

Clustering Minimum Wages By Regency/City In Central Java Using The K-Means Clustering Method

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Abstract

The Regency/City Minimum Wage (UMK) is an important indicator in describing the level of welfare and economic activity in a region. Central Java Province, which consists of 35 regencies/cities, has quite large variations in UMK between regions. This study aims to map the grouping of regencies/cities in Central Java based on the UMK level from 2021 to 2024. The analysis was conducted using the K-Means Clustering method with the help of Microsoft Excel and RStudio software through the stages of data standardization, the Kaiser Meyer Olkin test, determining the number of clusters using the Elbow method, and an iteration process to obtain optimal results. Based on the analysis results, it was obtained that the regencies/cities in Central Java can be divided into three clusters: cluster 1 consisting of 15 regions with a low UMK level, cluster 2 consisting of 14 regions with a medium UMK level, and cluster 3 consisting of 4 regions with a high UMK level. Most areas of Central Java are included in the low and medium UMK categories, while only a small number of regions are classified as having a high UMK. These results indicate the existence of welfare disparities between regions, so it is hoped that they can be a basis for the government in formulating policies to improve welfare and economic equality in Central Java Province.

Keywords: *minimum wage, central java, disparitis, k-means clustering*

1. INTRODUCTION

Wages are a crucial indicator for improving the economic conditions and welfare of workers [9]. According to research [1], wages are all types of payments made to an individual in accordance with an employment contract, regardless of the type of work or denomination. Wages represent the amount of money workers receive as compensation for their work, whether

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in cash or non-cash. Wages also play a role in maintaining social and economic stability because the wages workers receive directly impact their ability to adequately meet basic needs [3]. According to the Big Indonesian Dictionary (KBBI), the minimum wage is the lowest wage that, according to law or as agreed by a labor union, must be paid by a company to its employees. According to Minister of Manpower Regulation (Permenaker) No. 05 of 1989, the Regency/City Minimum Wage (UMK) is a minimum standard used by employers or industrial players to provide wages to employees, staff, or laborers within their business or work environment in a regency/city in a given year [2]. Central Java Province consists of 35 regencies/cities, this makes Central Java play a vital role in the national economy. Its central location makes it not only an economic center but also a strategic cultural and educational center for Indonesia's development, with diverse characteristics ranging from urban to rural areas. However, in addition to its natural wealth and human resources, Central Java has a problem in its economic condition, namely a very low minimum wage level. It is not surprising that currently, Central Java is often in the spotlight because despite increasing the minimum wage every year, this province is known as the region with the lowest wage level compared to other provinces on the island of Java. Based on official data from 2024, Banjarnegara Regency in Central Java recorded a minimum wage of Rp2,038,005.00, making it the region with the lowest minimum wage in all of Indonesia. This has resulted in the economic conditions in Central Java currently experiencing a downturn. The government must respond quickly to this situation to address the hampered economic development in the region. When evaluating economic growth in a region, particularly in Central Java, it is crucial to consider the fairness and appropriateness of wages paid to workers. Therefore, it is necessary to group regencies/cities in Central Java to more accurately determine the distribution of minimum wage conditions. This grouping can be done using the K-Means clustering method. This method is capable of grouping data based on specific characteristics, simplifying the analysis process. K-Means is a popular non-hierarchical clustering technique for grouping data based on object similarity. This algorithm divides data into several non-overlapping groups. Each data point is assigned to the cluster with the closest centroid (center point) [6]. This method is often used in segmentation analysis because of its ability to simplify complex data into more uniform groups, thus facilitating interpretation and decision-making. Several studies related to the application of the K-Means Clustering method have been conducted previously, one of which was by [7]. in 2022 who examined the grouping of regencies/cities in Central Java based on the number of cases of disease emergence using the K-Means algorithm. In this study, the authors propose the use of the K-Means method to map regencies/cities in Central Java based on the number of cases of disease emergence. The results of the analysis obtained were 3 clusters: high, medium, and low for 29 regencies and 6 cities. The percentage for cluster 1 was 34.29% consisting of 10 regencies and 2 cities, cluster 2 was 40% consisting of 11 regencies and 3 cities, and cluster 3 was 25.71% consisting of 8 regencies and 1 city. The clustering results can be used as a basis for making effective strategic decisions in developing disease prevention and control efforts in each region [7]. The K-Means Clustering method is highly suitable for solving this problem because its use in this research will identify the clusters of each region based on its minimum wage (UMK). Therefore, the research results are expected to assist the government and other parties in evaluating the economic conditions in Central Java based on the results of the regional clustering based on the minimum wage (UMK).

2. RESEARCH METHODS

2.1. Research Data. The data used in this field work practice report is the UMK data for all regencies/cities in Central Java from 2021 to 2024. This data was obtained from the Purbalangga Regency Bakeuda Website.

2.2. Research Methods and Steps. The author explored, reviewed, and understood various relevant references related to Regency/City Minimum Wages (UMK) and the K-Means clustering method. This process involved gathering information from various sources, such as

TABLE 1. Minimum Wage Data in Central Java for 2021-2024

Regency/City	2021	2022	2023	2024
Banjarnegara Regency	Rp1805000	Rp1819835	Rp1958170	Rp2038005
Banyumas Regency	Rp1970000	Rp1983261	Rp2130981	Rp2195690
Batang Regency	Rp2129117	Rp2132535	Rp2282026	Rp2379702
Blora Regency	Rp1894000	Rp1904196	Rp2040080	Rp2101813
Boyolali Regency	Rp2000000	Rp2010299	Rp2155712	Rp2250327
Brebes Regency	Rp1866722	Rp1885019	Rp2018837	Rp2103100
Cilacap Regency	Rp2228904	Rp2230731	Rp2383090	Rp2479106
Regency Demak	Rp2511526	Rp2513005	Rp2680421	Rp2761236
Grobogan Regency	Rp1890000	Rp1894032	Rp2029569	Rp2116516
Jepara Regency	Rp2107000	Rp2108403	Rp2272627	Rp2450915
Karanganyar Regency	Rp2054040	Rp2064313	Rp2207484	Rp2288366
Kebumen Regency	Rp1895000	Rp1906781	Rp2043902	Rp2121947
Kendal Regency	Rp2335735	Rp2340312	Rp2508300	Rp2613573
Klaten Regency	Rp2011514	Rp2015623	Rp2152233	Rp2244012
Kudus Regency	Rp2290995	Rp2293058	Rp2439814	Rp2516888
Magelang Regency	Rp2075000	Rp2081807	Rp2236777	Rp2316890
Pati Regency	Rp1953000	Rp1968339	Rp2107697	Rp2190000
Pekalongan Regency	Rp2084115	Rp2094646	Rp2247346	Rp2334886
Pemalang Regency	Rp1926000	Rp1940890	Rp2081783	Rp2156000
Purworejo Regency	Rp1905400	Rp1911850	Rp2035890	Rp2127641
Purbalingga Regency	Rp1988000	Rp1996814	Rp2130981	Rp2195571
Rembang Regency	Rp1861000	Rp1874322	Rp2015927	Rp2099689
Semarang Regency	Rp2302797	Rp2311254	Rp2480988	Rp2582287
Sragen Regency	Rp1829500	Rp1839429	Rp1969569	Rp2049000
Sukoharjo Regency	Rp1986450	Rp1998153	Rp2138248	Rp2215483
Tegal Regency	Rp1958000	Rp1968446	Rp2106238	Rp2191161
Temanggung Regency	Rp1885000	Rp1887832	Rp2027569	Rp2109690
Wonogiri Regency	Rp1827000	Rp1839043	Rp1968448	Rp2047500
Wonosobo Regency	Rp1920000	Rp1931285	Rp2076209	Rp2159175
Magelang City	Rp1914000	Rp1935913	Rp2066007	Rp2142000
Pekalongan City	Rp2139754	Rp2156213	Rp2305823	Rp2389801
Salatiga City	Rp2101457	Rp2128523	Rp2284180	Rp2378951
Semarang City	Rp2810025	Rp2835021	Rp3060349	Rp3243969
Surakarta City	Rp2013810	Rp2035720	Rp2174169	Rp2269070
Tegal City	Rp1982750	Rp2005930	Rp2145012	Rp2231628

e-books, scientific journals, textbooks, articles, and research reports that cover these topics in depth. The advantages of the K-Means method over other clustering methods are its ease of implementation, computational efficiency on large data sets, and its ability to generate clear clusters based on proximity. Furthermore, this method is highly suitable for numerical data such as the UMK data used in this study. Next, a case study was conducted by applying the K-Means clustering method to Regency/City data in Central Java based on UMK levels for the years 2021 to 2024. The steps taken in analyzing the data were as follows:

- (1) Determining descriptive statistics from the UMK data in Central Java.
- (2) Standardizing the data to detect outliers using the Z-Score formula:

$$Z = \frac{x_i - \bar{x}}{s} \quad (1)$$

with:

- Z : standardized data,
- x_i : data to be standardized,
- \bar{x} : average data,
- s : standard deviation of data.

- (3) Test whether the sample is representative of the population and therefore worthy of further analysis using the Kaiser Meyer Olkin (KMO) statistic. With the following formula:

$$KMO = \frac{\sum_{i=1}^p \sum_{j=1}^p r_{ij}^2}{\sum_{i=1}^p \sum_{j=1}^p r_{ij}^2 + \sum_{i=1}^p \sum_{j=1}^p a_{ij}^2}, \quad i \neq j \quad (2)$$

with:

- p : many data variables tested,
- r_{ij} : simple correlation coefficient between variables i and j ,
- a_{ij} : partial correlation coefficient between variables i and j .

- (4) Determine the number of clusters using the Elbow method with the following formula:

$$SSE = \sum_{k=1}^n \sum_{j=1}^{N_k} d(x_{ij} - c_{kj})^2 \quad (3)$$

with:

- N_k : amount of data on cluster k ,
- x_{ji} : observation value i from data x_j ,
- c_{ki} : new cluster from cluster k .

- (5) Determine the initial cluster centers based on the number of randomly selected clusters.
 (6) Perform the clustering iteration process using the following Euclidean distance formula:

$$d(x_{ji}, c_{ki}) = \sqrt{\sum_{i=1}^m (x_{ji} - c_{ki})^2} \quad (4)$$

with:

- $d(x_{ji}, c_{ki})$: distance between data j and centroid k ,
- m : the number of variables observed,
- x_{ji} : observation value i and centroid X_j ,
- c_{ki} : observation value i and centroid k .

3. RESULT AND DISCUSSION

3.1. Descriptive statistics. Descriptive statistics is a branch of statistics that deals with data collection, presentation, determination of statistical values, and creation of diagrams or images. The data is presented in a format that is easier to understand or read [8]. By definition, descriptive statistics is a statistical method related to data collection and presentation, thereby providing useful information. Providing useful information means that the presentation will make it easier for readers or users to read and utilize the data [5]. The results of descriptive statistical calculations from data from 35 regencies/cities in Central Java based on the minimum wage (UMK) level using Rstudio software can be seen in Figure 1 below.

```

> summary(tabel1)
Kabupaten.kota      x2021      x2022      x2023
Length:33           min.   :1805000 min.   :1819835 min.   :1958170
class :character    1st Qu.:1900200 1st Qu.:1909316 1st Qu.:2041991
mode  :character    median :1986450 median :1998153 median :218248
      mean  :2041501 mean  :2052652 mean  :2198930
      3rd Qu.:2104229 3rd Qu.:2118463 3rd Qu.:2277327
      max.   :2810025 max.   :2835021 max.   :3060349

x2024
min.   :2038005
1st Qu.:2124794
Median :2215483
Mean   :2288331
3rd Qu.:2379327
Max.   :3243969

```

FIGURE 1. Statistik Deskriptif

Based on Figure 4.1, the regency/city with the highest UMK level from 2021 to 2024 is Semarang City with a UMK of IDR 2,810,025 in 2021, IDR 2,835,021 in 2022, IDR 3,060,349 in 2023, and IDR 3,243,969 in 2024.

3.2. Data Standardization and Outlier Test. Data standardization is a step taken to equalize the data scale between variables, thus helping to detect the presence or absence of outliers. This step converts object values into Z-Score values by subtracting the average value from the object value, then dividing the result by the standard deviation, as explained in equation (2.1). The following is an example of calculating the Z-Score value in Banjarnegara Regency.

- *Z-Score* value of Banjarnegara Regency in 2021

$$Z = \frac{1805000 - 2041503}{209220.8} = -1.13040$$

- *Z-Score* value of Banjarnegara Regency in 2022

$$Z = \frac{1819835 - 2052652}{208928} = -1.11434$$

- *Z-Score* value of Banjarnegara Regency in 2023

$$Z = \frac{1958170 - 2198930}{225135.3} = -1.06940$$

- *Z-Score* value of Banjarnegara Regency in 2024

$$Z = \frac{2038005 - 2288331}{241060} = -1.03843$$

Furthermore, using Excel software, the results of the Z-Score values for regencies/cities in Central Java based on the UMK level were obtained as in Table 2.

TABLE 2. Z-Score values for regencies/cities in Central Java based on UMK levels

Regency/City	2021	2022	2023	2024
Banjarnegara Regency	-1.1304	-1.11434	-1.0694	-1.03843
Banyumas Regency	-0.34176	-0.33213	-0.30181	-0.38431
Batang Regency	0.418763	0.382345	0.369094	0.379037
Blora Regency	-0.70501	-0.71056	-0.70558	-0.77374
Boyolali Regency	-0.19837	-0.20272	-0.19196	-0.15765
Brebes Regency	-0.83539	-0.80235	-0.79993	-0.7684
Cilacap Regency	0.895709	0.852345	0.817997	0.791397
Regency Demak	2.24654	2.203404	2.138674	1.961765
Grobogan Regency	-0.72413	-0.75921	-0.75226	-0.71275
Jepara Regency	0.313051	0.266841	0.327346	0.674452
Karanganyar Regency	0.059922	0.055812	0.037995	0.000145
Kebumen Regency	-0.70023	-0.69819	-0.6886	-0.69022
Kendal Regency	1.406322	1.376836	1.374152	1.34921
Klaten Regency	-0.1434	-0.17724	-0.20702	-0.18385
Kudus Regency	1.192481	1.150663	1.069953	0.948129
Magelang Regency	0.160103	0.139544	0.168108	0.118472
Pati Regency	-0.42301	-0.40355	-0.40524	-0.40791
Pekalongan Regency	0.203669	0.200996	0.215053	0.193125
Pemalang Regency	-0.55206	-0.53493	-0.52034	-0.54895
Purbalingga Regency	-0.65052	-0.67393	-0.72419	-0.6666
Purworejo Regency	-0.25573	-0.26726	-0.30181	-0.3848
Rembang Regency	-0.86274	-0.85355	-0.81286	-0.78255
Semarang Regency	1.248891	1.237755	1.252838	1.219426
Sragen Regency	-1.0133	-1.02056	-1.01877	-0.99282
Sukoharjo Regency	-0.26313	-0.26085	-0.26954	-0.3022
Tegal Regency	-0.39912	-0.40304	-0.41172	-0.40309
Temanggung Regency	-0.74803	-0.78889	-0.76115	-0.74106
Wonogiri Regency	-1.02525	-1.02241	-1.02375	-0.99905
Wonosobo Regency	-0.58074	-0.58091	-0.5451	-0.53578
Magelang City	0.60942	0.55875	-0.59041	-0.60703
Pekalongan City	0.469604	0.495676	0.474795	0.420931
Salatiga City	0.286558	0.363143	0.378662	0.375921
Semarang City	3.673258	3.744681	3.826228	3.964301
Surakarta City	-0.13236	-0.08104	-0.10998	-0.0799
Tegal City	-0.28082	-0.22363	-0.23949	-0.23522

In Table 2, it can be seen that the Z-Score value of Banjarnegara Regency in 2021 was -1.1304, in 2022 it was -1.11434, in 2023 it was -1.0694, and in 2024 it was -1.03843, for other regions it has been attached in Table 3.2. Based on Table 2, it is known that there are two regencies/cities that have a Z-Score value of more than 2.00, namely Demak Regency and Semarang City, this resulted in the two regions being identified as outliers. Because outliers can significantly affect the clustering results, the data identified as outliers will be removed to avoid this risk. The updated data after the removal of outliers can be seen in Table 3.

TABLE 3. UMK Data in Central Java After Removing Outliers

Regency/City	2021	2022	2023	2024
Banjarnegara Regency	-1.1304	-1.11434	-1.0694	-1.03843
Banyumas Regency	-0.34176	-0.33213	-0.30181	-0.38431
Batang Regency	0.418763	0.382345	0.369094	0.379037
Blora Regency	-0.70501	-0.71056	-0.70558	-0.77374
Boyolali Regency	-0.19837	-0.20272	-0.19196	-0.15765
Brebes Regency	-0.83539	-0.80235	-0.79993	-0.7684
Cilacap Regency	0.895709	0.852345	0.817997	0.791397
Grobogan Regency	-0.72413	-0.75921	-0.75226	-0.71275
Jepara Regency	0.313051	0.266841	0.327346	0.674452
Karanganyar Regency	0.059922	0.055812	0.037995	0.000145
Kebumen Regency	-0.70023	-0.69819	-0.6886	-0.69022
Kendal Regency	1.406322	1.376836	1.374152	1.34921
Klaten Regency	-0.1434	-0.17724	-0.20702	-0.18385
Kudus Regency	1.192481	1.150663	1.069953	0.948129
Magelang Regency	0.160103	0.139544	0.168108	0.118472
Pati Regency	-0.42301	-0.40355	-0.40524	-0.40791
Pekalongan Regency	0.203669	0.200996	0.215053	0.193125
Pemalang Regency	-0.55206	-0.53493	-0.52034	-0.54895
Purbalingga Regency	-0.65052	-0.67393	-0.72419	-0.6666
Purworejo Regency	-0.25573	-0.26726	-0.30181	-0.3848
Rembang Regency	-0.86274	-0.85355	-0.81286	-0.78255
Semarang Regency	1.248891	1.237755	1.252838	1.219426
Sragen Regency	-1.0133	-1.02056	-1.01877	-0.99282
Sukoharjo Regency	-0.26313	-0.26085	-0.26954	-0.3022
Tegal Regency	-0.39912	-0.40304	-0.41172	-0.40309
Temanggung Regency	-0.74803	-0.78889	-0.76115	-0.74106
Wonogiri Regency	-1.02525	-1.02241	-1.02375	-0.99905
Wonosobo Regency	-0.58074	-0.58091	-0.5451	-0.53578
Magelang City	-0.60942	-0.55875	-0.59041	-0.60703
Pekalongan City	0.469604	0.495676	0.474795	0.420931
Salatiga City	0.286558	0.363143	0.378662	0.375921
Surakarta City	-0.13236	-0.08104	-0.10998	-0.0799
Tegal City	-0.28082	-0.22363	-0.23949	-0.23522

Based on Table 3, it is known that there are no Z-Score values greater than or equal to 2, indicating there are no outliers in this data. Thus, the clustering process can continue.

3.3. Kaiser Meyer Olkin Test. Data sampling must be representative of the population so that it is suitable for further analysis. This test is conducted using the Kaiser Meyer Olkin (KMO). One of the requirements for factor analysis to be carried out is that the KMO statistical value of the analyzed variables must reach a minimum of 0.5, so that variables with a KMO value below 0.5 are considered unsuitable for factor analysis testing because they do not represent the population [11]. Figure 2 below shows the results of the KMO calculation using the Rstudio software.

```

Kaiser-Meyer-Olkin factor adequacy
Call: kmo(r = tabel1[, 2:5])
Overall MSA = 0.77
MSA for each item =
x2021 x2022 x2023 x2024
0.85 0.70 0.74 0.81
    
```

FIGURE 2. KMO Test Results Using Rstudio Software

Based on Figure 3.2, the KMO value is 0.77. This means the KMO value is > 0.5 , so it can be concluded that this data sampling is representative of the population and therefore worthy of further analysis.

3.4. Determining the Number of Clusters. Dividing regencies/cities into several clusters allows for simpler yet still effective analysis. Determining the optimal number of clusters will impact the results. Therefore, the authors used Rstudio software to more accurately determine the optimal number of clusters.

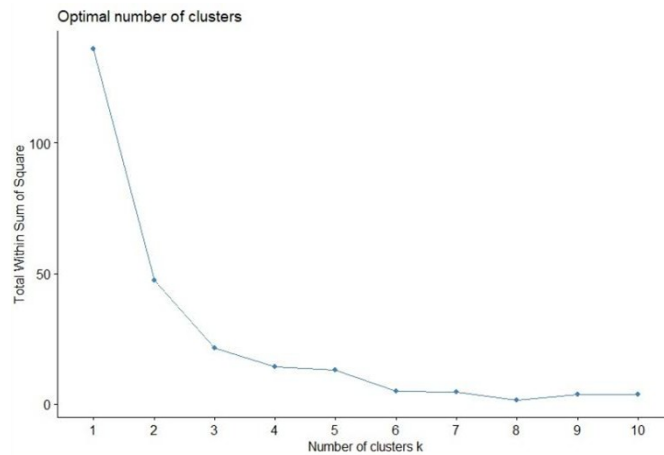


FIGURE 3. Elbow Method Plot Results

The point that shows the most significant decrease in the SSE value is considered the optimal number of clusters [4]. Figure 3 shows that the line that forms the most elbow is when the cluster number is 3. Therefore, the optimal number of clusters for grouping MSE data in Central Java for more efficient analysis is 3 clusters. The purpose of grouping into 3 clusters is to divide regions in Central Java into high, medium, and low levels.

3.5. Determination of Initial Centroid. After determining the optimal number of clusters, the next step is to determine the initial cluster centers (centroids) based on the known optimal number of clusters. In this report, the authors randomly determined the initial centroids, namely Banjarnegara Regency, Purbalingga Regency, and Semarang Regency.

3.6. Performing the Iteration Process. After determining the initial centroid, the next step is to calculate the distance of each data object from each centroid using the Euclidean distance formula. A smaller distance value indicates that the object is closer to a particular centroid [10]. Therefore, each object will be placed in the cluster with the closest distance. Distance calculations in the clustering process in this study use original data because all variables used have the same units and scale, namely the minimum wage value in rupiah for the period 2021 to 2024. With this uniform scale, the use of normalization such as the z-score is not necessary because there are no significant differences in scale between variables. Furthermore, the use

of original data aims to maintain the interpretation of clustering results so that they remain in line with the actual conditions of the minimum wage value in each region, thus making the clustering results easier to understand in practice. As an example calculation, the distance of Banjarnegara Regency from each initial centroid will be calculated.

First Iteration

- Calculation of the distance between Banjarnegara Regency and the initial centroid 1

$$d(x_{ij}, c_{k1}) = \sqrt{(1805000 - 1805000)^2 + (1819835 - 1819835)^2 + (1958170 - 1958170)^2 + (2038005 - 2038005)^2} = 0$$

- Calculation of the distance between Banjarnegara Regency and the initial centroid 2

$$d(x_{ij}, c_{k2}) = \sqrt{(1805000 - 1988000)^2 + (1819835 - 1996814)^2 + (1958170 - 2130981)^2 + (2038005 - 2195571)^2} = 345689.5$$

- Calculation of the distance between Banjarnegara Regency and the initial centroid 3

$$d(x_{ij}, c_{k3}) = \sqrt{(1805000 - 2302797)^2 + (1819835 - 2311254)^2 + (1958170 - 2480988)^2 + (2038005 - 2582287)^2} = 1029017$$

The distance calculation in the first iteration will be performed for the other 32 regencies/cities using the Euclidean distance formula. The calculation results can be seen in Table 4.

TABLE 4. Distance of each Regency/City from the centroid in the first iteration

Regency/City	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>
Banjarnegara Regency	0	345689.5	1029017
Banyumas Regency	329638.1	22532.15	700211
Batang Regency	651515.7	308306.7	377798.6
Blora Regency	160681.3	185654.6	870670
Boyolali Regency	398001.3	62735.05	631079.9
Brebes Regency	126397.8	219849.1	902796.4
Cilacap Regency	850680.4	506658.6	179372.4
Grobogan Regency	154893.5	191578.3	874755.6
Jepara Regency	666223.2	334480.6	374376.7
Karanganyar Regency	49617.1	152908.5	532967.1
Kebumen Regency	173366.2	172505.6	856068.9
Kendal Regency	1089265	745658	60448.64
Klaten Regency	401391.6	60899.08	628246.9
Kudus Regency	959917.2	614970.7	80266.49
Magelang Regency	544911	201752.1	484367.6
Pati Regency	299028.8	51078.43	730194.4
Pekalongan Regency	570252	227505.3	458842.8
Pemalang Regency	241864.2	104679.5	787547.3
Purworejo Regency	180615.4	166428.4	849860.7
Purbalingga Regency	345689.5	0	685582.8
Rembang Regency	115089.6	231439.1	913934.7
Semarang Regency	1029017	685582.8	0
Sragen Regency	35142.6	312136.5	996279.7
Sukoharjo Regency	358675.3	21295.36	670912.5
Tegal Regency	301455	48336.4	727886.9
Temanggung Regency	144839.7	201384.4	884747
Wonogiri Regency	32384.25	314888.4	999029.7
Wonosobo Regency	232940.9	115076.9	796102.9
Magelang City	218629.6	127579	811237.2
Pekalongan City	685444	341661.1	344026.7
Salatiga City	636947.2	295496	392437.7
Surakarta City	436181.8	97196.4	593022.1
Tegal City	372325.4	40095.39	656882.4

The results of the distance calculation between the centroid and the regency/city are used to group the regencies/cities based on the best cluster by selecting the cluster with the closest distance. The data objects that have been calculated will then be grouped into cluster 1, cluster 2, and cluster 3. The clustering results from the first iteration can be seen in Table 5.

TABLE 5. Regency/City Clustering Results in First Iteration

Regency/City	<i>Cluster</i>	Regency/City	<i>Cluster</i>
Banjarnegara Regency	1	Pemalang Regency	2
Banyumas Regency	2	Purworejo Regency	2
Batang Regency	2	Purbalingga Regency	2
Blora Regency	1	Rembang Regency	1
Boyolali Regency	2	Semarang Regency	3
Brebes Regency	1	Sragen Regency	1
Cilacap Regency	3	Sukoharjo Regency	2
Grobogan Regency	1	Tegal Regency	2
Jepara Regency	2	Temanggung Regency	1
Karanganyar Regency	2	Wonogiri Regency	1
Kebumen Regency	2	Wonosobo Regency	2
Kendal Regency	3	Magelang City	2
Klaten Regency	2	Pekalongan City	2
Kudus Regency	3	Salatiga City	2
Magelang Regency	2	Surakarta City	2
Pati Regency	2	Tegal City	2
Pekalongan Regency	2		

Based on Table 5, the results of the regency/city clustering based on the minimum wage (UMK) are obtained based on the closest distance to the centroid. Table 5 shows that there are 8 regions in cluster 1, 21 regions in cluster 2, and 4 regions in cluster 3. Next, a second iteration will be conducted to determine whether any regions have moved to another cluster. Before conducting the second iteration, a new centroid value will be determined by calculating the average value of the data calculated using the Euclidean distance formula. From the Excel calculation using the average formula, the new centroid value is obtained, as shown in Table 6 below.

TABLE 6. The New Centroid for the Second Iteration

Cluster	2021	2022	2023	2024
1	1857278	1867964	2003521	2083164
2	2005448	2017893	2161020	2249010
3	2289608	2293839	2453048	2547964

Next, the calculation continues to the second iteration using the new centroids that have been obtained. Using the same steps as in the previous iteration, the distance between Banjarnegara Regency and each centroid is calculated in the second iteration. The calculation results are as follows.

Second Iteration

- Calculation of the distance between Banjarnegara Regency and centroid 1

$$d(x_{ij}, c_{k1}) = \sqrt{(1805000 - 1857278)^2 + (1819835 - 1867964)^2 + (1958170 - 2003521)^2 + (2038005 - 2083164)^2}$$

$$= 95631,52$$

- Calculation of the distance between Banjarnegara Regency and centroid 2

$$d(x_{ij}, c_{k2}) = \sqrt{(1805000 - 2005448)^2 + (1819835 - 2017893)^2 + (1958170 - 2161020)^2 + (2038005 - 2249010)^2}$$

$$= 406297,2$$

- Calculation of the distance between Banjarnegara Regency and centroid 3

$$d(x_{ij}, c_{k3}) = \sqrt{(1805000 - 2289608)^2 + (1819835 - 2293839)^2 + (1958170 - 2453048)^2 + (2038005 - 2547964)^2}$$

$$= 982082,5$$

Distance calculations in the second iteration will be performed for the other 32 regencies/cities using the Euclidean distance formula. The calculation results can be seen in Table 7.

TABLE 7. Distance of each Regency/City from the centroid in the second iteration

Regency/City	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>
Banjarnegara Regency	95631.52	406297.2	982082.5
Banyumas Regency	234324.4	78748.23	653017.2
Batang Regency	556232.3	245274.9	330660.9
Blora Regency	65921.54	248276.1	823358.9
Boyolali Regency	302877.1	10828.14	584177.7
Brebes Regency	31813.5	280010.8	855808.8
Cilacap Regency	755346.8	444400.8	131540.9
Grobogan Regency	59507.58	251099.4	827655.2
Jepara Regency	572565.3	267818.3	331213.2
Karanganyar Regency	401219.6	90685.4	485601.2
Kebumen Regency	77874.85	233251.3	808962
Kendal Regency	994067.3	683047.1	107911.4
Klaten Regency	305951.3	11940.03	581001
Kudus Regency	864455.8	553839.2	33813.6
Magelang Regency	449631.1	138814.1	437243.7
Pati Regency	203726.6	107386.6	683125.2
Pekalongan Regency	475031.1	164031.9	411849.9
Pemalang Regency	146529.9	164835.5	740443.4
Purworejo Regency	85250.88	227250	802634.9
Purbalingga Regency	250144.1	67132.87	638042.8
Rembang Regency	21937.7	291249.9	867020
Semarang Regency	933858.7	622840.6	49355.78
Sragen Regency	62496.04	373449.4	949159.6
Sukoharjo Regency	263238.3	48920.39	623680.2
Tegal Regency	206048	105089.7	680756.4
Temanggung Regency	49448.99	261997.5	837654.4
Wonogiri Regency	65231.83	376192.9	951917
Wonosobo Regency	137858.2	173394	749145.7
Magelang City	123291.1	188578.9	764067.5
Pekalongan City	590163.7	279214.4	296795.5
Salatiga City	542009.3	231322	346138.2
Surakarta City	341066.4	31032.82	546117.9
Tegal City	277198.9	34881.12	609924.1

The clustering results in the first iteration can be seen in Table 8.

TABLE 8. Regency/City Clustering Results in the Second Iteration

Regency/City	Cluster	Regency/City	Cluster
Banjarnegara Regency	1	Pemalang Regency	1
Banyumas Regency	2	Purworejo Regency	1
Batang Regency	2	Purbalingga Regency	2
Blora Regency	1	Rembang Regency	1
Boyolali Regency	2	Semarang Regency	3
Brebes Regency	1	Sragen Regency	1
Cilacap Regency	3	Sukoharjo Regency	2
Grobogan Regency	1	Tegal Regency	2
Jepara Regency	2	Temanggung Regency	1
Karanganyar Regency	1	Wonogiri Regency	1
Kebumen Regency	1	Wonosobo Regency	1
Kendal Regency	3	Magelang City	1
Klaten Regency	2	Pekalongan City	2
Kudus Regency	3	Salatiga City	2
Magelang Regency	2	Surakarta City	2
Pati Regency	2	Tegal City	2
Pekalongan Regency	2		

Based on Table 3.8, the results of the clustering of regencies/cities based on the minimum wage (UMK) according to the closest distance to the centroid are obtained. Table 3.8 shows that several regions have moved to other clusters, namely Kebumen Regency, Pemalang Regency, Purworejo Regency, Wonosobo Regency, and Magelang City. The final results in Table 3.8 show that there are 13 regions in cluster 1, 16 regions in cluster 2, and 4 regions in cluster 3. Next, a third iteration will be carried out because there are still regions that have moved clusters. This step is carried out to determine whether any regions will move again to another cluster. Before carrying out the third iteration calculation process, as done in the previous step, a new centroid value will be determined. From the calculation in Excel using the average formula, the new centroid value is obtained, which can be seen in Table 9 as follow:

TABLE 9. The New Centroid for the Third Iteration

Cluster	2021	2022	2023	2024
1	1878356	1890033	2025535	2105544
2	2034625	2046814	2192352	2282653
3	2289608	2293839	2453048	2547964

With the same steps as in the previous iteration, the distance of Banjarnegara Regency to each centroid was calculated in the third iteration, the calculation results are as follows.

Third Iteration

- Calculation of the distance between Banjarnegara Regency and centroid 1

$$d(x_{ij}, c_1) = \sqrt{(1805000 - 1878356)^2 + (1819835 - 1890033)^2 + (1958170 - 2025535)^2 + (2038005 - 2105544)^2}$$

$$= 139314,1$$

- Calculation of the distance between Banjarnegara Regency and centroid 2

$$d(x_{ij}, c_2) = \sqrt{(1805000 - 2034625)^2 + (1819835 - 2046814)^2 + (1958170 - 2192352)^2 + (2038005 - 2282653)^2}$$

$$= 467911,4$$

- Calculation of the distance between Banjarnegara Regency and centroid 3

$$d(x_{ij}, c_3) = \sqrt{(1805000 - 2289608)^2 + (1819835 - 2293839)^2 + (1958170 - 2453048)^2 + (2038005 - 2547964)^2} \\ = 982082,5$$

Distance calculations in the third iteration will be performed for the other 32 regencies/cities using the Euclidean distance formula. The calculation results can be seen in Table 10.

TABLE 10. Distance of each Regency/City from the centroid in the third iteration

Regency/City	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>
Banjarnegara Regency	139314.1	467911.4	982082.5
Banyumas Regency	190618	139801.3	653017.2
Batang Regency	512482.7	183675.5	330660.9
Blora Regency	25900.05	309847.1	823358.9
Boyolali Regency	259170.4	70140.67	584177.7
Brebes Regency	14536.88	341637.1	855808.8
Cilacap Regency	711584.9	382811.2	131540.9
Grobogan Regency	16977.48	313621.8	827655.2
Jepara Regency	529432.7	209254.5	331213.2
Karanganyar Regency	357446	30737.04	485601.2
Kebumen Regency	34116.27	294903.9	808962
Kendal Regency	950316.8	621401.1	107911.4
Klaten Regency	262206.9	67841.38	581001
Kudus Regency	820689.3	492407.4	33813.6
Magelang Regency	405877.3	77462.16	437243.7
Pati Regency	159959.2	169032.7	683125.2
Pekalongan Regency	431278.4	102419.5	411849.9
Pemalang Regency	102791.1	226463.8	740443.4
Purworejo Regency	42460.25	288831.3	802634.9
Purbalingga Regency	206513.2	126584.4	638042.8
Rembang Regency	25974.05	352846.8	867020
Semarang Regency	900111.5	561191.4	49355.78
Sragen Regency	106193.7	435098.7	949159.6
Sukoharjo Regency	219465.3	110126.3	623680.2
Tegal Regency	162280.6	166731.5	680756.4
Temanggung Regency	8385.401	323624.2	837654.4
Wonogiri Regency	108928.7	437843.6	951917
Wonosobo Regency	94234.11	234993.5	749145.7
Magelang City	79639.72	250191.6	764067.5
Pekalongan City	546391.8	217661.6	296795.5
Salatiga City	498297.2	169848.5	346138.2
Surakarta City	297330.2	32733.32	546117.9
Tegal City	233456.9	95954.04	609924.1

The clustering results in the third iteration can be seen in Table 11.

TABLE 11. Regency/City Clustering Results in the Third Iteration

Regency/City	Cluster	Regency/City	Cluster
Banjarnegara Regency	1	Pemalang Regency	1
Banyumas Regency	2	Purworejo Regency	1
Batang Regency	2	Purbalingga Regency	2
Blora Regency	1	Rembang Regency	1
Boyolali Regency	2	Semarang Regency	3
Brebes Regency	1	Sragen Regency	1
Cilacap Regency	3	Sukoharjo Regency	2
Grobogan Regency	1	Tegal Regency	2
Jepara Regency	2	Temanggung Regency	1
Karanganyar Regency	2	Wonogiri Regency	1
Kebumen Regency	1	Wonosobo Regency	1
Kendal Regency	3	Magelang City	1
Klaten Regency	2	Pekalongan City	2
Kudus Regency	3	Salatiga City	2
Magelang Regency	2	Surakarta City	2
Pati Regency	1	Tegal City	2
Pekalongan Regency	2		

Based on Table 11, it can be seen that several regions have moved to other clusters, namely Pati Regency and Tegal Regency. The final results show 15 regions in cluster 1, 14 regions in cluster 2, and 4 regions in cluster 3. Next, a fourth iteration will be performed due to the presence of regions that have moved clusters. Before performing the fourth iteration calculation, as was done in the previous step, a new centroid value will be determined. From the Excel calculation using the average formula, the new centroid value is obtained, as shown in Table 12 below.

TABLE 12. The New Centroid for the Fourth Iteration

Cluster	2021	2022	2023	2024
1	1888641	1900481	2036393	2116882
2	2045929	2058017	2204549	2295807
3	2289608	2293839	2453048	2547964

With the same steps as in the previous iteration, the distance of Banjarnegara Regency to each centroid was calculated in the third iteration, the calculation results are as follows.

Fourth Iteration

- Calculation of the distance between Banjarnegara Regency and centroid 1

$$d(x_{ij}, c_1) = \sqrt{(1805000 - 1888641)^2 + (1819835 - 1900481)^2 + (1958170 - 2036393)^2 + (2038005 - 2116882)^2} \\ = 160748,7$$

- Calculation of the distance between Banjarnegara Regency and centroid 2

$$d(x_{ij}, c_2) = \sqrt{(1805000 - 2045929)^2 + (1819835 - 2058017)^2 + (1958170 - 2204549)^2 + (2038005 - 2295807)^2} \\ = 491875,9$$

- Calculation of the distance between Banjarnegara Regency and centroid 3

$$d(x_{ij}, c_3) = \sqrt{(1805000 - 2289608)^2 + (1819835 - 2293839)^2 + (1958170 - 2453048)^2 + (2038005 - 2547964)^2} \\ = 982082,5$$

Distance calculations in the fourth iteration will be performed for the remaining 32 regencies/cities using the Euclidean distance formula. The calculation results can be seen in Table 13.

TABLE 13. Distance of each Regency/City from the centroid in the fourth iteration

Regency/City	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>
Banjarnegara Regency	160748.7	491875.9	982082.5
Banyumas Regency	169201.9	163674.4	653017.2
Batang Regency	491006.4	159731.8	330660.9
Blora Regency	16828.53	333806.9	823358.9
Boyolali Regency	237708.3	94021.09	584177.7
Brebes Regency	34895.56	365606.9	855808.8
Cilacap Regency	690107.6	358866.8	131540.9
Grobogan Regency	9493.888	337591.7	827655.2
Jepara Regency	508228.6	186980.2	331213.2
Karanganyar Regency	335970.8	13015.38	485661.2
Kebumen Regency	12734.13	318883.4	808962
Kendal Regency	928839	597426.1	107911.4
Klaten Regency	240742.7	91607.4	581001
Kudus Regency	799223.5	468538.2	33813.6
Magelang Regency	384402.7	53797.93	437243.7
Pati Regency	138481.7	193011.3	683125.2
Pekalongan Regency	409800.8	78476.78	411849.9
Pemalang Regency	81357.22	250438	740443.4
Purworejo Regency	22937	312792	802634.9
Purbalingga Regency	185178.2	150203.4	638042.8
Rembang Regency	46505.98	376806.5	867020
Semarang Regency	868634.3	537214.6	49355.78
Sragen Regency	127665.6	459076.8	949159.6
Sukoharjo Regency	197997.2	134049.3	623680.2
Tegal Regency	140803.1	190710	680756.4
Temanggung Regency	17402.5	347595.3	837654.4
Wonogiri Regency	130402.2	461822	951917
Wonosobo Regency	72843.86	258956.7	749145.7
Magelang City	58364.16	274162.6	764067.5
Pekalongan City	524912.9	193744.4	296795.5
Salatiga City	476835.4	145974.3	346138.2
Surakarta City	275862.4	56272.54	546117.9
Tegal City	211991.9	119867.6	609924.1

The clustering results in the third iteration can be seen in Table 14.

TABLE 14. Regency/City Clustering Results in the Fourth Iteration

Regency/City	<i>Cluster</i>	Regency/City	<i>Cluster</i>
Banjarnegara Regency	1	Pemalang Regency	1
Banyumas Regency	2	Purworejo Regency	1
Batang Regency	2	Purbalingga Regency	2
Blora Regency	1	Rembang Regency	1
Boyolali Regency	2	Semarang Regency	3
Brebes Regency	1	Sragen Regency	1
Cilacap Regency	3	Sukoharjo Regency	2
Grobogan Regency	1	Tegal Regency	1
Jepara Regency	2	Temanggung Regency	1
Karanganyar Regency	2	Wonogiri Regency	1
Kebumen Regency	1	Wonosobo Regency	1
Kendal Regency	3	Magelang City	1
Klaten Regency	2	Pekalongan City	2
Kudus Regency	3	Salatiga City	2
Magelang Regency	2	Surakarta City	2
Pati Regency	1	Tegal City	2
Pekalongan Regency	2		

Based on Table 14, it can be seen that the clusters have stabilized because no regions have moved clusters. Therefore, the calculation process can be stopped at the fourth iteration. The final results in Table 15 show that there are 15 regions in cluster 1, 14 regions in cluster 2, and 4 regions in cluster 3.

3.7. Cluster Interpretation. Based on the clustering results, the members of each cluster can be seen in Table 15.

TABLE 15. Members of Each Cluster of Calculations

Cluster 1	Cluster 2	Cluster 3
Banjarnegara Regency	Banyumas Regency	Cilacap Regency
Blora Regency	Batang Regency	Kendal Regency
Brebes Regency	Boyolali Regency	Kudus Regency
Grobogan Regency	Jepara Regency	Semarang Regency
Kebumen Regency	Karanganyar Regency	
Pati Regency	Klaten Regency	
Pemalang Regency	Magelang Regency	
Purworejo Regency	Pekalongan Regency	
Rembang Regency	Purbalingga Regency	
Sragen Regency	Sukoharjo Regency	
Tegal Regency	Pekalongan City	
Temanggung Regency	Salatiga City	
Wonogiri Regency	Surakarta City	
Wonosobo Regency	Tegal City	
Magelang City		

Based on the results obtained, it can be seen in Table 3.15 that there are 15 regions included in cluster 1 which is a group of regions that have low UMK, 14 regions included in cluster 2 which is a group of regions that have medium UMK, and 4 regions included in cluster 3 which is a group of regions that have high UMK.

4. CONCLUSION AND SUGGESTIONS

4.1. **Conclusion.** The K-Means method was chosen in this study due to its advantages in terms of algorithmic simplicity, computational efficiency, and the ability to effectively cluster numerical data. Furthermore, this method is highly suitable for research purposes that focus on clustering regions based on the minimum wage (UMK) level. Other clustering methods, such as DBSCAN, have different characteristics, namely being more complex or requiring additional parameters. However, in the context of this study's numerical and relatively structured data, K-Means is considered more appropriate and efficient. This study does not conduct a direct comparison with other methods, so it cannot be concluded that other methods are inferior, but K-Means was chosen because it best suited the analysis needs. Based on the grouping of regions in Central Java based on the minimum wage (UMK) level from 2021 to 2024 using the K-Means clustering method, it was concluded that: Cluster 1 contains 15 regions with low MSE levels that require more attention than regions included in other clusters. The regions included in this cluster include Banjarnegara Regency, Blora Regency, Brebes Regency, Grobogan Regency, Kebumen Regency, Pati Regency, Pemalang Regency, Purworejo Regency, Rembang Regency, Sragen Regency, Tegal Regency, Temanggung Regency, Wonogiri Regency, Wonosobo Regency, and Magelang City. The regions included in this cluster have an average minimum wage of Rp1,888,641 in 2021, Rp1,900,481 in 2022, Rp2,036,292 in 2023, and Rp2,116,882 in 2024. Cluster 2 contains 14 regions with moderate minimum wages. The regions included in this cluster include Banyumas Regency, Batang Regency, Boyolali Regency, Jepara Regency, Karanganyar Regency, Klaten Regency, Magelang Regency, Pekalongan Regency, Purbalingga Regency, Sukoharjo Regency, Pekalongan City, Salatiga City, Surakarta City, and Tegal City. The regions included in this cluster have an average minimum wage of Rp2,045,929 in 2021, Rp2,058,017 in 2022, Rp2,204,549 in 2023, and Rp2,295,807 in 2024. Cluster 3 contains four regions with relatively high minimum wage levels so that they are expected to maintain their economic growth. The regions included in this cluster include Cilacap Regency, Kendal Regency, Kudus Regency, and Semarang Regency. The regions included in this cluster had an average minimum wage of Rp2,289,608 in 2021, Rp2,293,839 in 2022, Rp2,453,048 in 2023, and Rp2,547,964 in 2024. Based on these results, it can be concluded that most regions in Central Java Province still fall into the low and medium minimum wage categories, while only a small number of regions are classified as having a high minimum wage. This indicates an imbalance in welfare levels and economic activity between regions in Central Java.

4.2. **Suggestion.** In general, the results of this clustering are expected to serve as a reference for the Central Java Provincial Government in formulating more inclusive and equitable economic development policies, thereby reducing inter-regional disparities and improving the welfare of communities across the region. Furthermore, further research is recommended to include additional supporting variables to ensure the clustering results reflect the actual conditions in the relevant regions. Research using other clustering analysis methods can also be considered to compare the results and achieve optimal results.

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