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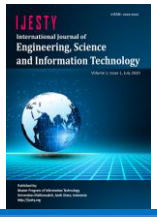

Public Facility Recommendation System in Subulussalam City Using Fuzzy C-Means Algorithm

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Abstract

Subulussalam City, as one of the autonomous regions in Aceh Province, Indonesia, has excellent potential to develop public facilities to improve the quality of life for its residents. Recommendation systems have become an effective solution in helping users find relevant information based on the preferences and needs of the community. This research focuses on developing a recommendation system using the Fuzzy C-Means algorithm. This algorithm is one of the clustering methods capable of handling uncertainty and ambiguity in data. This study aims to develop and analyze a public facility recommendation system in Subulussalam City using the Fuzzy C-Means algorithm. The dataset in this study was obtained from the Youth, Sports, and Tourism Office of Subulussalam City and the results of a research questionnaire. Regarding the names of each public facility, it provides information about the location and various forms of visitor assessments, including evaluations related to accessibility, facilities, costs, environment, and visitor experiences, using a rating scale of 1-5. Based on the testing results, the Fuzzy C-Means clustering algorithm can group facilities based on characteristics and user preferences, resulting in more personalized and relevant recommendations. The data to be clustered is divided into two categories: recommended and not recommended. The study's results using the Fuzzy C-Means algorithm show the final grouping based on the degree of membership from the last iteration of each public facility, with cluster 1 containing 31 locations and cluster 2 containing 31 locations.

Keywords: *Public Facilities, Clustering, Fuzzy C-Means, Subulussalam City.*

1. Introduction

Subulussalam City, as one of the autonomous regions in Aceh Province, Indonesia, has excellent potential to develop public facilities to improve the community's quality of life. Public facilities such as parks, health centers, schools, and places of worship are essential in supporting residents' social and economic activities. However, with rapid population growth and diverse needs, people often have difficulty finding public facilities that suit their needs.

Recommendation systems have become effective in helping users find relevant information based on their preferences and needs. In the context of public facilities, recommendation systems can provide correct and precise information about the location, type, and quality of available facilities so that people can more easily access the facilities they need, which can improve their quality of life and welfare [1].

The fuzzy C-Means algorithm is among the various methods that can be applied to develop a recommendation system. This algorithm is one of the clustering methods that can overcome uncertainty and ambiguity in data [2] [3]. In the context of public facilities, Fuzzy C-Means can cluster facilities based on user characteristics and preferences, resulting in more personalized and relevant recommendations. By using this method, the recommendation system is expected to be able to present results that are more precise and meet the needs of the community in Subulussalam City.

Some previous studies have used Fuzzy C-Means analysis in this study to facilitate grouping data based on demographic characteristics, pharmacological therapy, and patient glucose levels. In addition, the analysis results are expected to contribute to the treatment selection by the patient's condition to support the long-term survival of patients with type II diabetes mellitus [4].

In this study, the FCM algorithm worked effectively in grouping customers. This algorithm categorizes customers into three clusters (gold, silver, and bronze) with a cluster accuracy rate of 0.596277, which means the accuracy rate is quite good [5].
The Fuzzy C-Means (FCM) method produces two groups: the first consists of 479 data points, and the second contains 580 data points. In the clustering process using the FCM method, the research stage shows accurate results with a PCI value of 0.50002 and PEI of 0.99998. This indicates that the accuracy level of membership in the cluster is quite satisfactory [6] [7].
However, although the potential use of recommendation systems with the Fuzzy C-Means algorithm is auspicious, research on its application in Subulussalam City is still limited [8] [9]. Thus, this research aims to develop and analyze the Public Facility Recommendation System in Subulussalam City using the Fuzzy C-Means Algorithm and evaluate its effectiveness in meeting the community's needs. Thus, this research is expected to make a significant contribution to the area of information systems and public services.

2. Literature Review

2.1. Data Mining

Data processing is needed to obtain the correct information. One of the advances in information technology related to data processing is Data Mining [10].
In summary, it can be concluded that data mining, commonly referred to as knowledge discovery in databases (KDD), is a series of processes designed to extract significant or interesting patterns from large amounts of data that cannot be identified manually [11].

2.2. Public Facilities

Public facilities are infrastructure facilities provided by the government or private parties to meet the community's basic needs and support social, economic, and cultural activities[12]. These facilities include various types of services and infrastructure, such as education, health, transportation, recreation, and security [13]. Public facilities are essential in improving the community's quality of life, well-being, and social interaction. The availability and accessibility of adequate public facilities can contribute to an area's social and economic progress [14].

2.3. Clustering

The clustering method divides data into groups, where data with similar characteristics are grouped into the same cluster. The purpose of clustering is to reduce the objective function applied during the clustering process, which usually focuses on minimizing variation within a cluster and maximizing variation between clusters [15].

2.4. Fuzzy C-means

Fuzzy C-Means is a clustering method designed to divide data into several groups (clusters) by referring to similar characteristics. Unlike the k-means method, each data point can only be assigned to one cluster; FCM allows each point to show membership levels to all existing clusters [16].
Jim Bezdek first introduced this method in 1981 [17]. The FCM method is a data clustering technique in which the presence of each data point in a cluster is determined by the membership value and degree of membership, which ranges from 0 to 1 [18]. FCM is a data clustering method based on values between 0 and 1. The higher the membership value of a data, the higher the degree of membership, while the lower the membership value, the lower the degree of membership [19].
Fuzzy C-Means Algorithm calculation process [20]

1. Prepare the data to be clustered into a matrix X, with a size m x n matrix. m is the amount of data to be clustered, and n is the number of attributes of each data. Example Xij = i-th data (i= 1,2,...m), j-th attribute (j=1,2,...n).
2. Set:
   Number of clusters = c;
   Rank/Exponent = w;
   Maximum iterations = MaxIter;
   Expected error = ξ;
   Initial objective function = p0 = 0;
   First iteration = t = 1;
3. Generate random numbers μik (i=1, 2, ..., m and k=1, 2, ..., c) to form the initial partition matrix U elements, where Xi is the i-th data.

$$U = \begin{bmatrix} \mu_{11}(X_1) & \mu_{21}(X_1) & \dots & \mu_{c1}(X_1) \\ \mu_{12}(X_2) & \mu_{22}(X_2) & \dots & \mu_{c1}(X_2) \\ \vdots & \vdots & \dots & \vdots \\ \mu_{1i}(X_i) & \mu_{1i}(X_i) & \dots & \mu_{ci}(X_i) \end{bmatrix} \quad (1)$$

   With the total of each column in a row equal to 1

$$\sum_{i=1}^{c} \mu_{ci} = 1 \quad (2)$$

4. Calculate the kth cluster center: V_kj, with k = 1,2,...,c and j = 1,2,...,n
   Description:
   V_kj Kth cluster center
   X_ij The i-th sample data
   μ_ik= Degree of membership of the 1st cluster and the kth data
   i Data index, (1,2,...., c)

5. Calculate the objective function at the tth iteration, Pt:

$$P_t = \sum_{i=1}^{m}\sum_{k=1}^{c}\left(\left[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2\right](\mu_{ik})^w\right) \quad (3)$$

6. Calculate the change of membership degree of each data in each cluster (update the partition matrix U) with :

$$\mu_{ik} = \frac{[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c}[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}} \quad (4)$$

With: i = 1,2,....,n and k = 1,2,....,c

7. Check the stop condition:
If: $(|P_t - P_{t-1}| < \varepsilon)$ or $(t > MaksIter)$Then, the calculation stops. Otherwise: $t = t + 1$, then repeat step 4

3. Research Method

System research was conducted to determine recommendations for public facilities in Subulussalam City using the Fuzzy C-Means algorithm conducted in Subulussalam City and the Subulussalam City Youth, Sports, and Tourism Office. This location was chosen to facilitate research in finding and collecting data to build an application so that this research can run well. The study was conducted for 3 (three) months.

4. Results and Discussion

The dataset used in this research contains information about public facilities in Subulussalam City. The dataset was obtained from the Department of Youth, Sports, and Tourism in Subulussalam City, and the results of the research questionnaire data. Information about the place name of each facility, access, facilities, costs, environment, and visitors is also included in the data [21]. The following is data on Public Facilities in Subulussalam City.
As an example of the calculation of the implementation of the Fuzzy C-Means algorithm, an explanation of the calculation process will be carried out on the Rest Area public facility dataset only [22]. Still, the final results will be submitted for the public facility dataset of Places of Worship, Gasoline Stations, ATMs, Restaurants, Tourist Attractions, and Supermarkets so as not to display or present a long calculation process. Hence, the author chose the Rest Area public facility dataset as the calculation sample test data.

4.1. Context Diagram

A context diagram comprehensively explains the system's input, process, and output.

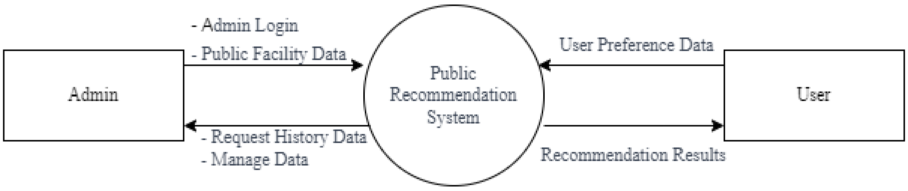

Fig 1. Context diagram

4.2. Data Flow Diagram

A data flow diagram (DFD) is a basic representation of the interactions between the system and external entities. Below is a depiction of the DFD [23].

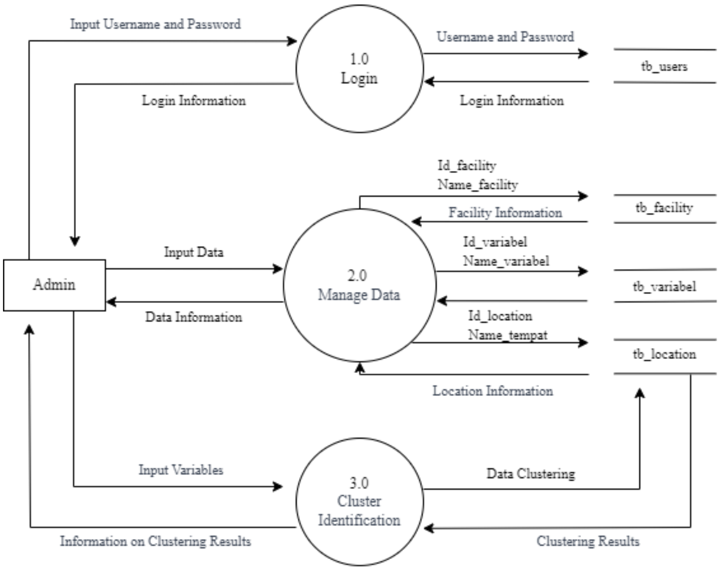

Fig 2. Data Flow Diagram (DFD)

4.3. Descriptive Data

The dataset used in this study contains information about public facilities in the City of Subulussalam. This dataset was obtained from the Youth, Sports, and Tourism Office located in the City of Subulussalam, as well as from the results of the research questionnaire. Information regarding the names of each facility, access, amenities, costs, environment, and visitors is also included in the data. Below is the data on public facilities in the City of Subulussalam.

Table 1. Public Facility Data For Rest Areas

Place Name	Rest Area																								
	Access					Facility					Cost					Environment					Visitor				
	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5
favorite Muslim restaurant	0	3	4	2	1	0	0	3	5	2	0	0	3	3	4	0	0	3	6	1	0	0	5	5	0
Bang Jali Pidie Jaya Seafood	0	0	6	1	3	0	0	1	5	4	0	0	3	4	3	0	0	2	5	3	0	0	2	6	2
Singon	0	0	1	3	6	0	0	2	6	2	0	0	3	3	4	0	0	6	4	0	0	0	4	4	2
Awak Away	1	0	7	0	2	0	0	8	2	0	0	0	4	2	4	0	0	8	2	0	0	0	7	3	0
Dinnar restaurant	0	2	5	2	1	0	0	8	2	0	0	0	4	3	3	0	0	8	2	0	0	0	6	4	0

The public facility dataset for the rest area provides information about the location and various forms of visitor assessments, including evaluations related to accessibility, amenities, costs, environment, and visitors at the rest area, using a rating scale of 1-5.

4.4. Manual Calculation of Fuzzy C-Means

Iteration Process 1

1. Set the initial values as follows:
   a. Number of Clusters: 2
   b. Exponent: 2
   c. Maximum Iterations: 100
   d. Expected Error: 0.001
   e. Initial Objective Function: 0
   f. First Iteration = 1

2. Generate random numbers μik (with i=1,2,…m and k=1,2,…c) to form the elements of the initial partition matrix U, where Xi is the i-th data.

Table 2. Table of Random Numbers

K1	K2	Total
0,379	0,621	1
0,058	0,942	1
0,309	0,691	1
0,264	0,736	1
0,441	0,559	1

3. Calculate the new cluster center (c) based on the established membership values.

Table 3. Calculate Cluster Center 1 Iteration 1

μ_{i1}	μ_{i1}^2	$\mu_{i1}^2 * X1$	$\mu_{i1}^2 * X2$	$\mu_{i1}^2 * X3$	$\mu_{i1}^2 * X4$	$\mu_{i1}^2 * X5$	$\mu_{i1}^2 * X6$	$\mu_{i1}^2 * X7$	$\mu_{i1}^2 * X8$	$\mu_{i1}^2 * X9$	$\mu_{i1}^2 * X10$	$\mu_{i1}^2 * X11$
0,379	0,143	0	0,430	0,574	0,287	0,143	0	0	0,430	0,718	0,287	0
0,058	0,003	0	0	0,020	0,003	0,010	0	0	0,003	0,016	0,013	0
0,309	0,095	0	0	0,095	0,286	0,572	0	0	0,190	0,572	0,190	0
0,264	0,069	0,069	0	0,487	0	0,139	0	0	0,557	0,139	0	0
0,441	0,194	0	0,388	0,972	0,388	0,194	0	0	1,555	0,388	0	0
Σ	**0,506**	**0,069**	**0,819**	**2,150**	**0,966**	**1,060**	**0**	**0**	**2,738**	**1,836**	**0,491**	**0**

Table 4. Calculate Cluster Center 1 Iteration 1 (Continuation)

$\mu_{i1^2} * X12$	$\mu_{i1^2} * X13$	$\mu_{i1^2} * X14$	$\mu_{i1^2} * X15$	$\mu_{i1^2} * X16$	$\mu_{i1^2} * X17$	$\mu_{i1^2} * X18$	$\mu_{i1^2} * X19$	$\mu_{i1^2} * X20$	$\mu_{i1^2} * X21$	$\mu_{i1^2} * X22$	$\mu_{i1^2} * X23$	$\mu_{i1^2} * X24$	$\mu_{i1^2} * X25$
0	0,430	0,430	0,574	0	0	0,430	0,861	0,143	0	0	0,718	0,718	0
0	0,010	0,013	0,010	0	0	0,006	0,016	0,010	0	0	0,006	0,020	0,006
0	0,286	0,286	0,381	0	0	0,572	0,381	0	0	0	0,381	0,381	0,190
0	0,278	0,139	0,278	0	0	0,557	0,139	0	0	0	0,487	0,209	0
0	0,777	0,583	0,583	0	0	1,555	0,388	0	0	0	1,166	0,777	0
0	**1,784**	**1,453**	**1,828**	**0**	**0**	**3,123**	**1,788**	**0,153**	**0**	**0**	**2,761**	**2,107**	**0,19**

The multiplication results of the columns in Table 3 and Table 4 for the value μ_i1 will be multiplied by each dataset to determine the result of cluster center 1, and the value obtained from Σ represents the sum of the columns in each respective column.

Table 5. Calculate Cluster Center 2, Iteration 1

μ_{i2}	μ_{i2^2}	$\mu_{i2^2} * X1$	$\mu_{i2^2} * X2$	$\mu_{i2^2} * X3$	$\mu_{i2^2} * X4$	$\mu_{i2^2} * X5$	$\mu_{i2^2} * X6$	$\mu_{i2^2} * X7$	$\mu_{i2^2} * X8$	$\mu_{i2^2} * X9$	$\mu_{i2^2} * X10$	$\mu_{i2^2} * X11$
0,621	0,385	0	1,156	1,542	0,771	0,385	0	0	1,156	1,928	0,771	0
0,942	0,887	0	0	5,324	0,887	2,662	0	0	0,887	4,436	3,549	0
0,691	0,477	0	0	0,477	1,432	2,864	0	0	0,954	2,864	0,954	0
0,736	0,541	0,541	0	3,791	0	1,083	0	0	4,333	1,083	0	0
0,559	0,312	0	0,624	1,562	0,624	0,312	0	0	2,499	0,624	0	0
Σ	**2,604**	**0,541**	**1,781**	**12,698**	**3,716**	**7,308**	**0**	**0**	**9,832**	**10,938**	**5,275**	**0**

Table 6. Calculate Cluster Center 2 Iteration 1 (Continuation)

$\mu_{i2^2} * X12$	$\mu_{i2^2} * X13$	$\mu_{i2^2} * X14$	$\mu_{i2^2} * X15$	$\mu_{i2^2} * X16$	$\mu_{i2^2} * X17$	$\mu_{i2^2} * X18$	$\mu_{i2^2} * X19$	$\mu_{i2^2} * X20$	$\mu_{i2^2} * X21$	$\mu_{i2^2} * X22$	$\mu_{i2^2} * X23$	$\mu_{i2^2} * X24$	$\mu_{i2^2} * X25$
0	1,156	1,156	1,542	0	0	1,156	2,313	0,385	0	0	1,928	1,928	0
0	2,662	3,549	2,662	0	0	1,774	4,436	2,662	0	0	1,774	5,324	1,774
0	1,432	1,432	1,909	0	0	2,864	1,909	0	0	0	1,909	1,909	0,954
0	2,166	1,083	2,166	0	0	4,333	1,083	0	0	0	3,791	1,625	0
0	1,249	0,937	0,937	0	0	2,499	0,624	0	0	0	1,874	1,249	0
0	**8,668**	**8,159**	**9,218**	**0**	**0**	**12,629**	**10,368**	**3,047**	**0**	**0**	**11,279**	**12,037**	**2,729**

The table shows the multiplication results between the column μ_i2 and all datasets to calculate the value of cluster center 2. The value Σ represents the sum of each column, and this Σ value will be used to determine the result of cluster center 2.

$$V_{kj} = \frac{\sum_{i=1}^{m}(\mu_{ik})^{w} * X_{ij}}{\sum_{i=1}^{m}(\mu_{ik})^{w}} \quad \text{.....(5)}$$

4. Calculate the Objective Function Value (FO)

Table 7. Calculate the Objective Function Value for Cluster 1, Iteration 1

$$\mu_{ik} = \frac{[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c}[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}$$

L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13
0,018	1,909	0,059	0,008	1,194	0	0	5,785	1,892	1,059	0	0	0,271
0,018	2,618	3,081	0,822	0,822	0	0	19,406	1,892	9,178	0	0	0,271
0,018	2,618	10,526	1,195	15,263	0	0	11,596	5,644	1,059	0	0	0,271
0,743	2,618	7,593	3,635	0,0086	0	0	6,732	2,638	0,941	0	0	0,229
0,018	0,145	0,570	0,008	1,194	0	0	6,732	2,638	0,941	0	0	0,229

Table 8. Calculate the Objective Function Value for Cluster 1, Iteration 1 (Continuation)

$$\mu_{ik} = \frac{[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c}[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}$$

L14	L15	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	Total
0,017	0,152	0	0	10,021	6,096	0,485	0	0	0,203	0,706	0,152	30,037
1,278	0,371	0	0	17,353	2,158	7,271	0	0	11,906	3,388	2,591	84,433
0,017	0,152	0	0	0,027	0,220	0,092	0	0	2,104	0,025	2,591	53,425
0,755	0,152	0	0	3,364	2,343	0,092	0	0	2,400	1,343	0,152	35,745
0,017	0,371	0	0	3,364	2,343	0,092	0	0	0.301	0,025	0,152	19,148

Table 9. Calculate the Objective Function Value for Cluster 2, Iteration 1

$$\mu_{ik} = \frac{[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}{\sum_{k-1}^{c}[\sum_{i-1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}$$

L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13
0,043	5,363	0,766	0,328	3,261	0	0	0,600	0,640	0,000	0	0	0,107
0,043	0,468	1,264	0,182	0,037	0	0	7,700	0,640	3,898	0	0	0,107
0,043	0,468	15,017	2,475	10,202	0	0	3,150	3,241	0,000	0	0	0,107
0,627	0,468	4,514	2,035	0,649	0	0	17,850	4,837	4,102	0	0	0,451
0,043	1,731	0,015	0,328	3,261	0	0	17,850	4,837	4,102	0	0	0,451

Table 10. Calculate the Objective Function Value for Cluster 2, Iteration 1 (Continuation)

$$\mu_{ik} = \frac{[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}{\sum_{k-1}^{c}[\sum_{i-1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}}$$

L14	L15	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	Total
0,017	0,212	0	0	3,418	4,076	0,028	0	0	0,448	0,143	1,098	20,556
0,752	0,290	0	0	8,116	1,038	3,348	0	0	5,431	1,900	0,906	36,128
0,017	0,212	0	0	1,324	0,000	1,369	0	0	0,109	0,386	0,906	39,033
1,283	0,212	0	0	9,928	3,924	1,369	0	0	7,125	2,629	1,098	63,107
0,017	0,290	0	0	9,928	3,924	1,369	0	0	2,787	0,386	1,098	52,425

Table 11. Objective Function Value Iteration 1

Total Cluster 1	Total Cluster 2	Total
30,037	20,556	50,593
84,433	36,128	120,562
53,425	39,033	92,458
35,745	63,107	98,853
19,148	52,425	71,573
Objective Function Value (FO)		**434,042**

The value (FO) is obtained by multiplying the distance between the data and the cluster center by the square of the degree of membership, resulting in a value of 434.042, the objective function value from the first iteration. This value will be compared with other objective function values to determine whether the iteration process will continue or be halted.

5. Calculate the change in membership degree in the partition matrix for each data point in each cluster.

Total Cluster 1	Total Cluster 2	Total	U1	U2
30,037	20,556	50,593	0,593	0,406
84,433	36,128	120,562	0,700	0,299
53,425	39,033	92,458	0,577	0,422
35,745	63,107	98,853	0,361	0,638
19,148	52,425	71,573	0,267	0,732

In the first and second columns, the values are obtained from the summation frac $[\sum_{j=1}^{n}(X_{ij} - V_{kj})^2]^{\frac{-1}{w-1}}$, . The third column is derived from the summation of the total columns of cluster 1 and cluster 2. The fourth and fifth columns are obtained by dividing the total column of cluster 1 and cluster 2 by the total column.

6. Check the stopping condition where $(|Pt - P_{t-1}| < \varepsilon)$.. The value of $P_1 = 434{,}0423549$ and $P_0 = 0$, thus $|P_1 - P_0| = 434{,}042$· Since the value of P_1 is greater than $\varepsilon = 0{,}001$, the iteration process continues by increasing the iteration t = t + 1 and then repeating step 3 until the last iteration, when the process has stopped using the new matrix (U) generated in the previous step.

Table 12. Calculation of the Final Iteration Partition Matrix

Total Cluster 1	Total Cluster 2	Total	U1	U2
15,266	47,650	62,917	0,153	0,846
23,779	100,821	124,600	0,104	0,895
31,955	70,639	102,594	0,206	0,793
93,983	19,270	113,254	0,960	0,039
78,006	10,599	88,605	0,960	0,039

Table 13. Results of Rest Area Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Favorite Muslim Restaurant	0,846	0,153	0,846	Recommendation
2	Bang Jali Pidie Jaya Seafood	0,895	0,104	0,895	Recommendation
3	Singon	0,793	0,206	0,793	Recommendation
4	Awak Away	0,039	0,960	0,960	Not Recommended
5	Dinnar Restaurant	0,039	0,960	0,960	Not Recommended

Table 14. Results of Place of Worship Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Great Mosque of Subulussalam	0,162	0,837	0,837	Not Recommended
2	Assilmi Mosque	0,083	0,916	0,916	Not Recommended
3	Al Mukarramah Mosque	0,129	0,870	0,870	Not Recommended
4	Taqwa Muhammadiah Mosque	0,161	0,838	0,838	Not Recommended
5	Al Munawwarah Mosque	0,093	0,906	0,906	Not Recommended
6	Nur Lail Mosque	0,086	0,913	0,913	Not Recommended
7	Baiturrahmah Mosque	0,084	0,915	0,915	Not Recommended
8	Al Anshor Mosque	0,216	0,783	0,783	Not Recommended
9	At Taubah Mosque	0,191	0,808	0,808	Not Recommended
10	Baitul Makmur Mosque	0,146	0,853	0,853	Not Recommended
11	Al Muttaqin Mosque	0,144	0,855	0,855	Not Recommended
12	Al Iman Mosque	0,078	0,921	0,921	Not Recommended
13	GMII Lahai roi Penanggalan	0,964	0,035	0,964	Recommendation
14	GKPPD Resort	0,942	0,057	0,942	Recommendation
15	Catholic Church Stations of Blessed Dionysius and Redemptus	0,905	0,094	0,905	Recommendation

Table 15. Results of Gas Station Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Oyon Subulussalam gas station	1	0	1	Recommendation
2	Kasman Lizar Penanggalan gas station	4,34E-32	1	1	Not Recommended

Table 16. Result of ATM (Automated Teller Machine) Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	BSI KCP Penanggalan	0,535	0,464	0,535	Recommendation
2	BSI KCP Subulussalam	0,866	0,133	0,866	Recommendation
3	BSI Hotel Khairulsyah	0,049	0,950	0,950	Not Recommended
4	BANK ACEH KCP Subulussalam	0,815	0,184	0,815	Recommendation
5	BANK ACEH Cab. Subulussalam	0,880	0,119	0,880	Recommendation

Table 17. Result of Restaurant Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Nusantara Restaurant	0,798	0,201	0,798	Recommendation
2	Garuda Restaurant	0,302	0,697	0,697	Not Recommended
3	Anda Restaurant	0,373	0,626	0,626	Not Recommended
4	Jogja Restaurant	0,642	0,357	0,642	Recommendation
5	Barak Restaurant	0,688	0,311	0,688	Recommendation
6	Simpang Raya Restaurant	0,720	0,279	0,720	Recommendation
7	Pondok Minang Restaurant	0,513	0,486	0,513	Recommendation
8	Ampera Buyuang Restaurant	0,255	0,744	0,744	Not Recommended
9	Carano Restaurant	0,256	0,743	0,743	Not Recommended
10	Ranah Minang Restaurant	0,445	0,554	0,554	Not Recommended
11	Gadih Minang Restaurant	0,538	0,461	0,5381	Recommendation

Table 18. Result of Tourist Attraction Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Rafting	0,800	0,199	0,800	Recommendation
2	Religious Tourism: Tomb of Sheikh Hamzah Fansuri	0,501	0,498	0,501	Recommendation
3	Grandcanyon Penuntungan	0,519	0,480	0,519	Recommendation
4	Soraya Waterfall	0,532	0,467	0,532	Recommendation
5	Kedabuhan Waterfall	0,881	0,118	0,881	Recommendation
6	Sarindan Spring Pool	0,766	0,233	0,766	Recommendation
7	Grand Canyon Babah Luhung	0,674	0,325	0,674	Recommendation
8	Sikelang Swimming Pool	0,549	0,450	0,549	Recommendation
9	SKPC Waterfall	0,192	0,807	0,807	Not Recommended
10	Penuntungan Waterfall	0,165	0,834	0,834	Not Recommended
11	Silelangit Waterfall	0,773	0,226	0,773	Recommendation
12	Lae Impal Waterfall	0,177	0,822	0,822	Not Recommended

Table 19. Result of Supermarket Clustering

No	Place Name	Cluster		Selected Cluster	Total
		Cluster 1	Cluster 2		
1	Prosperous self-service	0,770	0,229	0,770	Recommendation
2	MR. DIY	0,735	0,264	0,735	Recommendation
3	Raudah Market	0,794	0,205	0,794	Recommendation
4	Al Fatih	0,684	0,315	0,684	Recommendation
5	Alfamidi	0,461	0,538	0,538	Not Recommended
6	Indomaret T. Umar Penanggalan	0,384	0,615	0,615	Not Recommended
7	Indomaret T. Umar No 79	0,483	0,516	0,516	Not Recommended
8	Indomaret T. Umar No 42	0,196	0,803	0,803	Not Recommended
9	Indomaret Sim. Beringin	0,242	0,757	0,757	Not Recommended
10	Indomaret T. Umar Subulussalam	0,194	0,805	0,805	Not Recommended
11	Indomaret T. Umar No 39	0,609	0,390	0,609	Recommendation

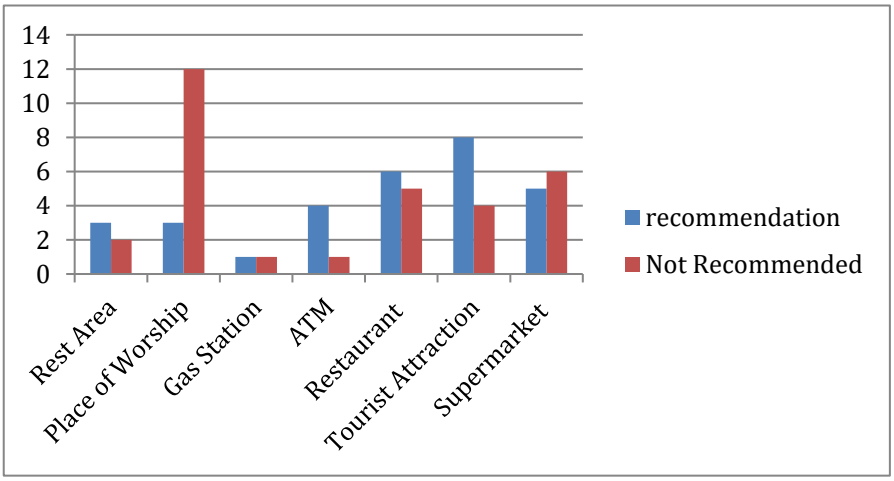

Fig 3. Cluster Result Chart of Public Facilities in Subulussalam City

From calculations using Fuzzy C-Means, previously obtained cluster results from each public facility in Subulussalam City are then displayed in the form of a bar chart, as shown above.

4.5. System Implementation

System implementation is the application and operation of a system that has been designed and subsequently developed. This process includes various steps to ensure the system runs smoothly and meets user needs.

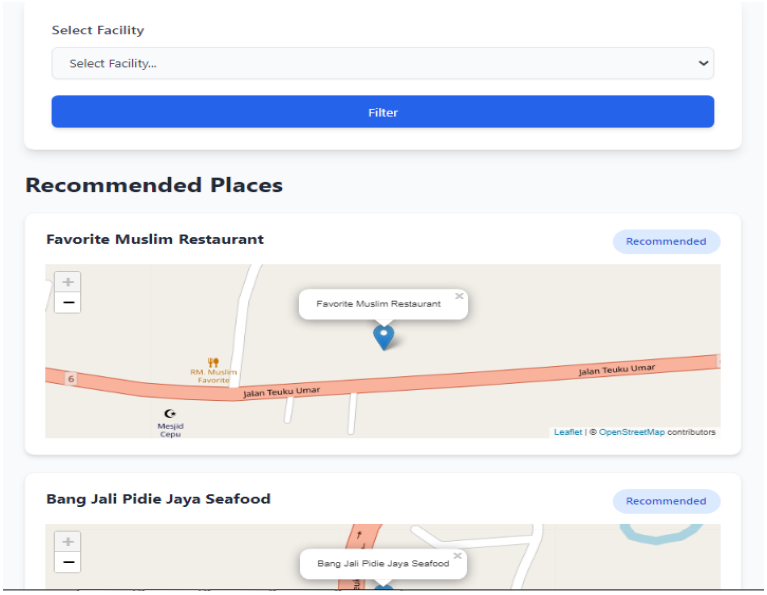

Fig 4. Home Page

The image above shows the initial display when the system is run. Users can select the facility they want on this page to view the recommendation results.

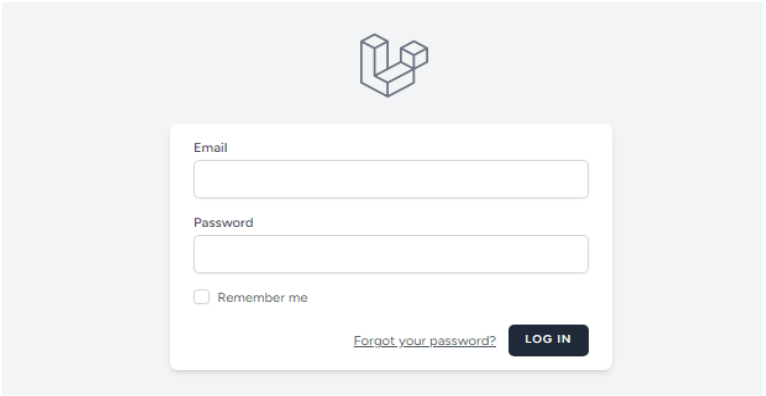

Fig 5. Login Page

On the login page, the admin must enter a username and password to access the next page, which is the dashboard.

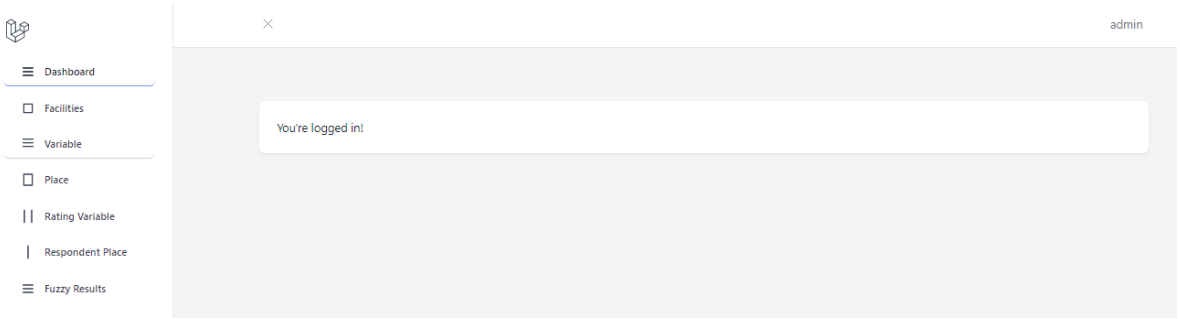

Fig 6. Dashboard Page

The dashboard page is the system's main page after the admin successfully logs in. All the menus available within the system will be shown on this page.

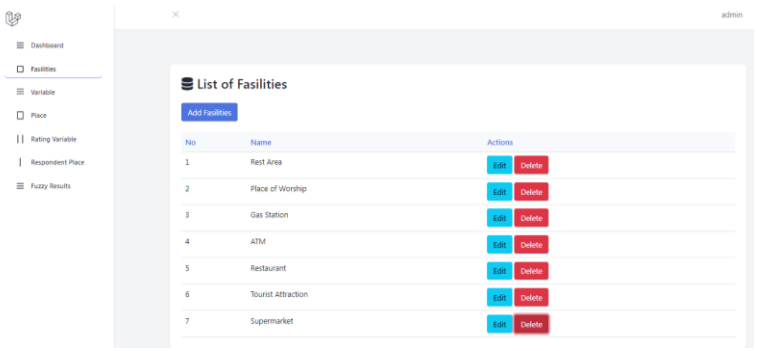

Fig 7. Facility Page

This page displays facility data and includes several menus: add facility, edit, and delete facility data.

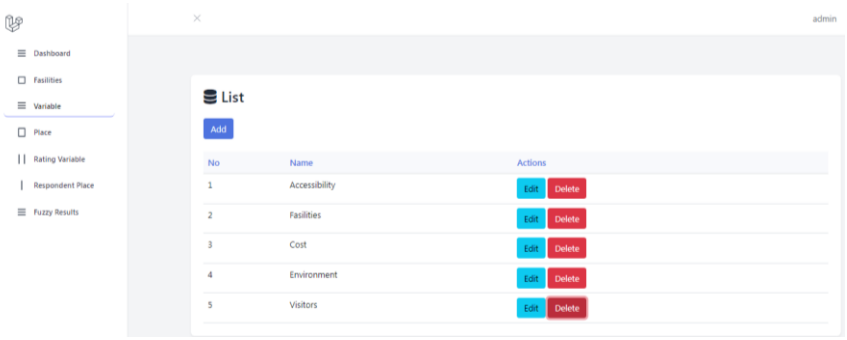

Fig 8. Variable Page

This page presents variable data and includes several menus: add variable, edit, and delete variable data.

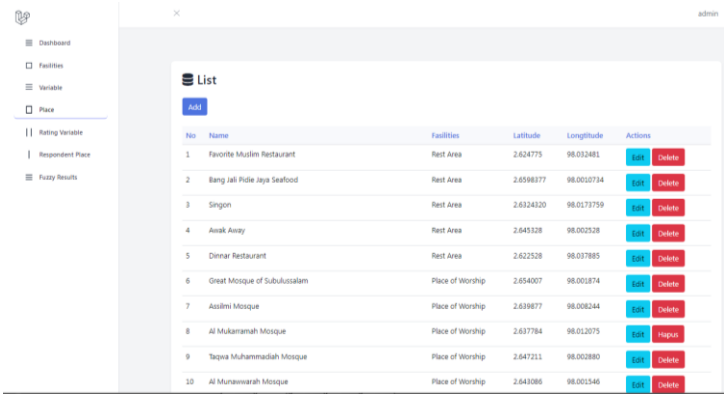

Fig 9. Place Data Page

This page displays location data and includes several menus: add Place, edit, and delete Place data.

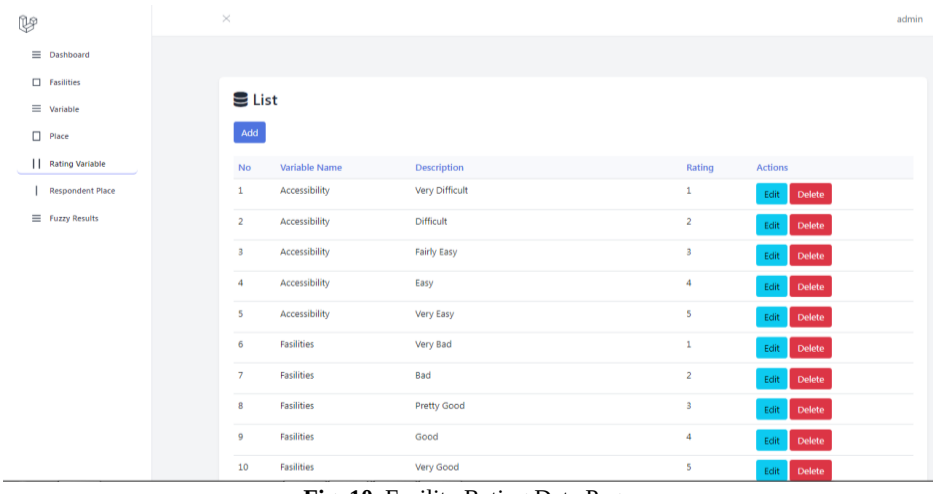

Fig 10. Facility Rating Data Page

This page displays variable rating data and includes several menus: add, edit, and delete facility rating data.

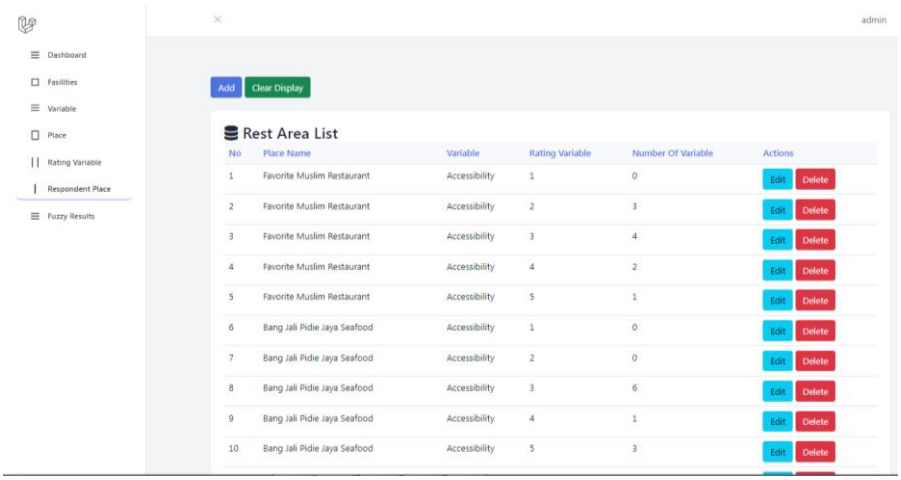

Fig 11. Respondent Location Data Page

This page displays respondent location data and includes several menus: add, edit, and delete respondent location data.

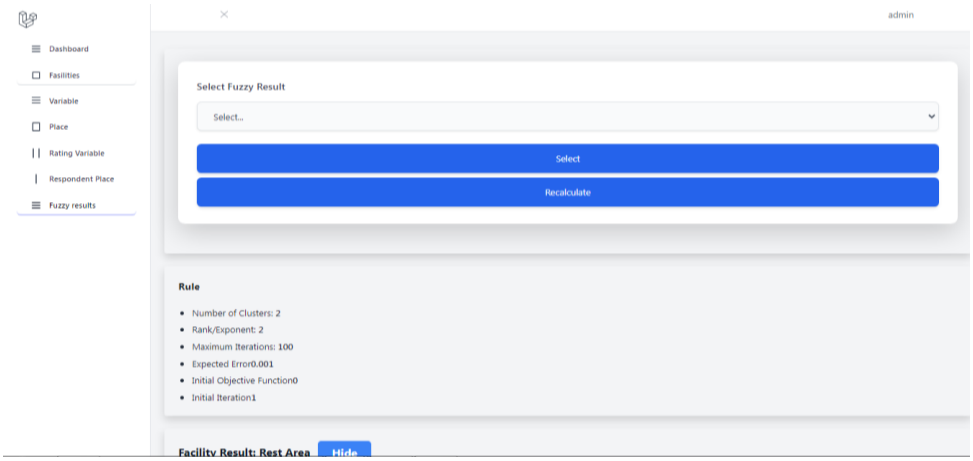

Fig 12. Fuzzy Results Page

This page includes features such as the initial value determination process for fuzzy c-means calculations. This calculation aims to determine clusters. The system will divide the data into Cluster 1 for recommendations and Cluster 2 for non-recommendations.

5. Conclusion

From the study's results on clustering public facility recommendations in Subulussalam City using the FCM algorithm, the obtained data was divided into 2 clusters: cluster 1 (recommended) and cluster 2 (not recommended). From 7 public facilities: Rest Area, Place of Worship, Gas Station, ATM, Restaurant, Tourist Attractions, and Supermarket, it can be concluded that cluster 1 consists of 31 places including Favorite Muslim Restaurant, Bang Jali Pidie Jaya Seafood, Singon, GMII Lahai Roi Penanggalan, GKPPD Resort, St. Dionisius and Redemtus Catholic Church, Oyon Subulussalam Gas Station, BSI KCP Penanggalan, BSI KCP Subulussalam, BANK ACEH KCP Subulussalam, BANK ACEH Branch Subulussalam, RM. Nusantara, RM. Jogja, Barak, RM. Simpang Raya, RM. Pondok Minang, RM. Gadih Minang, Rafting/Arum Jeram, Religious Tourism of Sheikh Hamzah Fansuri's Tomb, Grandcanyon Penuntungan, Soraya Waterfall, Kedabuhan Waterfall, Sarindan Spring Pool, Grandcanyon Babah Luhung, Sikelang Swimming Pool, Silelangit Waterfall, Sejahtera, MR. DIY, Raudah Market, Al Fatih, Indomaret T. Umar No 39. Cluster 2 consists of 31 places including Awak Away, Dinner Restaurant, Grand Mosque of Subulussalam City, Assilmi Mosque, Al Mukarramah Mosque, Taqwa Muhammadiah Mosque, Al Munawwarah Mosque, Nur Lail Mosque, Baiturrahmah Mosque, Al Anshor Mosque, At Taubah Mosque, Baitul Makmur Mosque, Al Muttaqin Mosque, Al-Iman Mosque, Kasman Lizar Penanggalan Gas Station, BSI Khairulsyah Hotel, Garuda Restaurant, Anda Restaurant, Ampera Buyuang Restaurant, Carano Restaurant, Ranah Minang Restaurant, SKPC Waterfall, Penuntungan Waterfall, Lae Impal Waterfall, Alfamidi, Indomaret T. Umar Penanggalan, Indomaret T. Umar No 79, Indomaret T. Umar No 42, Indomaret Sim. Beringin, Indomaret T. Umar Subulussalam.

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