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Clustering of Regencies and Municipalities Based on the Number of Livestock in East Java Province Using the Fuzzy C-Means Method

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ABSTRACT

This study was conducted to cluster regencies and municipalities in East Java Province based on the population of livestock, aiming to identify regional distribution patterns according to livestock characteristics. The clustering was performed using the Fuzzy C-Means algorithm and validated through the Partition Coefficient Index method. The implementation was carried out in a web-based application using the Laravel framework. The stages of this research included data collection, normalization, Fuzzy C-Means computation, evaluation using the Partition Coefficient Index, and profiling of cluster characteristics. The results of the study, tested with cluster numbers ranging from 2 to 10, indicated that the optimal number of clusters was two for both 2021 and 2022, with Partition Coefficient Index values of 0.7507 for 2021 and 0.7486 for 2022. In 2021, the optimal clustering produced Cluster 1 consisting of 7 regencies and 9 cities, and Cluster 2 consisting of 22 regencies. In 2022, the optimal clustering resulted in Cluster 1 consisting of 21 regencies, and Cluster 2 consisting of 8 regencies and 9 cities.

1. INTRODUCTION

East Java Province is identified as one of the regions that serves as a livestock supplier, playing a crucial role in accelerating overall regional growth and development (Trisman, I., Firman, A., & Herlina, 2022). East Java consists of 29 regencies and 9 cities, with Surabaya as its capital, making it one of the provinces with the highest number of administrative regions in Indonesia due to its strategic location (Widianti & Yuniseffendri, 2024). The significance of livestock in both regencies and cities, particularly in agrarian areas such as East Java Province, encompasses several key aspects that have a major influence on the economy, food security, and community welfare (Edi, 2020).

Livestock refers to animals raised by humans for food, industrial, and service purposes, while animal husbandry is the practice of breeding and managing these animals (Fadila et al., 2021). In East Java Province, local communities serve as the main actors in livestock rearing and consumption. This condition has been sustained over time, following local traditions and societal needs. Each type of livestock has different benefits, for example, cattle, goats, and chickens are commonly consumed, whereas horses and pigs have limited consumption due to religious and cultural factors (Maiyena & Mawarnis, 2022).

Based on the analysis of livestock population distribution, it is necessary to group data at the regency and city levels in East Java to support the formulation of policies aligned with regional characteristics. This clustering is based on the similarity in the number and types of livestock so that programs such as livestock assistance, animal health services, and livestock development can be implemented more efficiently. This approach is consistent with the directives of the East Java Livestock Service, which emphasize the importance of area-based strategies to optimize local potential.

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The Fuzzy C-Means (FCM) method is one of the techniques in data mining that plays an important role in pattern recognition, data clustering, and time series prediction. The selection of Fuzzy C-Means is based on its advantages in handling complex and uncertain data, as well as its ability to produce more accurate clustering results compared to other clustering methods. FCM provides deeper insights into the structure of the data by considering each livestock record as a member of multiple clusters with a certain degree of membership. The researchers chose to apply the Fuzzy C-Means (FCM) algorithm because several previous studies have shown that FCM achieves higher accuracy compared to the K-Means algorithm (Firmansyah et al., 2023).

Livestock in East Java exhibits wide diversity and is distributed across various regions with differing environmental and climatic conditions. The main types of livestock raised include cattle, goats, chickens, pigs, and horses, each providing distinct benefits and production outputs. Some animals, such as horses, are more commonly used as working animals, resulting in tougher meat compared to that of cattle or sheep, while pigs represent one of the livestock types with a large population (Kurniati et al., 2022). However, the consumption of pork is limited or even prohibited due to religious factors, particularly among Muslim communities, where not all types of meat are considered halal (Maiyena & Mawarnis, 2022). Therefore, most communities are more accustomed to consuming common meat types such as beef, goat meat, and chicken. The data used in this study include livestock population data for goats, chickens, and cattle in 2021 and 2022.

2. LITERATURE REVIEW

2.1. Clustering

Clustering is a data grouping technique that classifies data into clusters so that each cluster contains objects with similar characteristics while differing from objects in other clusters (Alfian & Hidayat, 2024). Clustering partitions data objects into several subsets, known as clusters. Objects within the same cluster share similar characteristics, while those in different clusters are dissimilar. This approach results in a high degree of similarity within a class and a low degree of similarity between classes. Clustering is a highly useful data segmentation method for analysis and prediction of specific problems (Al-abdaliah et al., 2020).

2.2. Data Normalization

In data analysis, the initial step is data normalization, as the analytical process involves several data attributes with different ranges. The data normalization method transforms the range of data values into a standardized scale between 0 and 1 (Permanan, 2022).

$$x = \frac{x_i - min_{(x_k)}}{max_{(x_k)} - max_{(x_k)}}, \quad (1)$$

where:

x = the average result of the division

x_{ik} = the attribute value

$min(x_k)$ = the minimum value of the attribute

$max(x_k)$ = the maximum value of the attribute

2.3. Fuzzy C-Means Algorithm

Fuzzy C-Means (FCM) is one of the clustering algorithms introduced by Jim Bezdek (1981), in which each data point can have a degree of membership in more than one cluster. An iterative process is carried out to adjust the cluster centers and data memberships until an

optimal position is achieved (Rahakbauw et al., 2017). The Fuzzy C-Means algorithm can be described as follows:

1. Input the data to be clustered, X, which is represented as a matrix of size $n \times m$, where n is the number of data samples and m is the number of attributes for each sample. The element X_{ij} represents the value of the i data sample ($i = 1,2, \dots, n$) and the j attribute ($j = 1,2, \dots, m$).
2. The next step is to determine the input parameters required for calculating FCM, which include:
    a. The number of clusters (c)
    b. The fuzziness coefficient or weighting exponent (m)
    c. The maximum number of iterations (MaxIter)
    d. The minimum error threshold (ξ)
    e. The initial objective function value ($P_0 = 0$)
    f. The initial iteration ($t = 1$)
3. Generate random numbers μ_{ik}, where $i = 1,2, \dots, n$; $k = 1,2, \dots, c$, as the elements of the initial partition matrix U.

    Then, calculate the sum of each column using the following equation:

$$Q_i = \sum_{k=1}^{c} \mu_{ik} \text{ for } j = 1,2, \dots, n$$

$$\mu_{ik} = \frac{\mu_{ik}}{Q_i} \quad (2)$$

4. Calculate the Cluster Centers

$$V_{kj} = \frac{\sum_{i-1}^{n} \left((\mu_{ik})^W * X_{ij} \right)}{\sum_{i-1}^{n} (\mu_{ik})^W}, \quad (3)$$

5. Calculate the Objective Function at the t Iteration

$$P_t = \sum_{i=1}^{n} \sum_{k=1}^{c} \left(\left[\sum_{j=1}^{m} (X_{ij} - V_{kj})^2 \right] (\mu_{ik})^w \right), \quad (4)$$

6. Compute the Change in the Partition Matrix

$$\mu_{ik} = \frac{\left[\sum_{j=1}^{m} (X_{ij} - V_{kj})^2 \right]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c} \left[\sum_{j=1}^{m} (X_{ij} - V_{kj})^2 \right]^{\frac{-1}{w-1}}}, \quad (5)$$

The iterative process continues until the convergence condition is met, that is, when the difference between the cluster centers in iteration $t$and iteration $t - 1$is smaller than the threshold value (ξ), or when the number of iterations has not exceeded the maximum limit (MaxIter). If these conditions are not satisfied, the iteration proceeds by incrementing the value of $t$and recalculating the cluster centers (Zahro et al., 2024).

3. METHOD

The research methodology comprises the data and data collection techniques, the research model, the operational definition of variables, and the data analysis procedure.

The data collection process was carried out using information obtained from the Central Bureau of Statistics (Badan Pusat Statistik/BPS) of East Java Province, covering 38 regencies and municipalities for the years 2021 and 2022.

3.1. Application of the Fuzzy C-Means Algorithm

a) The first step is to establish the initial partition matrix (U), consisting of livestock data with three attribute types, goats, chickens, and cattle — covering 38 regencies and municipalities in the years 2021 and 2022.

b) Determine the initial parameter values:
- Number of clusters = 10
- Exponent = 2
- Maximum iterations = 1000
- Minimum error = 0.001
- Initial objective function = 0
- Initial iteration = 1

c) Determining the Centroid or Cluster Center. After the membership degree values are calculated, the cluster centers (centroids) are updated using the weighted average of all data points, with the weights determined by their respective membership degrees in the current iteration. This step aims to adjust the centroid positions to better reflect the data distribution pattern in the subsequent iterations. The results of the centroid calculation are presented as follows.

Table 1. Cluster Centers for the Year 2021

Cluster	Goat	Chicken	Cattle
1	0,188	0,273	0.345
2	0,242	0,398	0.330

Table 2. Cluster Centers for the Year 2022

Cluster	Goat	Chicken	Cattle
1	0,278	0,447	0,388
2	0,206	0,253	0,291

d) Based on data processing using the Fuzzy C-Means algorithm implemented with the Laravel framework and a PHP backend, the results were obtained as shown in Table 1.

Table 3. Livestock Data of East Java Province in 2021 After Clustering

Data No.	Regency/City	Cluster 1	Cluster 2
1	Pacitan Regency	0,242	0.758
2	Ponorogo Regency	0,298	0.702
3	Trenggalek Regency	0,304	0.696
4	Tulungagung Regency	0,032	0.968
5	Blitar Regency	0,062	0.938
…	…	…	…
38	Batu City	0,998	0,002

In the first data entry, the membership degree for the first cluster is 0.242, while the membership degree for the second cluster is 0.758. This indicates that the first data entry belongs to the second cluster, as it has a higher membership degree in the second cluster compared to the first.

Furthermore, in the second data entry, the membership degree for the first cluster is 0.298, while the membership degree for the second cluster is 0.702. This indicates that the second data entry belongs to the second cluster. The classification continues up to the 38th data entry, where the membership degree for the first cluster is 0.998 and for the second cluster is 0.002.

This indicates that the 38th data entry belongs to the first cluster. The overall clustering tendencies can be observed in Table 2.

Table 4. Cluster Profiling for the Year 2021

Data No.	Regency/City	Cluster 1	Cluster 2
1	Pacitan Regency		*
2	Ponorogo Regency		*
3	Trenggalek Regency		*
4	Tulungagung Regency		*
5	Blitar Regency		*
6	Kediri Regency		*
7	Malang Regency		*
8	Lumajang Regency		*
9	Jember Regency		*
10	Banyuwangi Regency		*
11	Bondowoso Regency		*
12	Situbondo Regency	*	
13	Probolinggo Regency		*
14	Pasuruan Regency		*
15	Sidoarjo Regency	*	
16	Mojokerto Regency	*	
17	Jombang Regency	*	
18	Nganjuk Regency		*
19	Madiun Regency		*
20	Magetan Regency	*	
21	Ngawi Regency	*	
22	Bojonegoro Regency		*
23	Tuban Regency		*
24	Lamongan Regency		*
25	Gresik Regency	*	
26	Bangkalan Regency		*
27	Sampang Regency		*
28	Pamekasan Regency		*
29	Sumenep Regency		*
30	Kediri City	*	
31	Blitar City	*	
32	Malang City	*	
33	Probolinggo City	*	
34	Pasuruan City	*	

35	Mojokerto City	*	
36	Madiun City	*	
37	Surabaya City	*	
38	Batu City	*	

e) The next step is processing the livestock population data for the year 2022. The data were also obtained from the Central Bureau of Statistics (BPS) of East Java Province. The final results are presented in Table 3.

Table 5. Livestock Data of East Java Province in 2022 After Clustering

Data No.	Regency/City	Cluster 1	Cluster 2
1	Pacitan Regency	0.843	0.157
2	Ponorogo Regency	0.686	0.314
3	Trenggalek Regency	0.704	0.296
4	Tulungagung Regency	0.973	0.0267
5	Blitar Regency	0.941	0.059
…	…	…	…
38	Batu City	0.002	0.998

Based on Table 3, several regencies and municipalities exhibit membership values that are more dominant in one cluster, similar to the previous calculations. This indicates the overall clustering tendencies, which can be observed in Table 4.

Table 6. Cluster Profiling for the Year 2022

Data No.	Regency/City	Cluster 1	Cluster 2
1	Pacitan Regency	*	
2	Ponorogo Regency	*	
3	Trenggalek Regency	*	
4	Tulungagung Regency	*	
5	Blitar Regency	*	
6	Kediri Regency	*	
7	Malang Regency	*	
8	Lumajang Regency	*	
9	Jember Regency	*	
10	Banyuwangi Regency	*	
11	Bondowoso Regency	*	
12	Situbondo Regency		*
13	Probolinggo Regency	*	
14	Pasuruan Regency	*	
15	Sidoarjo Regency		*
16	Mojokerto Regency		*
17	Jombang Regency		*
18	Nganjuk Regency	*	
19	Madiun Regency	*	
20	Magetan Regency		*
21	Ngawi Regency		*

22	Bojonegoro Regency	*	
23	Tuban Regency	*	
24	Lamongan Regency	*	
25	Gresik Regency		*
26	Bangkalan Regency	*	
27	Sampang Regency	*	
28	Pamekasan Regency		*
29	Sumenep Regency	*	
30	Kediri City		*
31	Blitar City		*
32	Malang City		*
33	Probolinggo City		*
34	Pasuruan City		*
35	Mojokerto City		*
36	Madiun City		*
37	Surabaya City		*
38	Batu City		*

4. RESULT AND DISCUSSION

4.1. Testing the Partition Coefficient Index

The calculations were performed for 2 to 10 clusters using the Laravel framework with a PHP backend. The results of the Partition Coefficient Index for the year 2021 are presented in Table 5.

Table 7. Cluster Profiling for the Year 2021

Cluster	Partition Coefficient Index
2	0,751
3	0,663
4	0,620
5	0,610
6	0,643
7	0,665
8	0,626
9	0,599
10	0,629

Based on the Partition Coefficient Index (PCI) calculation, the number of clusters that yields a PCI value closest to 1 is two, indicating the optimal cluster with a value of 0.751. A higher PCI value reflects a clearer and more distinct cluster separation. The closer the value is to 1, the better the quality of the clustering result. Therefore, the PCI value is used as a reference to determine the most appropriate number of clusters for the year 2021. It can thus be concluded that the optimal number of clusters for the 2021 data is two. The results for 2022 are presented in Table 6.

Table 8. Partition Coefficient Index for the Year 2022

Cluster	Partition Coefficient Index
2	0,749

3	0,657
4	0,599
5	0,603
6	0,635
7	0,659
8	0,638
9	0,601
10	0,624

Based on the Partition Coefficient Index (PCI) calculation for 2022, the number of clusters that yields a PCI value closest to 1 is two, indicating the optimal cluster with a value of 0.749. A higher PCI value reflects a clearer and more distinct cluster separation. The closer the value is to 1, the better the quality of the clustering results. Therefore, the PCI value serves as a reference for determining the most appropriate number of clusters. It can be concluded that the optimal number of clusters for the 2022 data is two.

4.2. Profiling of the Optimal Clusters

To identify the most optimal number of clusters and to understand the characteristics of each group, cluster profiling was conducted following the calculation of the Partition Coefficient Index. This profiling involved examining the maximum and minimum values of each variable within each cluster, thereby highlighting the distinctive features that differentiate one cluster from another.

Table 9. Members of Cluster 1 for the Year 2021

Regency/City	Goat	Chicken	Cattle
Situbondo Regency	32,108	341,734	182,081
Sidoarjo Regency	41,999	397,297	14,735
Mojokerto Regency	40,393	678,463	50,396
Jombang Regency	11,106	919,606	73,372
Magetan Regency	44,726	613,865	118,251
Ngawi Regency	86,464	626,744	85,847
Gresik Regency	79,059	759,629	59,259
Kediri City	4,683	84,011	4,101
Blitar City	3,114	81,528	3,863
Malang City	1,576	49,770	2,697
Probolinggo City	3,247	86,437	11,061
Pasuruan City	3,232	51,400	454
Mojokerto City	1,065	13,010	103
Madiun City	2,765	57,840	209
Surabaya City	996	8,941	113
Batu City	5,735	34,985	2,572

In 2021, the profile of Cluster 2 illustrates the distribution of livestock populations, including goats, chickens, and cattle, across various regencies and municipalities in East Java Province. The data show considerable differences among the types of livestock in each region. Goat populations ranged from 51,499 to 432,539 heads, chicken populations ranged from 607,932 to 2,869,560 heads, and cattle populations ranged from 38,840 to 383,059 heads.

The results for 2022 show a similar pattern to those of 2021, with the optimal cluster remaining Cluster 2. Therefore, the same profiling method was used to analyze the characteristics of each cluster, as presented in Table 9.

Table 10. Members of Cluster 2 for the Year 2021

Regency/City	Goat	Chicken	Cattle
Pacitan Regency	321,971	1.040,372	95,954
Ponorogo Regency	255,771	993,406	85,716
Trenggalek Regency	432,539	1.443,265	38,840
Tulungagung Regency	209,955	2.306,751	144,801
Blitar Regency	157,100	2.862,560	153,829
Kediri Regency	147,285	1.276,882	234,177
Malang Regency	290,378	2.506,274	246,734
Lumajang Regency	138,112	1.877,348	225,394
Jember Regency	56,194	2.152,656	274,162
Banyuwangi Regency	120,698	1.361,913	134,307
Bondowoso Regency	54,809	701,846	237,407
Probolinggo Regency	51,499	629,689	319,388
Pasuruan Regency	72,160	1.434,504	117,679
Nganjuk Regency	128,141	1.308,429	143,682
Madiun Regency	87,243	1.841,526	65,745
Bojonegoro Regency	154,758	1.633,128	258,563
Tuban Regency	137,675	1.555,181	354,650
Lamongan Regency	92,109	1.390,992	117,889
Bangkalan Regency	86,607	1.607,189	276,476
Sampang Regency	57,164	607,932	217,129
Pamekasan Regency	66,433	866,239	194,292
Sumenep Regency	156,034	794,762	383,059

In 2021, the profile of Cluster 2 illustrates the distribution of livestock populations—including goats, chickens, and cattle, across various regencies and municipalities in East Java Province. The data reveal significant differences among the types of livestock in each region. Goat populations ranged from 51,499 to 432,539 heads, chicken populations ranged from 607,932 to 2,869,560 heads, and cattle populations ranged from 38,840 to 383,059 heads.

The results for 2022 exhibit a pattern similar to that of 2021, with the optimal cluster remaining Cluster 2. Consequently, the same profiling method was applied to analyze the characteristics of each cluster, as presented in Table 9.

Table 11. Members of Cluster 1 for the Year 2022

Regency/City	Goat	Chicken	Cattle
Pacitan Regency	360.782	1.610.925	98.153
Ponorogo Regency	256.082	1.049.857	86.259
Trenggalek Regency	447.649	1.524.877	40.034
Tulungagung Regency	214.754	2.361.079	152.539
Blitar Regency	160.291	2.907.230	155.944
Kediri Regency	149.137	1.276.914	240.852
Malang Regency	299.773	2.553.233	252.930
Lumajang Regency	145.918	1.911.444	232.944

Jember Regency	63.444	2.190.706	280.067
Banyuwangi Regency	124.929	1.366.565	138.544
Bondowoso Regency	57.235	696.715	262.003
Probolinggo Regency	53.675	646.335	331.294
Pasuruan Regency	70.676	1.398.915	120.328
Nganjuk Regency	129.201	1.323.279	144.911
Madiun Regency	90.139	1.901.073	67.127
Bojonegoro Regency	162.091	1.649.949	269.803
Tuban Regency	141.202	1.608.070	360.473
Lamongan Regency	91.812	1.343.658	120.843
Bangkalan Regency	89.131	1.650.046	287.921
Sampang Regency	58.881	586.087	219.107
Pamekasan Regency	157.224	794.762	388.090
Sumenep Regency	156,034	794,762	383,059

The data reveal significant differences among the types of livestock in each region. Goat populations ranged from 53,675 to 447,649 heads, chicken populations ranged from 586,087 to 2,907,230 heads, and cattle populations ranged from 40,034 to 388,090 heads.

Table 12. Members of Cluster 2 for the Year 2022

Regency/City	Goat	Chicken	Cattle
Situbondo Regency	31.720	308.542	183.902
Sidoarjo Regency	43.426	403.690	15.150
Mojokerto Regency	39.901	683.460	51.131
Jombang Regency	120.758	883.120	75.215
Magetan Regency	45.511	607.881	120.014
Ngawi Regency	95.436	632.044	86.531
Gresik Regency	80.986	774.848	61.220
Pamekasan Regency	58.881	586.087	200.933
Kediri City	4.967	141.482	4.214
Blitar City	3.073	83.364	4.044
Malang City	1.640	49.201	2.767
Probolinggo City	3.057	88.092	11.429
Pasuruan City	3.309	52.633	466
Mojokerto City	1.058	13.574	104
Madiun City	2.767	57.111	205
Surabaya City	971	8.259	158
Batu City	5.792	34.009	2.591

The data reveal significant differences among the types of livestock across the regions. Goat populations ranged from 971 to 120,758 heads, chicken populations ranged from 8,259 to 883,120 heads, and cattle populations ranged from 104 to 200,933 heads.

5. CONCLUSION

Based on the analysis and discussion presented in the previous chapter, the following conclusions are drawn:

1. The optimal number of clusters, as determined using the Fuzzy C-Means algorithm with the Partition Coefficient Index method,

a. In 2021, the optimal number of clusters determined using the Fuzzy C-Means algorithm was two, with a Partition Coefficient Index value of 0.751.
b. In 2022, the optimal number of clusters determined using the Fuzzy C-Means algorithm was two, with a Partition Coefficient Index value of 0.749.

2. The clustering results indicate that the optimal clusters consist of two clusters each, with the members of each cluster as follows:
   a) In 2021, Cluster 1 included 7 regencies and 9 cities, totaling 16 regions, namely Situbondo Regency, Sidoarjo Regency, Mojokerto Regency, Jombang Regency, Magetan Regency, Ngawi Regency, Gresik Regency, Kediri City, Blitar City, Malang City, Probolinggo City, Pasuruan City, Mojokerto City, Madiun City, Surabaya City, and Batu City.
   Cluster 2 included 22 regencies, namely Pacitan Regency, Ponorogo Regency, Trenggalek Regency, Tulungagung Regency, Blitar Regency, Kediri Regency, Malang Regency, Lumajang Regency, Jember Regency, Banyuwangi Regency, Bondowoso Regency, Probolinggo Regency, Pasuruan Regency, Nganjuk Regency, Madiun Regency, Bojonegoro Regency, Tuban Regency, Lamongan Regency, Bangkalan Regency, Sampang Regency, Pamekasan Regency, and Sumenep Regency.
   b) In 2022, Cluster 1 included 21 regencies, namely Pacitan Regency, Ponorogo Regency, Trenggalek Regency, Tulungagung Regency, Blitar Regency, Kediri Regency, Malang Regency, Lumajang Regency, Jember Regency, Banyuwangi Regency, Bondowoso Regency, Probolinggo Regency, Pasuruan Regency, Nganjuk Regency, Madiun Regency, Bojonegoro Regency, Tuban Regency, Lamongan Regency, Bangkalan Regency, Sampang Regency, and Sumenep Regency.
   Cluster 2 comprised 17 regions, including 8 regencies and 9 cities, namely Situbondo Regency, Sidoarjo Regency, Mojokerto Regency, Jombang Regency, Magetan Regency, Ngawi Regency, Gresik Regency, Pamekasan Regency, Kediri City, Blitar City, Malang City, Probolinggo City, Pasuruan City, Mojokerto City, Madiun City, Surabaya City, and Batu City.

6. REFERENCES

Al-abdaliah, U., Sujaini, H., & Muhardi, H. (2020). *Pengklasteran Dosen Berdasarkan Evaluasi Mahasiswa Menggunakan Metode Fuzzy C-Means Lecturer Clustering Based on Student Evaluation Using Fuzzy C-Means*. *08*(4), 403–408. https://doi.org/10.26418/justin.v8i4.40094

Alfian, W., & Hidayat, T. (2024). Analisis Clustering Pegawai Berdasarkan Tingkat Kedisiplinan Menggunakan Algoritma K-Means dan Davies-Bouldin Index. *Journal of Electrical Engineering and Computer*, *6*(2), 437–448. https://doi.org/10.33650/jeecom.v4i2

Edi, D. N. (2020). Analisis Potensi Wilayah untuk Pengembangan Komoditas Ternak Ruminanisa di Provinsi Jawa Timur. *Briliant: Jurnal Riset Dan Konseptual*, *5*(3), 562. https://doi.org/10.28926/briliant.v5i3.473

Fadila, P., Stmik, S., & Binjai, K. (2021). *Pengelompokan Populasi Hewan Ternak Menggunakan Metode Clustering (Studi Kasus : Dinas Pertanian dan Ketahanan Pangan Kabupaten Langkat)*.

Firmansyah, I., Fauziah, S., Ibrahim, N. H., & Fauzi, F. (2023). *Clustering Untuk Menetukan Indeks Kesejahtraan Rakyat Di Provinsi Jawa Tengah 2022 Menggunakan Metode Fuzzy C-Means*. *1*(2), 81–91.

Kurniati, Y., Rahmat, A., Nugraheni, R., & Dahlan Malik, A. (2022). Pengembangan Peternakan dan Pemanfaatannya Sebagai Hewan Kurban Desa Mangli Kediri. *Jurnal Ilmiah Pangabdhi*, *8*(2), 75–78. https://doi.org/10.21107/pangabdhi.v8i2.15828

Maiyena, S., & Mawarnis, E. R. (2022). *Kajian Analisis Konsumsi Daging Sapi dan Daging*

Babi Ditinjau dari Kesehatan. *6*, 3131–3136.

Permanan, I. (2022). The Effect of Data Normalization on the Performance of the Classification Results of the Backpropagation Algorithm Pengaruh Normalisasi Data Terhadap Performa Hasil Klasifikasi Algoritma Backpropagation. *Journal of Informatic Research and Software Engineering*, *2*(1), 67–72.

Rahakbauw, D. L., Ilwaru, V. Y. I., & Hahury, M. H. (2017). Implementation of fuzzy c-means clustering in scholarship determination. *Jurnal Ilmu Matematika Dan Terapan*, *11*(1), 1–12.

Trisman, I., Firman, A., & Herlina, L. (2022). Penentuan Wilayah Pengembangan Ternak Ruminansia Besar Di Provinsi Jawa Timur. *Jurnal Ilmu Ternak Universitas Padjadjaran*, *22*(2), 125. https://doi.org/10.24198/jit.v22i2.41717

Widianti, A., & Yuniseffendri. (2024). Toponimi Nama Kabupaten dan Kota di Jawa Timur. *BAPALA*, *11(3)*, 305–317.

Zahro, I. H., Rosyidah, U. A., & Handayani, L. (2024). Implementasi Algoritma Fuzzy C-Means untuk Pengelompokkan Provinsi di Indonesia Berdasarkan Kualitas Perguruan Tinggi. *BIOS : Jurnal Teknologi Informasi Dan Rekayasa Komputer*, *5*(1), 80–86. https://doi.org/10.37148/bios.v5i1.102