

## **Analysis of the Distribution of Public Fuel Stations in Pati Regency Based on a Geographic Information System**

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### **ABSTRACT**

#### **KEYWORDS:**

*Affordability,  
Distribution Patterns,  
Gas Stations*

Pati Regency is one of the largest districts in Central Java Province. This causes population density which can affect population mobility there too. The large population in Pati Regency can affect population mobility. This mobility requires fuel consumption. The provision of fuel by the government and private sector through public fuel stations is one of the most important infrastructures available. With the existence of Public Fuel Filling Stations (SPBU) the wheels of the economy will run properly. This study uses a descriptive method with a qualitative approach. The aim of this research is to examine the distribution pattern and affordability of Public Fuel Filling Stations in Pati Regency. The nearest neighbor analysis method is used to calculate the distribution pattern of location points between Public Fuel Filling Stations. Also, Buffer analysis is carried out to detect conditions around objects with a certain radius/distance. The results of the research show that the distribution of gas station locations in Pati Regency forms a cluster pattern and the distance between gas station locations is included in the very close criteria.

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## **1. INTRODUCTION**

Every year cities experience development, therefore meeting the increasing needs of the population influences very rapid development. This is comparable to a shift in land use functions and an increase in people's movement behavior to meet their needs. The development of an urban area is influenced by three factors: economic development, population growth, and developments in land use patterns. for businesses, thereby increasing traffic. When there is a strong correlation between economic growth and population variables, there will be an upward trend. The denser the population, the more mobility the population will have. Population mobility is not far from the existence of public transportation, where these vehicles can operate because of the presence of fuel oil (Moelyanto A A & Buchori I, 2012).

An important city fuel distribution infrastructure is the fuel oil filling station. The role of gas stations in supporting the national economy is very important and strategic because it takes into account the public interest. Fuel storage, storage and distribution places are available to the wider community to meet their fuel oil needs. Gas stations serve private customers and retail businesses, especially for motorized vehicles that do not have fuel tank capacity or limited fuel capacity Yusuf Almijan & Koto Arthur Gani (2020). For private and public vehicles, public service stations are locations that function as fuel refills. Fuel can be purchased not only from gas stations but also from dealers. There are advantages and disadvantages to each of the two methods of obtaining fuel. People usually don't have to wait long to buy fuel from retail stores. Retail gas stations have these advantages and disadvantages because the prices and number of portions are higher than gas stations (Syam Alexander, 2016). Urban areas are influenced by three factors: economic growth, increasing population, and changes in land use patterns by entrepreneurs, which result in an increase in the number of vehicles passing through the area. There is no strong correlation between

population changes and economic growth, so the increasing trend which is always accompanied by an increase in the number of motorized vehicles is a normal phenomenon.

In terms of geography, the Administrative City of Pati Regency has the largest area among other cities in the province. Apart from that, in terms of demographics, Pati Regency has the largest population compared to all districts within one province. As a result of the census conducted by the Pati Regency Central Statistics Agency in 2021, the total population of the Pati Regency Administrative City is 1,349,172 people, consisting of 671,225 men and 677,947 women. Additionally, the population increased from 0.75% in 2019–2020 to 1.94% in 2020–2021 (BPS Kabupaten Pati 2021). The increasing population and increasing purchasing power have resulted in an increase in motor vehicle ownership. The increasing number of public vehicles must be accompanied by the provision of evenly distributed public fuel filling locations. The uneven distribution of Public Fuel Filling Stations in Pati Regency has hampered population mobility. Analysis of the spatial distribution model of gas stations in Pati Regency is very important from the perspective of mobility and fuel oil availability, as well as sustainable urban development planning. In situations like this, understanding the gas station distribution model can be useful for energy management decisions and transportation infrastructure in the district

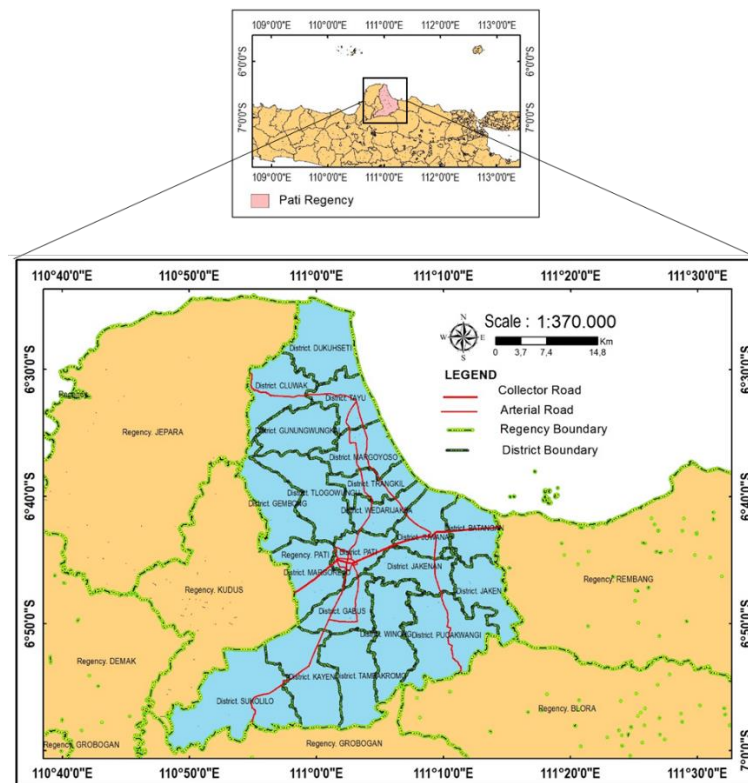
Piani *et al* (2023), researching the distribution of public fuel filling stations in Jakarta, Indonesia, the distribution of gas stations is in accordance with city growth patterns and population density, areas with many residents have more gas stations to meet community needs. Gas station clusters can be seen in several areas of Pati Regency. This may be due to things such as licensing policies, strategic business considerations, and increased fuel demand in the region. Analysis of the spatial distribution patterns of gas stations in Pati Regency also provides important information for planning sustainable development of gas station infrastructure and allows decisions to be made about the location and number of gas stations in the area.

A study of the gas station distribution model in Pati Regency can provide an idea of what the possible distribution of gas stations is. Geographic, demographic and regional developments influence urban gas stations. In addition, this analysis can find gaps in fuel services in various regions, evaluate the performance of current gas station locations, and provide suggestions for future development or changes to gas station locations. Basically, there are three distribution models, namely uniform, randomly distributed (random pattern), and clusters spread over areas that are not evenly distributed with the phenomena that occur (Rizki Y M, 2017). Based on the research background that has been described, this research aims to analyze the distribution pattern and affordability of public fuel filling stations in Pati Regency. This research also has recommendations to the government or related institutions so that they can implement the creation of public fuel filling stations while still paying attention to equality, and so that the use of green energy can always be developed.

## 2. MATERIALS AND METHODS

### 2.1. Research areas and data used

The research location is Pati Regency, which is an administrative map of Pati Regency which can be seen from Fig 1. As one of the regencies in Central Java, Pati Regency is astronomically located between (6°25' - 7°00' South Latitude and 100°50' - 111°15' East Longitude) and based on Its geographic location borders Jepara Regency and the Java Sea in the north, Grobogan and Blora Regency in the south, Kudus and Jepara Regency in the West, and Rembang Regency in the East. Based on the results of the 2002 EPT, the area of Pati Regency is 150368 Ha consisting of 59332 Ha of rice fields, 66086 Ha of non-rice fields and 24 950 Ha of non-agricultural land (Pemerintah Kabupaten Pati, 2018)



**Fig. 1.** Pati Regency as a research location for gas station distribution patterns

The tools and materials used in this research are presented in Table 1 and Table 2. This research uses data processed using Arcmap 10.8 as well as coordinate point data obtained from Google maps.

**Table 1. Tools used in research**

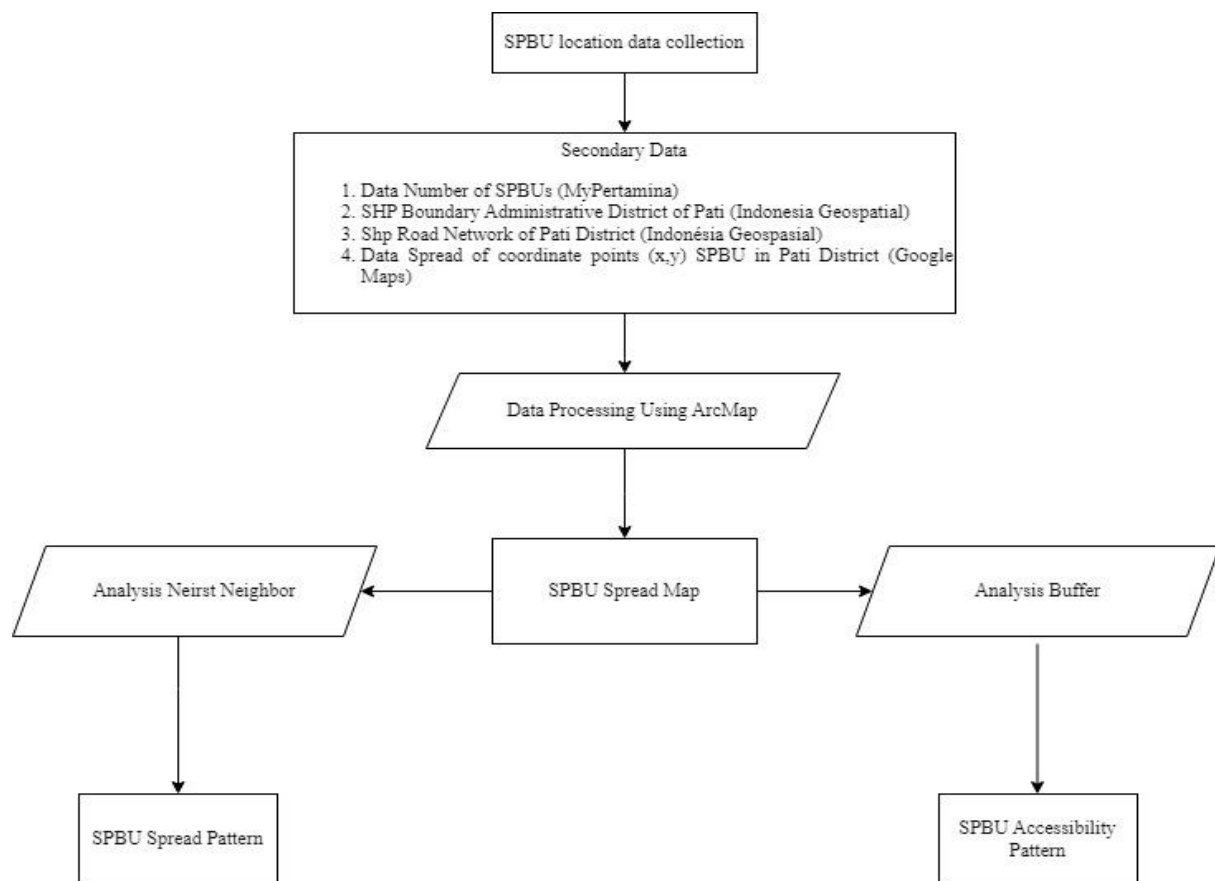
| Tool's name | Function                                 |
|-------------|------------------------------------------|
| ArcMap 10.8 | Spatial data processing and map creation |
| Google maps | Coordinate point data processing         |

**Table 2. Data used in research**

| Data name                                      | Function                                                   | Source                                                                                                                                                                                          |
|------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pati Regency Administration Shp                | Making a map of the Pati Regency Administration            | <a href="https://www.indonesia-geospasial.com/2020/01/shp-rbi-provinsi-jawa-tengah-perregion.html">https://www.indonesia-geospasial.com/2020/01/shp-rbi-provinsi-jawa-tengah-perregion.html</a> |
| Data on Gas Station Names/Code in Pati Regency | Record the names and codes of gas stations in Pati Regency | MyPertamina                                                                                                                                                                                     |

## 2.2. Data Processing and Analysis

Below is a research flow diagram, which shows the process of this research.



**Figure 2. Research flowchart**

### 2.2.1. Data Processing Using ArcMap

Data analysis is the process of examining data and processing it to convert it into useful information, draw conclusions, and help in solving a problem (Kartika I H D & Fikriyah V N , 2023). In this research, the Geographic Information System supports the obtaining of research results. Geographic Information Systems (GIS) have developed into a transformative tool that can change the data collection processes required for utility management (Alausa *et al*, 2023). In this research, descriptive quantitative research is used to analyze physical sensitivity, while Geographic Information System tools (Dewa, et al. 2023). And in processing it can use data with ArcMap, this research contains the distribution patterns of Public Fuel Filling Stations in the Pati Regency area. Processing is carried out with secondary data in the form of shapefile data for the administrative boundaries of Pati Regency, shapefile of the road network, data on the number and codes of Public Fuel Filling Stations (SPBU) as well as data on the coordinates of Public Fuel Filling Stations in Pati Regency. The results of this shapefile processing are a map of the distribution of public fuel filling stations.

### 2.2.2. Analysis Nearst Neighbour

Neirst Neighbor Analysis. After that, the map of the distribution of public gas filling stations is carried out by Neirst Neighbor Analysis. The process for producing a map of the spatial distribution pattern and affordability of gas stations goes through various stages as explained in Fig 2, namely a flow diagram that has been modified in such a way as to suit the needs of the analysis (Purbani, et al., 2019). This research only uses secondary data, namely data that is not obtained directly, such as plotting coordinate points carried out in Google Maps software. The coordinate point data is processed in Microsoft Excel so that it becomes a suitable format for spatial analysis. ArcGIS 10.8 is the software used for all spatial analysis of research objects. The

previous data which is already in Arcgis continues processing by selecting the arcToolbox icon in Arcgis after that select spatial statistics tools then select analyzing pattern and Average Nearest Neighbor (Fitriani, 2023). The spatial analysis of gas station objects in Pati Regency is in the form of spatial statistical analysis in the form of Nearest Neighbor Analysis (NNA) or Nearest Neighbor Analysis in Indonesian, which is a method for exploring patterns in location data by graphically comparing the distribution of functions observed from event to event. events or random point-to-event distances from nearest neighbors (Upton, 1985). There are several steps that must be taken into account when using Nearest Neighbor Analysis, including (Riadi, 2020): First, determine the specific area or region and its borders to determine the spatial distribution pattern. Second, changing to a point distribution pattern in the form of the location coordinates of each object if the initial data is an object such as a building or individual from the object distribution pattern. Third, assign serial numbers to all points in the data to make it easier to identify and group points in analysis. Fourth, measure the closest distance of each point to its nearest neighbor in a straight line. Fifth, calculate the Nearest Neighbor parameters using the following formula.

$$T = \frac{J_u}{J_h} \quad (1)$$

Information:

T= nearest neighbor distribution index

J<sub>u</sub> = the average distance measured between one point and its nearest neighbor

J<sub>h</sub> = average distance obtained if all points had a random pattern

$$Z = \frac{J_u - J_h}{\delta J_h} \quad (2)$$

$$\text{Where } \delta J_h = \frac{0.26136}{\sqrt{Np}} \quad (3)$$

Information:

Z= standard diversity of the normal curve

= standard error of mean distance to nearest neighbor  $\delta J_h$

P = point density

N= number of observed distance measurements

The ANN (Average Nearest Neighbor) measure is used to measure the distance pattern between observed objects compared to the expected distance pattern in a random pattern. The range of ANN values is 0 to 2.15, with a value of 1 indicating a random pattern. If the value of ANN is smaller than 1, it indicates the presence of a group or cluster pattern, while if the value of ANN is greater than 1, it indicates a uniform pattern or regular dispersion. If the reliability of each distance measure can be ensured, then using the values D<sub>0</sub> (average observed distance) and DE (average expected distance) in tests with a normal curve will increase the usefulness of these two values. Normal curves are used to check whether the population distribution follows a non-random pattern. If both distributions follow a normal pattern, this indicates that the distance measurements used in the ANN calculation are reliable.

### 2.2.3. Analysis Buffer

Buffer Analysis, Spatial analysis of reachability in this research uses the buffer zone (radius area) analysis method (Januarman, 2019). Buffer zone analysis is an application of a Geographic Information System (GIS) which aims to detect conditions around objects with a certain

radius/distance and works by assessing geographic features (Sapakoly, 2023). The following is buffer zone data for gas station service coverage (Sarasadi, 2011).

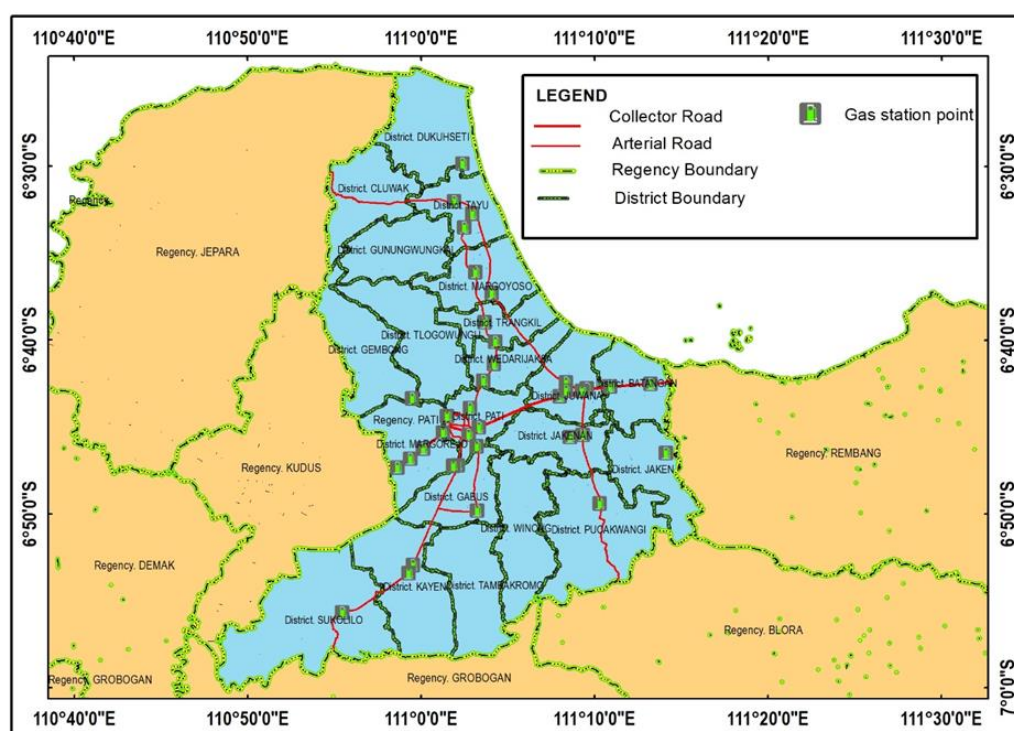
**Table 3. Distance classes and criteria**

| Class Distance (Km) | Criteria     |
|---------------------|--------------|
| < 2.25              | Very close   |
| 2.25 – 2.5          | Near         |
| 2.5 – 2.75          | Close enough |
| 2.75 - 3            | Far          |
| > 3                 | Very far     |

### 3. RESULTS AND DISCUSSION

#### 3.1. Spatial Distribution of Gas Stations in Pati

This research uses secondary data in the form of coordinates for each gas station object in Pati Regency. Data on gas station objects in Pati Regency was obtained by Google Map. The result is a map of the distribution of gas stations, as shown in Fig 3.



**Figure 3. Map of the Distribution of Public Fuel Filling Stations (SPBU) in Pati Regency**

The following is data on the distribution of gas station locations in Pati Regency, totaling 37 points.

**Table 4. Data on the distribution of gas stations in Pati district**

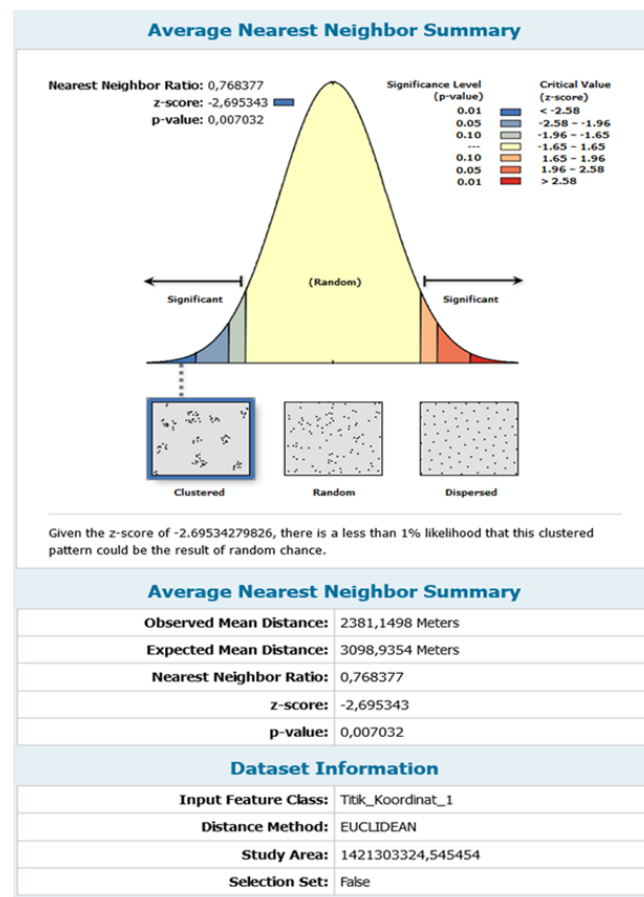
| No | Gas station number   | Address                               |
|----|----------------------|---------------------------------------|
| 1  | Gas Station 44.58103 | DS. WIDOROKANDANG KEC. STARCH         |
| 2  | Gas Station 44.59101 | WANGUNREJO, KALIAMPO                  |
| 3  | Gas Station 44.59102 | JL. RAYA JUANA - REMBANG              |
| 4  | Gas Station 44.59103 | JL. RAYA PATI-TAYU KM. 08 DS. PAGGUNG |
| 5  | Gas Station 44.59104 | JL. P. SUDIRMAN 2C                    |
| 6  | Gas Station 44.59105 | JL. RAYA PATI - JUWANA                |
| 7  | Gas Station 44.59106 | DS. WATUROYO, MARGOYOSO               |

| No | Gas station number   | Address                                  |
|----|----------------------|------------------------------------------|
| 8  | Gas Station 44.59109 | MARGOREJO                                |
| 9  | Gas Station 44.59110 | DS. JATIROTO KEC. KAYEN                  |
| 10 | Gas Station 44.59111 | JL. RAYA PATI - KATEN KM. 3              |
| 11 | Gas Station 44.59112 | DS LOCATION. LENGKONG KEC. BRICK         |
| 12 | Gas Station 44.59113 | DS. TAYU UTAWA, GROWONG KIDUL, JUWANA    |
| 13 | Gas Station 44.59114 | JL. KOL. SUNANDAR, DS. WINONG, KEC. PATI |
| 14 | Gas Station 44.59115 | JL. RAYA JUWANA PATI, DS. GROWONG LOR    |
| 15 | Gas Station 44.59116 | JL. KYAI PUPUS, DS. SAMPIR, KEC          |
| 16 | Gas Station 44.59117 | DS. PUNDUNREJO, TAYU                     |
| 17 | Gas Station 44.59118 | DS. RACI, BATAN DISTRICT                 |
| 18 | Gas Station 44.59119 | JL. PERTIGAAN NGEBRUK, DS. BUMIREJO      |
| 19 | Gas Station 44.59120 | JL. RAYA VILLAGE GABUS KEC. CORK         |
| 20 | Gas Station 44.59121 | JL. RAYA PATI - GABUS KM.2               |
| 21 | Gas Station 44.59122 | JL. MANGKUDIPURO KM.01 DS. GROWONGK      |
| 22 | Gas Station 44.59123 | JL. RAYA PATI - TAYU DS. KETANEN         |
| 23 | Gas Station 44.59124 | JL. DS. SUKOLILO KEC. SUKOLILO           |
| 24 | Gas Station 44.59125 | JL. RAYA PATI TAYU DS. MEDIUM HARJO      |
| 25 | Gas Station 44.59126 | DS. DUKUH MULYO KEC. JAKENAN             |
| 26 | Gas Station 44.59127 | PAHIJO HILL, BULUMANIS VILLAGE           |
| 27 | Gas Station 44.59128 | DS. BUMIREJO KEC. MANGOREJO              |
| 28 | Gas Station 44.59129 | JL. PUCCEL - TAYU                        |
| 29 | Gas Station 44.59130 | LANGENHARJO VILLAGE KEC. MARGOREJO       |
| 30 | Gas Station 44.59131 | JL. RAYA PATI GEMBONG DS. TAMANSARI      |
| 31 | Gas Station 44.59132 | JL. JAKENAN - PUCAKWANGI KEL. PELEM      |
| 32 | Gas Station 44.59133 | JL. RAYA JAKEN KM. 1 KEL. SRIKATON K     |
| 33 | Gas Station 44.59134 | JL. RAYA PATI-TAYU, KEL. MARGOREJO, K    |
| 34 | Gas Station 44.59135 | JL. RAYA PATI - TAYU KEL. KAJAR KEC      |
| 35 | Gas Station 44.59136 | JL. RAYA PATI - KAYEN, KEL. KAYEN,       |
| 36 | Gas Station 44.59207 | DS. MULYOHARJO                           |
| 37 | Gas Station 44.59401 | JL. DIPONEGORO 58 TAYU                   |

### 3.2. Nearest Neighbor Analysis

Nearest Neighbor Analysis (NNA) can be used to evaluate the distribution pattern of gas stations in Pati Regency. This research is an application of a geographic information system program using ArcGIS 10.8 software and the Spatial Statistics Tool to carry out Nearest Neighbor Analysis. Figure 4 shows the results of the nearest neighbor analysis of Pati Regency gas stations, which is the average nearest dispersion index, which is calculated using the nearest neighbor analysis formula.

Based on the results of the nearest neighbor analysis of the distribution of fuel stations in Pati Regency, the T value obtained is 0.768377 (nearest neighbor index according to the "Average Nearest Neighbor" formula in ArgGIS 10.8). If the Average Nearest Neighbor result is 0.5 then categorized as having a clustered pattern, but if the calculated value is in the range 0.5 - 1.575 then the distribution pattern will be categorized as random and if the calculated value is 1.576 the distribution will be uniform (dispersed). The results of data processing are obtained by the Average Index. Nearest Neighbor (Nearest Neighbor Ratio) for Fuel Filling Stations in Pati Regency is 0.768377, which indicates that the Average Nearest Neighbor value is in the range of 0.5, so the distribution pattern of gas stations in Pati Regency is clustered, as explained in the Fig. 4 below.



**Figure 4. Nearest Neighbor Analysis Results for Pati Regency SPBU**

The following is a table and explanation of the Nearest Neighbor Analysis results

**Table 5. ANN area and percentage results**

| Class Distance (Km) | Criteria     | Area(Ha)  | Percentage % |
|---------------------|--------------|-----------|--------------|
| < 2.25              | Very close   | 37.693.51 | 25.06%       |
| 2.25 – 2.5          | Near         | 5.664.93  | 3.76%        |
| 2.5 – 2.75          | Close enough | 5.589.35  | 3.71%        |
| 2.75 – 3            | Far          | 5.518.11  | 3.66%        |
| ≥ 3                 | Very far     | 95.952.11 | 63.81%       |

This analysis uses ArcGIS 10.8 software, by calculating the buffer or area distance between public fuel filling stations (SPBU) based on the table. The aim of using this buffer is to map the reachability area of each gas station within a certain distance. In this analysis, buffer calculations were carried out using area distances of 2.25 km, 2.5 km, 2.75 km and 3 km. The results of this buffer analysis are then displayed in the form of a map, which can be found in Fig 5. Through Fig 5, it can be observed that almost all gas stations are less than 2.25 km apart, indicating that these gas stations are in very close proximity one another. In this category, it shows that the majority of gas stations are close to each other and can reach around 25.06% in the analyzed area. However, in the second position in the image, you can see a number of gas stations that are farther away, grouped in the very far category with a distance of more than or equal to 3 km. The percentage of gas stations included in this category is 63.81%, indicating that many sub-districts are not yet reached by existing gas stations because there are several gas stations located more geographically spread out in urban areas. In third position, a percentage of 3.76% is visible, indicating that several gas stations are located within a distance of between 2.25 km and 2.5 km. This category can be classified as a distance that is still relatively close, although it is farther than the very close

category. Finally, there are two distance categories that have percentages that are not much different, namely 3.71% and 3.66%. The first category includes gas stations located within a distance of 2.5 km to 2.75 km, which is still in the fairly close category. Meanwhile, the second category includes gas stations located within a distance of between 2.75 km to 3 km, indicating that these gas stations are located at a longer distance.

### 3.3. Buffer

The results of data processing obtained an Average Nearest Neighbor Index (Nearest Neighbor Ratio) for Fuel Filling Stations in Pati Regency of 0.768377, which indicates that the Average Nearest Neighbor value is in the range of 0.5, so the distribution pattern of gas stations in Pati Regency is clustered. ). Based on the results of the Buffer analysis, the points between Public Fuel Filling Stations are very close together. However, there are several fuel filling stations that are furthest away, this is due to the lack of population in the sub-district.

Based on data analysis carried out on 37 gas station points in Pati Regency using the buffer zone method, it can be concluded that almost all areas of Pati Regency still have quite good access to fuel. This can be seen from the results of calculating the area in the very close group category using ArcGIS 10.8, which reached 25.06%. These results show that fuel distribution in Pati Regency is relatively even, covering the entire region quite well, which makes it a positive stage for the future.

There is a positive correlation between population density and motorized vehicles and the presence of gas stations in the area (Syamsuddin, 2013). This can be seen from the fact that the sub-districts of Pati, Juwana, Margorejo, have more than 4 gas stations in these sub-districts or have a significant number of gas stations. This is due to the large population in these sub-districts, as a result many gas stations are placed in the three sub-districts. Apart from that, there are several sub-districts that only have less than three gas stations, such as Sukolilo, Kayen, Jaken, Jakenan and Gabus sub-districts. This is because the population is smaller than other sub-districts.

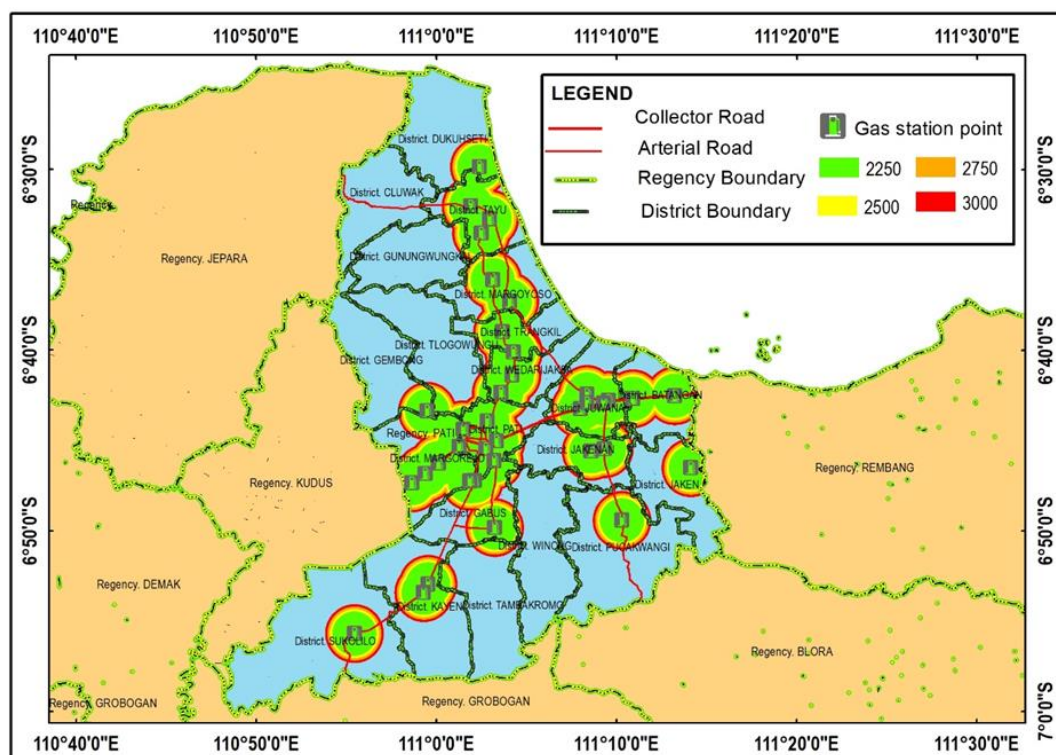


Figure 5. Map of gas station affordability in Pati Regency

#### 4. CONCLUSIONS

The pattern of distribution of public fuel filling stations is quite even, this pattern follows population density. The closer you get to the city, the more people there are, so the more gas stations there are. However, there are still gaps in several sub-districts where there are only one or two gas stations, especially in suburban areas. Based on affordability, public filling stations in Pati Regency are close to each other, especially in the city center area. Suggestions for further research include research subjects from public gas stations along with retail or Pertamina gas stations, so that the distribution can be seen evenly.

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