteri Negara Lingkungan Hidup No 12 Tahun 2010). In this research, the emission calculation uses the tier 2 method, using the vehicle kilometer total (VKT) as activity data. Meanwhile, the emission factor refers to the national emission factor according to the Minister of Environment Regulation No. 12 of 2010. The emission load is calculated using the following equation 2.

$$E_a = \sum_{b=1,c=1}^{n,m} (VKT_{b,c} \ x \ FE_{a,b,c} \ x \ 10^{-6}) \quad (2)$$

Where:
Ea= emission load for pollutant a (ton /year)
VKTb,c = total distance traveled
FEa,b,c = emission factor
a= pollutant type
b= motor vehicle category
c= fuel type

RESULTS AND DISCUSSION

Rice Distribution Channels

The rice distribution channel starts from rice mills as producers and then flows through distributors, sub-distributors, and retailers. Distributors have a large inventory of rice and get direct supply from rice mills from within and outside the Tasikmalaya area. Sub-distributors are traders or agents who only sell rice and distribute it to retailers or directly to consumers, while retailers are stores that sell rice and other products and sell directly to consumers. Retail consists of two channels, namely traditional markets and modern markets.

Tasikmalaya City in 2022 had ten traditional markets and 190 modern shop units, while Tasikmalaya Regency had 21 traditional markets and 235 modern shop units (BPS, 2023b, 2023a). Of the 31 traditional markets in Tasikmalaya, there are 3 main markets, Cikurubuk Market, Pancasila Market, and Singaparna Market (Darmawan, 2017; Salam et al., 2023). The traditional market channel also includes a network of traditional shops such as grocery stores or food stalls. And because in the traditional market channel, sub-distributors and retailers are mostly located in and around traditional markets, in this study, distributors are traditional markets in the Tasikmalaya area.

Rice milling

Rice mills in this study were classified into four categories, namely micro or hullers with a milling capacity below 300 kg/hour, small rice mills (PPK) with a milling capacity of 300-700 kg/hour, medium rice mills (PPS) with a milling capacity of 700-1,000 kg/hour, and large rice mills (PPB) with a milling capacity of more than 1,000 kg/hour (Widowati 2001). The rice mills observed in this study consisted of 15 huller business units, 11 PPK business units, 17 PPS business units, and 5 PPB business units. Of these, all PPS and PPB supply rice to Cikurubuk Market.

Rice Distribution Pattern in Tasikmalaya

Rice from rice mills in Tasikmalaya is distributed to consumers through several distribution patterns. First, hullers only perform milling services from farmers (Figure 1.a). Secondly, PPK, in addition to milling services, also buys grain from farmers to sell the rice to sub-distributors and retailers (Figure 1.b). Third, PPS buys unhusked rice from farmers or collectors and then sells the rice to distributors, sub-distributors, and retailers (Figure 1.c). Fourth, PPB buys grain from farmers or collectors and then sells the rice to distributors and sub-distributors (Figure 1.d).

Based on the research results, the differences between the four distribution patterns are in the level of inventory of raw materials (grain) and products (rice), product packaging, and minimum order quantity (MOQ). PPK has no inventory, no self-packaging and without MOQ or very small. Therefore, production tends to follow the harvest season. PPS and PPB have different levels of inventory, PPB has enough raw material inventory to support production throughout the year so that it is not to follow the season. PPS does limited packaging while PPB packs in several sizes of packaging and has a trademark on the product packaging. The MOQ for PPB is larger and does not serve retail. A schematic of the rice distribution pattern can be shown in Figure 1.

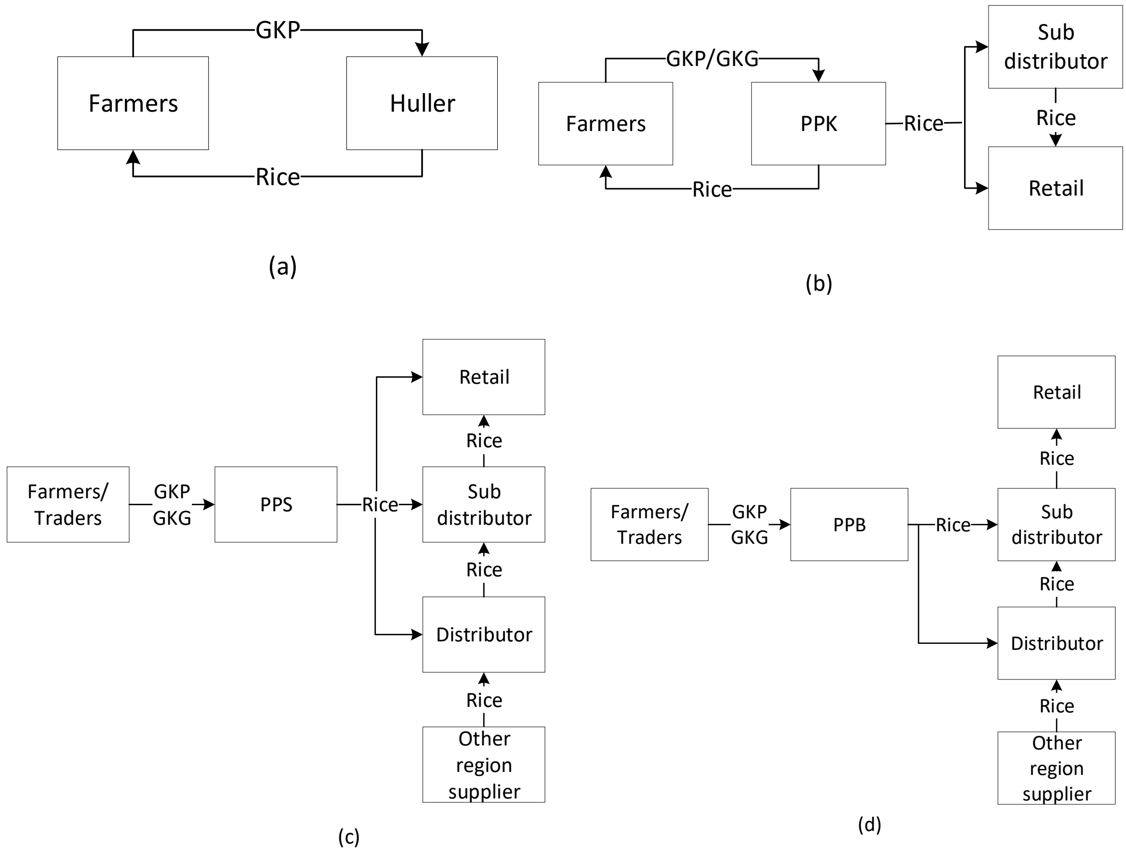

Figure 1: Rice distribution patterns. (a) Huller, (b) PPK, (c) PPS, (d) PPB

Map of Rice Distribution Network in Tasikmalaya

Data on rice distribution channels in Tasikmalaya and related geospatial data were then entered into QGIS to create a map of the rice distribution network in Tasikmalaya. This map shows the location of rice mills (15 hullers, 11 PPKs, 17 PPSs, and 5 PPBs), 31 traditional markets, and the available road network. A clearer picture can be seen in Figure 2.

Spatial Analysis

The data was then analyzed spatially to study the interaction and relationship patterns between existing distribution channels. Buffering to see the distribution of distribution channels in Tasikmalaya with the assumption that the service area of one distribution channel is within a radius of 3 km. The buffering results show that distribution channels are still concentrated around Tasikmalaya City (Figure 3). Pattern Analysis, shows that PPK supplies their rice to the traditional market closest to their milling location, while PPS and PPB supply rice to surrounding traditional markets and to Cikurubuk Market (Figure 4).

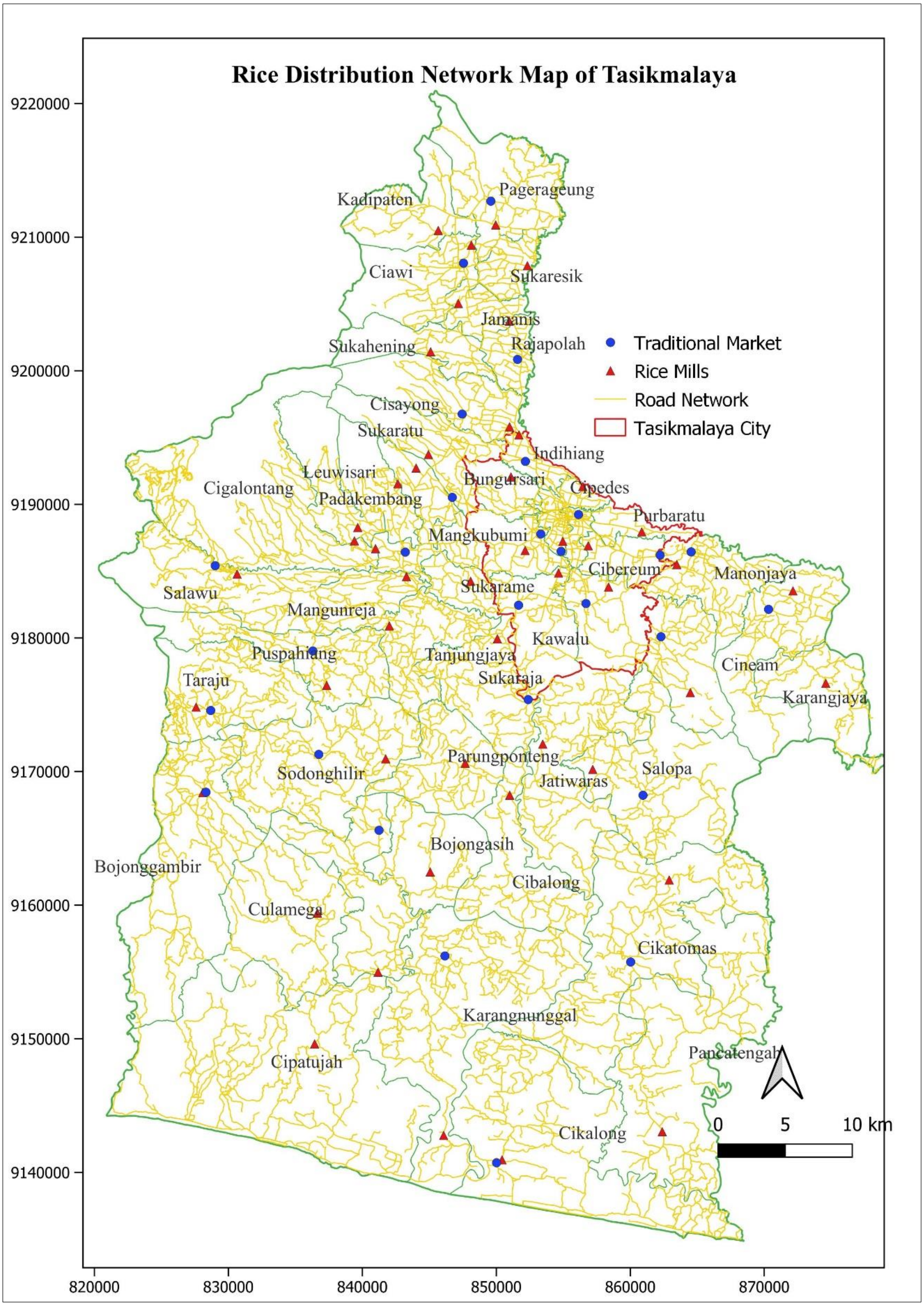

Figure 2: Map of Rice Distribution Network in Tasikmalaya

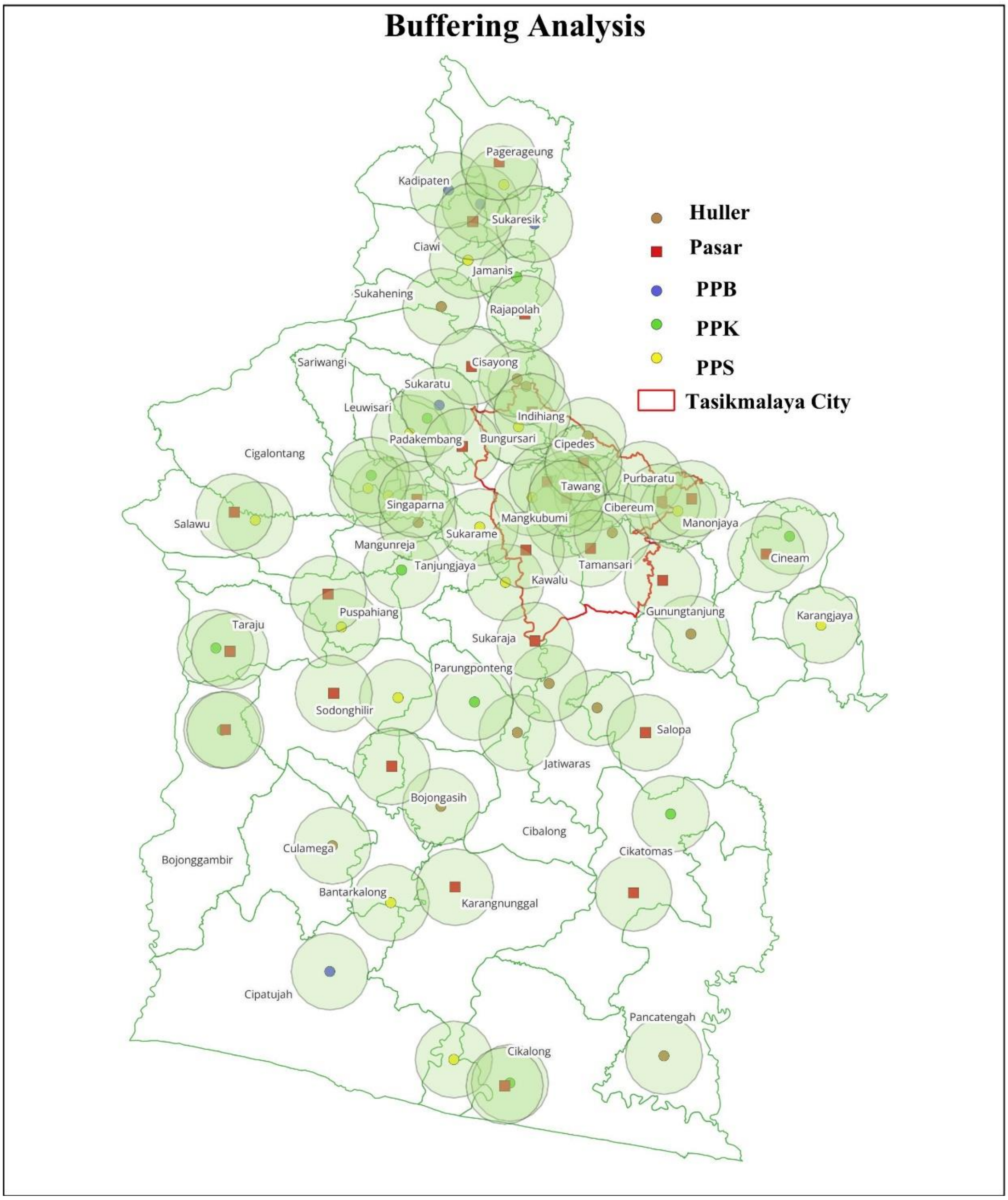

Figure 3: Spatial Analysis result

Distribution Center

Based on the results of spatial analysis, it was identified that Cikurubuk Market has become the meeting point for rice flows from rice mills as producers to retail traders, who serve as the final distribution channel before rice reaches consumers. Therefore, Cikurubuk Market has established itself as a l distribution centre within the rice distribution network in Tasikmalaya. Further analysis was conducted on 22 rice milling businesses that supply rice to Cikurubuk Market as the distribution centrer.

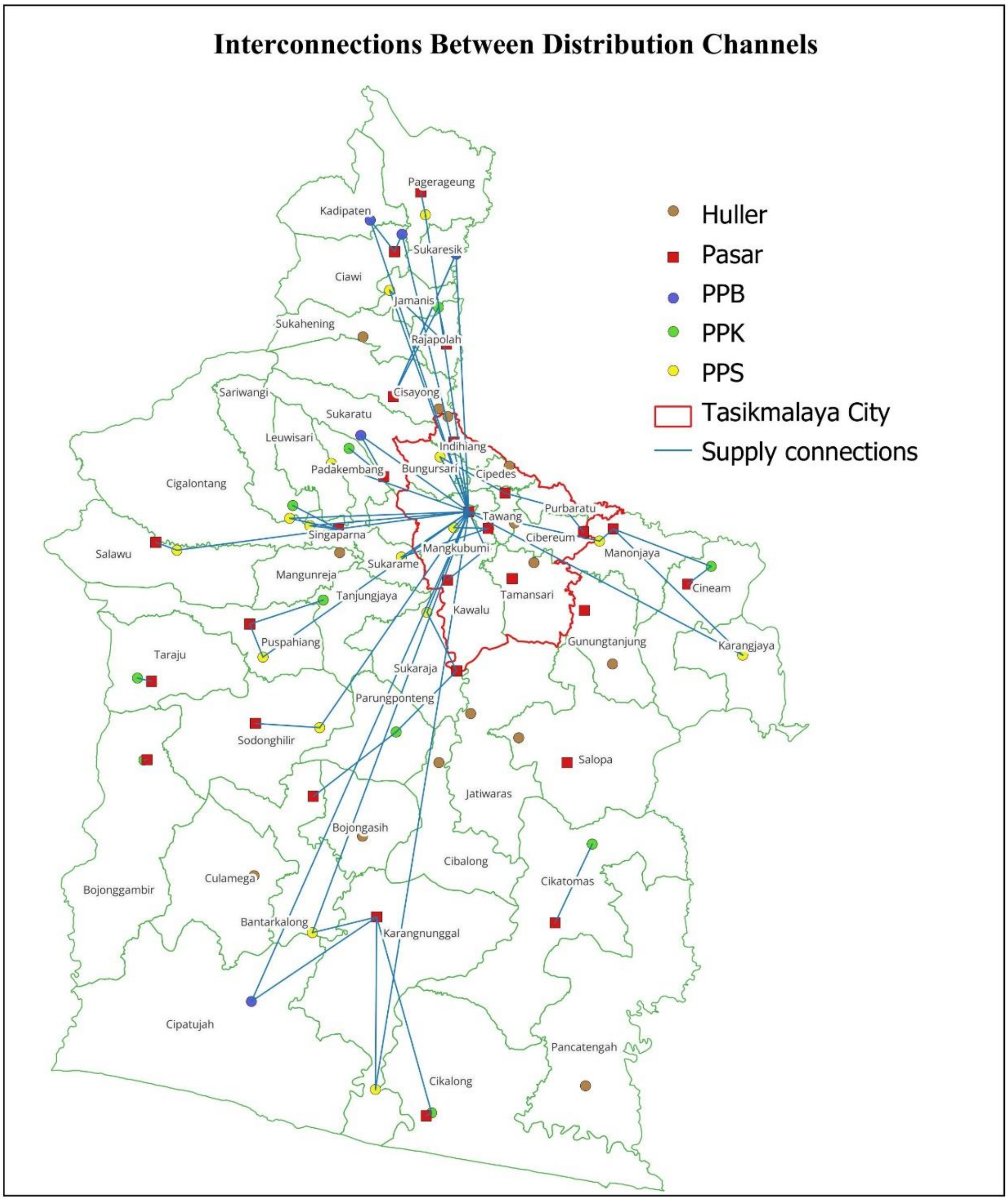

Figure 4: Spatial Analysis result for Patern Analysis

Network Analysis

The shortest routes and distances from rice mills to the three main markets were measured following the available road network. These distances represent the road lengths of the shortest paths connecting the rice mill locations to the traditional market locations. The network of paths (routes) from 22 rice mills (PP) to the three main markets—Cikurubuk Market (PSCB), Pancasila Market (PSPC), and Singaparna Market (PSSP)—is illustrated in Figure 5.

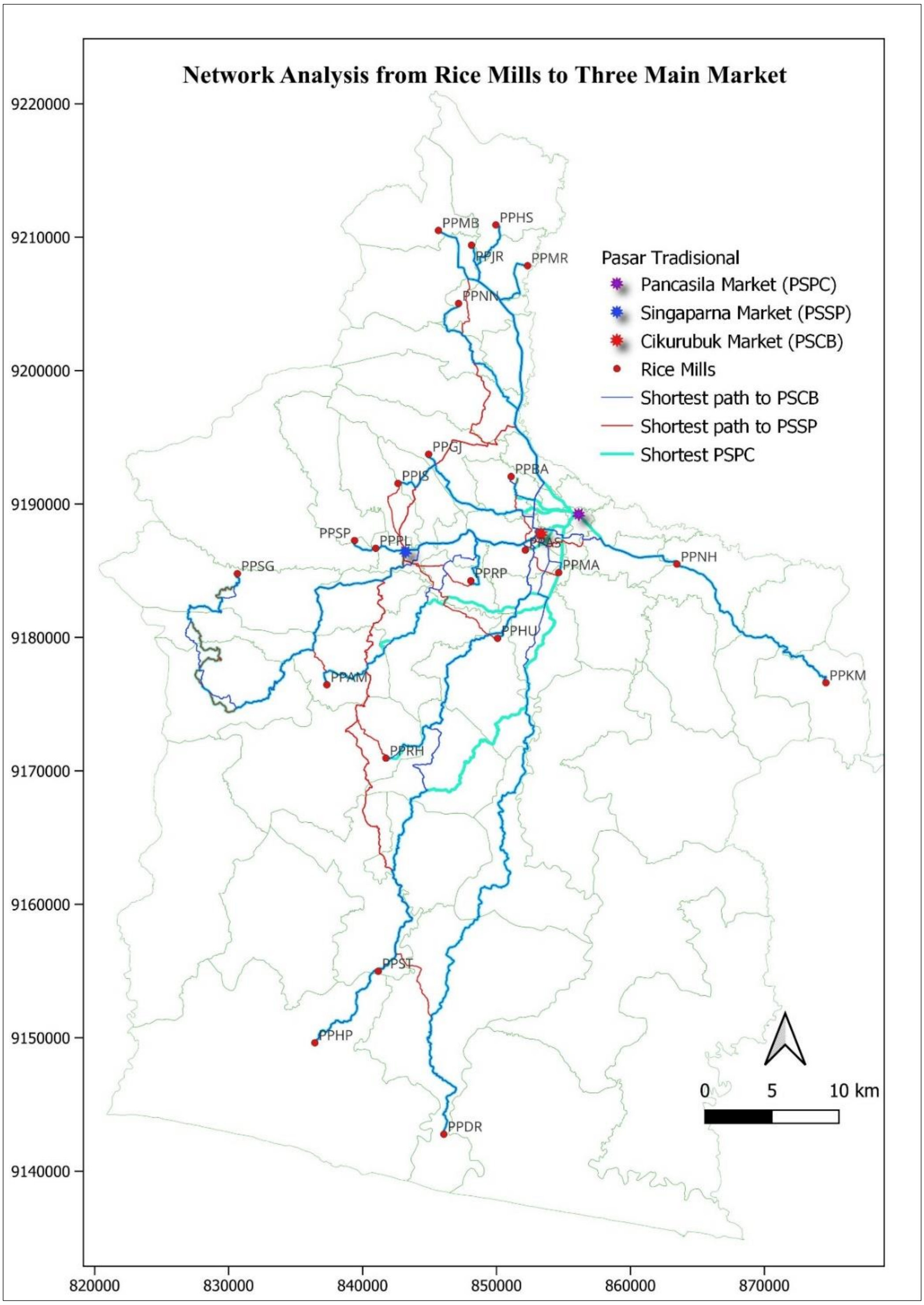

Figure 5. Network Analysis From Rice Mills to Three Main Market

Location Analysis

Twenty-two rice mills (17 PPS and 5 PPB), supply rice to Pasar Cikurubuk. For this study, it is assumed that each rice mill uses only one type of vehicle Colt Diesel Engkel (CDE) truck for PPS with capacity of 2.6 tons, with an average diesel consumption of 11 km per liter, and Colt

Diesel Double (CDD) truck for PPB with capacity of 4.3 tons and an average diesel consumption of 8 km per liter. The density of the diesel fuel is 0.82 kg per liter. The location analysis compares the optimality of Pasar Cikurubuk (PSCB) with two other main markets, Pasar Pancasila (PSPC) and Pasar Singaparna (PSSP). The distance calculations from the rice mills to these three markets, as well as the total distance traveled and fuel consumption from the mills to the distribution center (PSCB), are presented in Table 1.

Table 1. Calculation of Vehicle Kilometer and Fuel Consumptions

PP Code	Truck	Load (ton)	Distance PSCB (km)	Distance PSPC (km)	Distance PSSP (km)	Trips to PSCB	Vehicle kilometer (km)	Fuel (liters)
PPAS	CDE	495	2,6	5,3	9,9	190	497	45
PPMA	CDE	432	4,6	4,7	13,3	166	765	70
PPNH	CDE	294	11,8	8,5	21,9	113	1.330	121
PPPL	CDE	360	13,3	16,5	2,3	138	1.836	167
PPIS	CDE	546	14,2	16,1	5,4	210	2.992	272
PPHP	CDD	3.240	51,9	52,6	48,2	753	39.123	4.890
PPJR	CDD	3.780	22,2	21,7	29,0	879	19.537	2.442
PPNN	CDE	420	20,8	20,3	26,1	162	3.365	306
PPST	CDE	324	43,8	44,5	40,1	125	5.455	496
PPMB	CDD	2.160	24,6	24,1	31,3	502	12.365	1.546
PPDR	CDE	360	55,7	56,4	54,9	138	7.713	701
PPKM	CDE	252	28,4	25,1	38,5	97	2.750	250
PPBA	CDE	462	5,8	6,4	15,1	178	1.023	93
PPSG	CDE	360	51,0	58,2	43,9	138	7.060	642
PPSP	CDE	240	15,2	18,5	4,2	92	1.405	128
PPHS	CDE	396	24,5	24,0	31,3	152	3.727	339
PPAM	CDE	378	26,5	29,6	15,9	145	3.847	350
PPHU	CDE	504	9,9	11,8	10,7	194	1.911	174
PPGJ	CDD	2.160	11,5	13,4	8,2	502	5.779	722
PPRH	CDE	540	25,0	27,1	20,9	208	5.188	472
PPRP	CDE	288	10,2	13,4	6,5	111	1.127	102
PPMR	CDD	2.850	22,0	21,5	28,8	663	14.551	1.819
Total		**20.841**	**495,3**	**519,6**	**506,3**	**5.858**	**143.344**	**16.145**

Load distance

According to equation (1), the load distance (LD) value of each traditional market is obtained from the total multiplication between the distance from PP (di) to each market and the load (Wi). A smaller LD value indicates that the location is more optimal compared to other locations.

Referring to Table 1, the LD values for the three markets are:

LD PSCB = (495x2.6)+..+(2,850x22)
= 527.998
LD PSPC = (495x5.3)+…+ 2.850x21.5)
= 539.812
LD PSSP = (495x9.9)+...+(2.850x28.8)
= 568.129

Based on the LD values above, Pasar Cikurubuk, with the smallest LD value of 527.998, is more optimal than Pasar Pancasila with an LD of 539.812, and Pasar Singaparna with an LD of 568.129.

Location Factor Rating

The researcher asked the expert respondents about the influential factors with their respective weights to compare the location optimality of the three big markets in Tasikmalaya. The higher the rating on a factor, the better the location is considered to be. Markets with a higher total weight value have a higher level of location optimization. The weighted numbers of the three locations can be seen in Table 2.

Tabel 2. Location Factor Rating for Distribution Centre

No	Location Factor	Weight	Pasar Singaparna		Pasar Cikurubuk		Pasar Pancasila	
			Rating	Weight	Rating	Weight	Rating	Weight
1	Distance & number of customer	20	4	80	5	100	4	80
2	Distance & number of Suppliers	26	4	105	3	79	3	79
3	Infrastructure and utility	18	3	53	4	70	4	70
4	Close to transportation route	18	4	70	5	88	4	70
5	Land availability	13	3	38	5	63	3	38
6	Courier availability	5	5	25	5	25	5	25
7	Governance policy	1	4	5	4	5	4	5
Total		**100**		**375**		**429**		**366**

Using the Location Factor Rating technique, Pasar Cikurubuk emerges as the most optimal location with the highest rating score of 429, compared to Pasar Singaparna with a score of 375 and Pasar Pancasila with a score of 366.

Weighted Multi Criteria Overlay Analysis

The next location analysis uses Weighted Multi Criteria Overlay Analysis (WMCA). This analysis is used to determine whether Pasar Cikurubuk is already in an optimal area to be used as a rice distribution center. This analysis uses raster data so that the resulting location suitability is a continuous area. The WMCA analysis first conducted Proximity Analysis on three factors (layers) namely road networks, rice mills, and traditional markets. The results of the proximity analysis have not been focused, therefore to help sharpen the analysis, the analysis area was reclassified. For this study, the analysis area was classified into three classes: less than 1 km, 1-5 km, and more than 5 km. Next, an overlay process of the three layers was conducted. The results of the WMCA analysis show that Cikurubuk Market is in an optimal area because it has proximity to several rice mills and traditional markets as well as to the arterial road network. The complete results of the WMCA analysis can be seen in Figure 6.

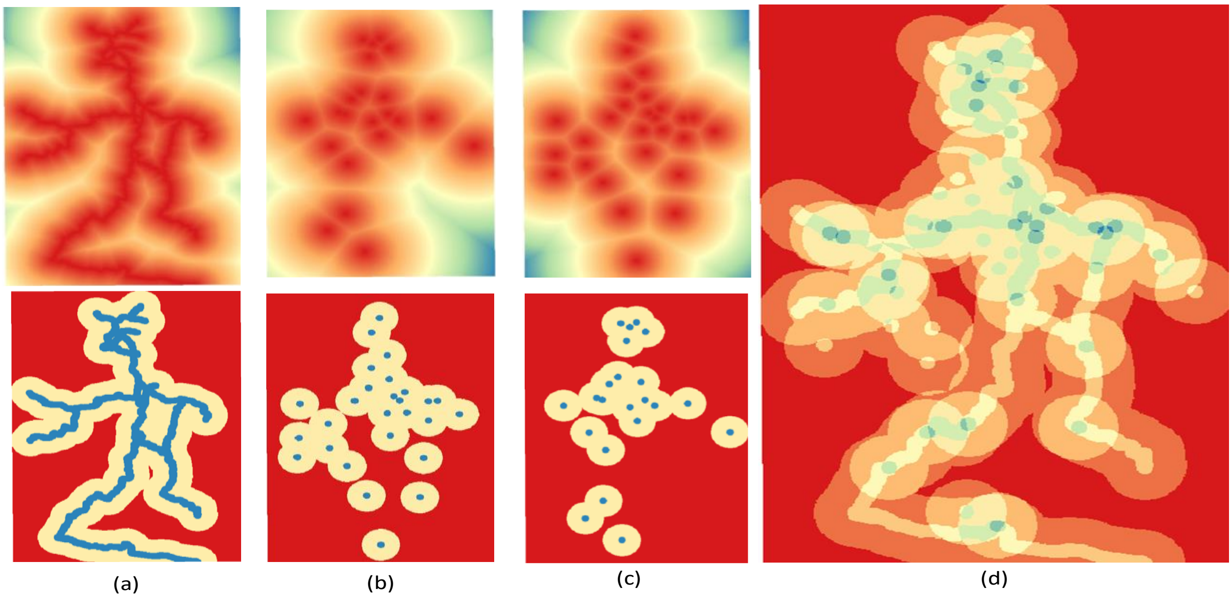

Figure 6: (a) Proximity Analysis and Reclassification Road Network Layer (b) Proximity Analysis and Reclassification Traditional Market Layer (c) Proximity Analysis and Reclassification Rice Mills Layer (d) WMCA Result of Three Layers

The Load of Exhaust Gas Emissions

As shown in Table 3, the VKT for the rice distribution network is 143,344 km, with fuel consumption of 16,145 liters. The VKT is then multiplied by the emission factor for each polutan. For CO2 emissions, is based on the fuel consumption, instead of VKT (Muziansyah et al. 2015). Detailed emission load are presented in Table 3.

Table 3. Calculation of Annual Exhaust Gas Emission Load

Exhaust gases	Emissions Factor	Emissions (ton)
CO	8.4 (g/km)	1,20
HC	1.8 (g/km)	0,26
NOx	17.7 (g/km)	2,54
PM10	1.4 (g/km)	0,20
CO2	3172 (g/kg fuel)	41,99
SO2	0.82 (g/km)	0,12

Strategies for Enhancing the Efficiency of the Rice Distribution Network

Efforts to enhance the optimization and efficiency of rice distribution include establishing new distribution centre. This approach not only improves efficiency from producers or rice mills to distribution centres but also enhances efficiency from distribution centres to subsequent channels until the rice reaches consumers.

A key initiative is the construction of a new wholesale market in Tasikmalaya Regency, specifically through the relocation and capacity enhancement of the Singaparna Market, which is deemed unsuitable due to increasing trade activity and its location in the city centre. The new Singaparna wholesale Market will be built in Cilampunghilir Village, Padakembang District. Construction is planned to commence in 2024, with operations expected to begin in 2026. This wholesale market is anticipated to serve as an alternative and a balancing counterpart to the Cikurubuk Market, particularly for areas within Tasikmalaya Regency.

This study employs network analysis to simulate the scenario of having two rice distribution centres in Tasikmalaya: the first being Cikurubuk Market, which serves the eastern, northern, southern, and urban areas of Tasikmalaya, and the second being the Singaparna Wholesale Market, which serves the western part of Tasikmalaya. The simulation uses data from rice mills that supply rice to Cikurubuk Market, dividing them based on their respective locations.

The simulation will calculate the Vehicle Kilometers Traveled (VKT) from the rice mills to both distribution centres and compare it with the VKT required when using a single distribution centre. Network simulation results for the two-centre rice distribution network can be seen in Figure 7.

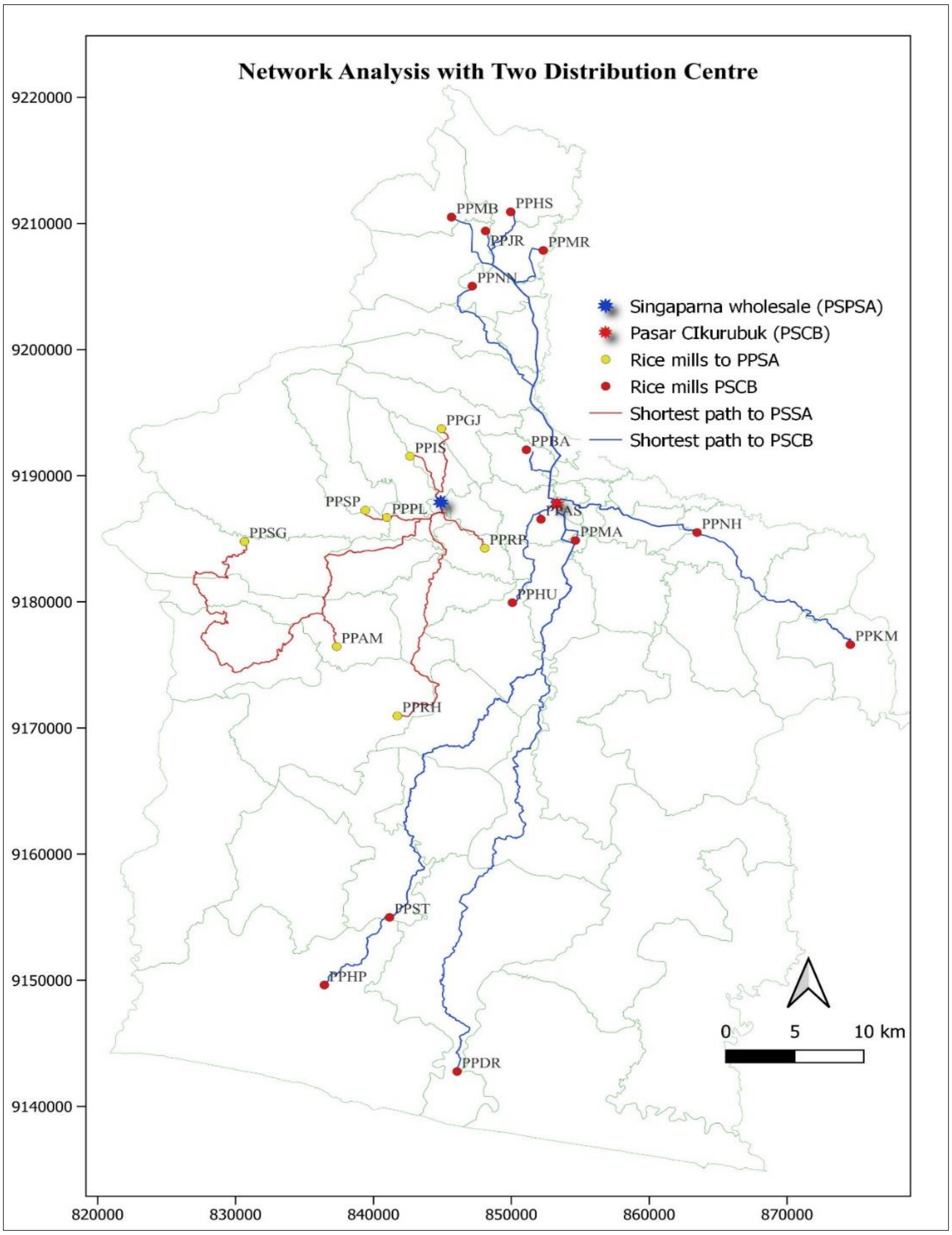

Figure 7: Network Analysis with Two Distribution Centres.

Based on network analysis, the distances between rice mills and the two distribution centres. The calculated VKT and annual fuel consumption for both distribution centres from each rice mill are presented in Table 4.

The calculations presented in Table 4 reveal differences in VKT and fuel consumption. The VKT with two distribution centres is 134,518 km, which is 6.16% lower than using only one distribution centre which totals 143,344 km. Similarly, fuel consumption decreases by 5.45%, from 16,145 liters to 15,265 liters. The reductions is directly proportional to the decrease in exhaust gas emissions generated.

Tabel 4. Calculation of Vehicle Kilometer and Fuel Consumptions with Two Distribution Centers: Cikurubuk Central Market and Singaparna Central Market

PP Code	Vehicle	Distance (km)	Load (ton)	Trips	Vehicle Kilometer (km)	Fuel (liter)
Supply to Singaparna Main Market						
PPPL	CDE	4.97	360	139	691	63
PPIS	CDE	4.67	546	210	981	89
PPSG	CDE	46.65	360	139	6.484	589
PPSP	CDE	6.94	240	93	645	59
PPGJ	CDD	6.77	2.160	503	3.405	426
PPRH	CDE	22.49	540	208	4.678	425
PPRP	CDE	5.70	288	111	633	58
PPAM	CDE	18.67	378	146	2.726	248
Supply to Cikurubuk Market						
PPAS	CDE	2,61	495	191	499	45
PPMA	CDE	4,60	432	167	769	70
PPNH	CDE	11,76	294	114	1.341	122
PPHP	CDD	51,92	3.240	754	39.149	4.894
PPST	CDE	43,77	324	125	5.472	497
PPDR	CDE	55,71	360	139	7.743	704
PPKM	CDE	28,38	252	97	2.752	250
PPBA	CDE	5,76	462	178	1.024	93
PPHU	CDE	9,86	504	194	1.913	174
PPNN	CDE	20,83	420	162	3.375	307
PPMB	CDD	24,61	2.160	503	12.381	1.548
PPHS	CDE	24,47	396	153	3.744	340
PPJR	CDD	22,22	3.780	880	19.557	2.445
PPMR	CDD	21,95	2.850	663	14.556	1.819
Total		**445,32**	**20.841**	**5.869**	**134.518**	**15.265**

Reducing travel distance can accelerate rice delivery to consumers, enhance the efficiency of transportation modes and lower operational costs. The establishment of two distribution centres also brings markets closer to producers, potentially increasing the absorption of local production. The reduction in fuel consumption, and emissions positively impacts human health and the environment. The increase in CO2 emissions is a major driver of the greenhouse effect, which raises global surface temperatures and accelerates climate change, directly affecting agriculture and food security.

The construction of the Singaparna Wholesale Market, which involves relocating and revitalizing the current Singaparna Market, not only contributes to reducing emissions but also has the potential to boost the local economy, support price and supply stability, increase regional income, and simplify spatial planning in the area of the current Singaparna Market. The former market site can later be repurposed for other public uses that enhance the community's social life, such as creating a city park or other facilities.

While the development of the Singaparna Wholesale Market may attract economic activities away from Cikurubuk Market, it still offers positive impacts for Tasikmalaya City. The reduced density at Cikurubuk Market can help alleviate traffic congestion in its vicinity, which is close to the government centre. Additionally, the space left by some traders can be utilized for other economic activities that align better with urban spatial planning objectives.

The significant investment required to realize the construction of the Singaparna Central Market by the government is undoubtedly justified by the benefits it will bring. These benefits encompass economic, environmental, and social improvements.

CONCLUSION

Based spatial analysis identified Pasar Induk Cikurubuk as the rice distribution centre in Tasikmalaya. Its optimal location is confirmed through location analysis using the load distance, location factor rating, and weighted multi-criteria analysis techniques, all of which indicate that Pasar Cikurubuk is well-suited as a rice distribution hub.

The development of Singaparna wholesale market as a second rice distribution centre is proposed as a strategy to enhance the efficiency of the rice distribution. Simulations using two distribution centres shown an improvement in distribution efficiency by reducing total travel distance by 6.16% and annual fuel consumption decreases by 5.45%. The reductions is directly proportional to the decrease in exhaust gas emissions generated.

Further research incorporating additional factors, such as cost, will provide insights into how increased rice distribution efficiency impacts economic outcomes. This study is limited to calculating emissions from rice transportation between mills and distribution centres using tier-2 calculations. Future studies that include broader input data and emissions calculations from distribution centres to consumers could offer a more accurate depiction of emissions generated by the entire rice distribution system, particularly in the Tasikmalaya region.

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