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Ranting Muhammadiyah Clustering Using the K-MODES Algorithm

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***Abstract*--Research on Muhammadiyah often focuses on its preaching models, responses to various conditions, and strategies in proselytization or resource management, but there is limited exploration of the Muhammadiyah organization itself. Specifically, the condition of *Pimpinan Ranting Muhammadiyah* (The Leader of Muhammadiyah Sub-Branch or PRM) as the lowest organizational structure, is seldom addressed. Currently, the LPCR utilizes SICARA to categorize organizations based on scores reflecting routine activities, yet it does not map these organizations based on similar potential. Thus, there is a need for a method to group these organizations based on a condition mapping to facilitate targeted revitalization efforts. This study aims to cluster PRM based on the Branch and Sub-branch Information System (*Sistem Informasi Cabang dan Ranting* or SICARA) questionnaire responses. Given that the SICARA questionnaire data is categorical, the K-MODES method was chosen for clustering. The optimal number of clusters was determined using the elbow method. The resulting clusters, derived using the elbow method, there are eight clusters, each exhibiting distinct characteristics.**

Keywords: **Clustering; Clusters; Elbow method; K-Modes; Sub-branch or *Ranting* Muhammadiyah.**

I. INTRODUCTION

Muhammadiyah is one of the oldest organizations in Indonesia which still carries out many activities. There were many studies about Muhammadiyah as a da'wah organization, such as how Muhammadiyah responds to digital da'wah [1], [2], [3], [4], [5], da'wah models in remote areas [6], da'wah management and strategies [7], [8], digital da'wah using television [9], then multilevel da'wah using print media [4]. Studies on Muhammadiyah's educational goals [10] and community empowerment efforts [11], [12], [13], [14] demonstrated that Muhammadiyah is an interesting institution to study. Studies on waqf management [15], [16] and waqf management based on the SIMAM application examined the accounting side [17] and demonstrated how Muhammadiyah uses information technology to manage assets. However, studies that discuss its driving organization, the Muhammadiyah Branch Leadership (PRM), are still rare.

The 46th Muhammadiyah Congress in Yogyakarta regarding the guidelines for revitalizing Branches and Sub-Branches [18], showed that there were problems in the driving organization, namely the activity of the Muhammadiyah Branch Leadership (*Pimpinan Cabang Muhammadiyah* or PCM) and the Muhammadiyah Sub-branch Leadership (*Pimpinan Ranting Muhammadiyah* or PRM). Responding to this problem, an institution was formed, namely the Branch and Sub-Branch Development Institute (*Lembaga Pengembangan Cabang dan Ranting* or LPCR), an institution whose main task is to handle the problem of PCM and PRM activity. LPCR conducted data collection and mapping of PCM and PRM conditions starting with piloting in two locations, namely the Special Region of Yogyakarta [19] and DKI Jakarta [20], [21]. This condition mapping uses a scoring method to categorize activity, so that organizations can be grouped into Active, Less Active, and Vacuum. This method was then implemented in the SICARA application as a tool that facilitates mapping and data collection of PCM and PRM throughout Indonesia [22], [23]. Along the way, apart from using scores, LPCR also created a categorization of excellence with certain criteria to award superior PCM and PRM [24].

Grouping organizations based on scores is not yet suitable for revitalization, as it only looks at routine activities, not the same potential. This necessitates a method for grouping these organizations based on condition mapping to facilitate revitalization within specific groups. This grouping is still based on answers to a questionnaire completed in the SICARA application.

Currently, there is no organizational clustering, especially for PRM as the driving force of organizations at the lowest level. This prompted the purpose of this study to create a PRM clustering based on the SICARA

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questionnaire. Because the questionnaire data in SICARA is categorical, the K-MODES method was chosen for clustering. Then, to determine the optimum number of clusters, the elbow method was used.

Clustering is primarily used to form groups with large dissimilarities [25] so that there are significant differences between one group and another. This clustering has been used for grouping the working age population [26], grouping the population by gender [27], grouping provinces based on employment characteristics [28], grouping districts based on performance indicators [29]. There were also a clustering of households in the use of clean water [30] and clustering of causes of stress in students [31]. Based on the data processed in it, clustering can be divided into two: numerical data and categorical data. Numerical data is data in the form of numbers, while categorical data is in the form of text, or labels other than numbers. The clustering method used for numerical data is K-Means and for categorical data using K-Modes. K-Modes was first introduced by Huang in 1998, which is a modification of K-Means for clustering categorical data [32]. The use of both methods requires determining the optimal number of clusters so that the clusters formed are appropriate. One of the methods used to determine the optimum number of clusters is the elbow method [33], [34], [35].

II. METHOD

This study used 9,506 existing PRM from SICARA in 2021. These PRM data were collected since 2018 (Fig. 1). Twenty-one variables were used, including geographic location, deliberations, office ownership, frequency of member studies, frequency of general studies, places of worship, membership, social issues, number of members, and the presence of Muhammadiyah's Charity Business (*Amal Usaha* Muhammadiyah or AUM). The PRM data input activity is shown in Table I.

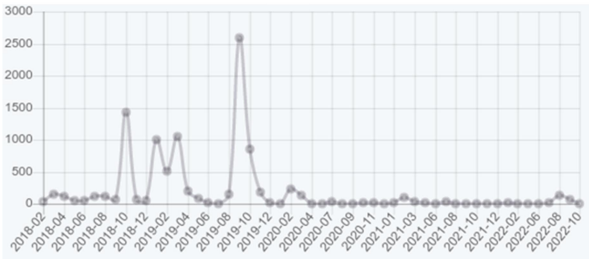

Fig. 1. PRM data input activity on sicara.id

TABLE I
Variabel Data

No.	Column Name	Keterangan
1.	prm_type	Sub-branch types (urban, rural, or inland)
2.	prm_musran	Conference year
3.	prm_status_kantor	Office ownership status
4.	prm_kajian_anggota	Presence or absence of membership studies
5.	prm_kajian_umum	Presence or absence of general studies
6.	prm_pusat_kegiatan	Activity center in the form of a mosque or prayer room
7.	prm_paud	Presence of early childhood education (*Pendidikan Anak Usia Dini* or PAUD)
8.	prm_tk	Presence of kindergarten
9.	prm_sd	Presence of elementary school
10.	prm_sltp	Presence of junior high school
11.	prm_sma	Presence of senior/ vocational/islamic high school
12.	prm_tpq	Presence of islamic religious education institutions (*Taman Pendidikan Al-Qur'an* or TPQ)
13.	prm_pontren	Presence of islamic boarding schools
14.	prm_rs	Presence of hospitals
15.	prm_paym	Presence of orphanages
16.	prm_pengangguran	Unemployment problems
17.	prm_pendidikan	Education problems
18.	prm_kriminal	Crime problems
19.	prm_kristenisasi	Christianization problems
20.	prm_sm	Subscriptions to Suara Muhammadiyah Magazine
21.	prm_jmlm	Number of Muhammadiyah members

The steps are as shown in Fig. 2. Starting with text preprocessing, which checked the prm_musran column and changed its contents to the conference year period, namely '2005-2010', '2010-2015', and '2015-2020'. The next step was Filtering Null Data, which filtered the data to ensure there are no empty or null columns. Then, the optimum number of clusters was calculated using the elbow method. Clustering was then carried out using K-Modes.

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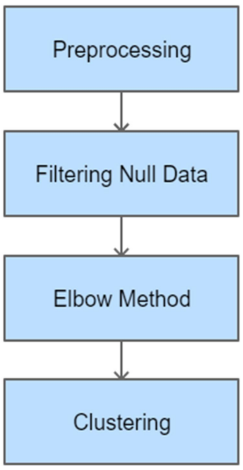

Fig. 2. Research Stages

III. RESULT AND DISCUSSION

This clustering used Python programming with a library from scikitlearn [36]. This clustering began by determining the optimum number of clusters used. The calculation of the optimum number of clusters was done by comparing the scores and changes in the slope of the scores at each iteration. The optimum number of clusters calculated using the elbow method was displayed using KelbowVisualizer [37] and the optimum number of clusters was 8 (shown in Fig. 3). The optimum number of clusters is shown in the vertical line that shows a decrease in the distortion number and the sloping graph afterward. This optimum number of clusters was then used as the number of clusters in the K-Modes calculation.

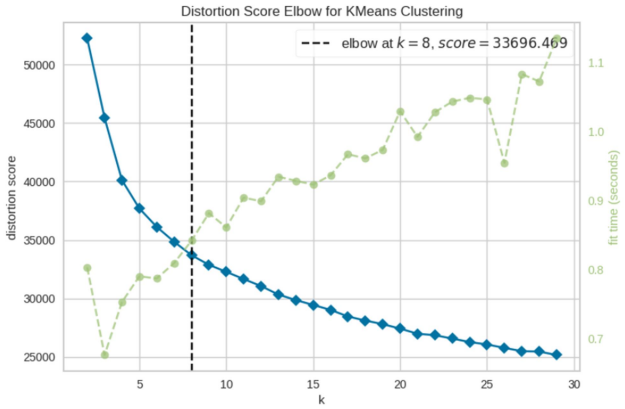

Fig. 3. Optimal Cluster Visualization

The K-Modes calculation yields eight centroids, indicating the centers of the clusters (shown in Table II). These centroids demonstrate the unique characteristics of each cluster. The significant differences between these clusters indicate that each cluster has its own characteristics. From these cluster centroids, we can map their characteristics, such as type, monsoon year, office status, and member studies. Each cluster may still overlap, but it already has certain characteristics.

TABLE II
Centroid cluster formed

	prm_type	prm_musran	prm_status_kantor	prm_kajian_anggota	prm_kajian_umum	prm_pusat_kegiatan	prm_paud	prm_tk	prm_sd	prm_sltp
0	Pedesaan	2015-2020	Numpang Rumah Pengurus	Satu kali	Satu kali	Masjid	Tidak	Tidak	Tidak	Tidak
1	Pedesaan	2015-2020	Hak Milik Ranting	Lebih dari dua kali	Lebih dari dua kali	Masjid	Ya	Ya	Ya	Tidak
2	Perkotaan	2015-2020	Numpang Rumah Pengurus	Tidak ada	Tidak ada	Tidak ada	Tidak	Tidak	Tidak	Tidak
3	Pedesaan	nihil	nihil	nihil	nihil	nihil	Tidak	Tidak	Tidak	Tidak
4	Perkotaan	2015-2020	Numpang Amal Usaha	Satu kali	Lebih dari dua kali	Masjid	Tidak	Ya	Ya	Ya
5	Pedesaan	2015-2020	Numpang Rumah Pengurus	Lebih dari dua kali	Satu kali	Masjid	Ya	Ya	Tidak	Tidak
6	Perkotaan	2015-2020	Numpang Amal Usaha	Lebih dari dua kali	Lebih dari dua kali	Masjid	Tidak	Ya	Ya	Tidak
7	Pedesaan	2015-2020	Numpang Rumah Pengurus	Satu kali	Satu kali	Mushalla	Tidak	Tidak	Tidak	Tidak

Pedesaan = Rural. *Perkotaan* = Urban.
Numpang Rumah Pengurus = Sharing the Administrator's House.
Hak Milik Ranting = Sub-branch Ownership.
Nihil = -. *Tidak ada* = None.
Satu kali = Once.
Lebih dari dua kali = More than twice.
Masjid = Mosque. *Mushalla* = Prayer room.
Tidak = No, *Ya* = Yes.

The members of these eight clusters are diverse (shown in Table II). Cluster_0 has the largest number of members, with 4,400 PRMs, and Cluster_4 has the smallest number of members, with 392 PRMs. Two clusters, Cluster_2 and Cluster_7, have more than 1,000 PRMs.

From the formed clusters, the distribution according to the variables used can be seen. Based on the PRM type shown in Fig, 4, each cluster has members with the PRM type of Inland, Rural, Urban, and some who did not complete the questionnaire. PRM with the Rural type is more than the Urban and Rural types, namely in Cluster_0, Cluster_1, Cluster_2, Cluster_5, and Cluster_8. PRM with the Urban type is more than Rural and Rural in Cluster_2, Cluster_4, and Cluster_6. The cluster with the most people who did not complete the questionnaire is in Cluster_3 with 235 PRM. Meanwhile, the cluster with the fewest who did not complete the questionnaire is Cluster_4, namely only 2 PRM who did not complete the questionnaire. The characteristics of each cluster are shown in Table III.

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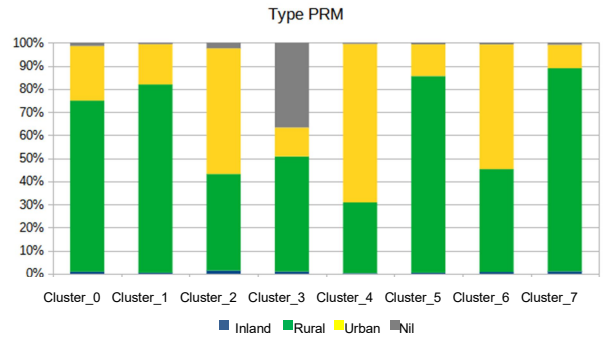

Fig. 4. Type PRM

TABLE III
Clusters and Number of Members

No.	Cluster	Jumlah Anggota
1.	Cluster_0	4400
2.	Cluster_1	946
3.	Cluster_2	1022
4.	Cluster_3	640
5.	Cluster_4	392
6.	Cluster_5	699
7.	Cluster_6	402
8.	Cluster_7	1005

The characteristics of Cluster_0:
1. The largest number of members, namely 4,400 PRMs.
2. Branch type is predominantly rural.
3. Organizational order.
4. PRM office: shared with the administrator's house (68%).
5. Has a mosque.
6. Membership study once.
7. General study once.
8. Problems: education, unemployment, Christianization, crime.
9. A small percentage of AUM members in PRM (TPQ 22% and TK 15%).
10. Subscribe to Suara Muhammadiyah or SM (24%).
11. The estimated number of members in PRM is less than 100 (78%).

The characteristics of Cluster_1:
1. Cluster with 946 PRM members.
2. Predominantly rural branch type.
3. Well-organized organization.
4. PRM office: Branch ownership rights 44.08%.
5. Has a mosque, one member study.
6. One general study.
7. Problems: unemployment, education, christianization, crime.
8. Order of AUM in PRM environment: TPQ, SD/MI, TK, PAUD.
9. Subscribe to SM (73%).
10. Estimated number of PRM members is 100-500 (67%).

The characteristics of Cluster_2:
1. Cluster with the largest number of members, namely 1,022 PRMs.
2. Branch types are predominantly urban.
3. Organizational order.
4. PRM offices are housed by administrators (78.77%).
5. No mosque/prayer room.
6. Most members have no studies.
7. Most have no general studies.
8. Problems: unemployment, education, christianization, crime.
9. Order of AUM in the PRM environment: TPQ (Islamic Boarding School), Kindergarten, Elementary School/Islamic Elementary School, Early Childhood Education (PAUD).
10. Subscribers to SM (15%).
11. The estimated number of members in PRM is less than 100 (87%).

The characteristics of Cluster_3:
1. Cluster with the largest num*ber of members, namely 640 PRMs.*
2. Branch type: predominantly rural.
3. Organizational disorganization.
4. PRM office: no answer 88.59%.
5. Did not provide information on having a mosque/prayer room.
6. Majority did not provide information on member survey.
7. Majority did not provide information on general survey.
8. Problems: unemployment, education, crime, Christianization.
9. Order of number of AUMs within the PRM environment: TPQ, SD/MI, TK, PAUD.
10. Majority did not provide information on SM subscriptions.
11. The estimated number of members in the PRM was mostly not provided.

The characteristics of Cluster_4:
1. The cluster with the largest number of members, namely 392 PRMs.
2. The majority of the branches are urban.

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3. Organizational order.
4. The PRM office is *Numpang Amal Usaha* or Donate to a Charity Business (68.37%).
5. Have a mosque.
6. One-time member study.
7. One-time general study.
8. The problems are: unemployment, education, crime, Christianization.
9. The order of the number of AUMs within the PRM environment is: Elementary School/Islamic Elementary School, Islamic Boarding School, Kindergarten, Junior High School, Senior High School, Early Childhood Education, Islamic Boarding School, Hospital.
10. Subscribers to SM (79%).
11. The estimated number of members in PRM is less than 100 (62%).

The characteristics of Cluster_5:

1. Cluster with 699 PRM members.
2. Predominantly rural branch type.
3. Well-organized organization.
4. PRM office using the administrator's house (61.95%).
5. Have a mosque.
6. One-time member study.
7. One-time general study.
8. Problems: education, unemployment, Christianization, crime.
9. Order of AUM in PRM environment: TPQ, Kindergarten, Early Childhood Education, Elementary School/Islamic Elementary School, Junior High School, Senior High School, Islamic Boarding School, Islamic Boarding School, Hospital.
10. Subscribe to SM (20%).
11. The estimated number of members in PRM is less than 100 (53%).

The characteristics of Cluster_6:

1. Cluster with 402 PRM members.
2. Balanced urban and rural branch types.
3. Organizational order.
4. PRM office serving as a charity business (61.94%).
5. Have a mosque.
6. One-time member study.
7. One-time general study.
8. Problems: education, unemployment, crime, Christianization.
9. Order of AUM within the PRM environment: Kindergarten, Elementary School/Islamic Elementary School, Islamic Boarding School, Middle School, High School, Islamic Boarding School, Islamic Boarding School, Islamic Boarding School, Hospital.
10. Subscribe to SM (30%).
11. The estimated number of members in PRM is 100–500 (66%).

The characteristics of Cluster_7:

1. Cluster with 1,005 PRM members.
2. Predominantly rural branch type.
3. Well-organized organization.
4. PRM office using the administrator's house (79.70%).
5. Have a prayer room.
6. Once member study.
7. Once general study.
8. Problems: unemployment, education, Christianization, crime.
9. Order of AUM in PRM environment: TPQ, Kindergarten, Elementary/Islamic Elementary School, Early Childhood Education, Junior High School.
10. Subscribe to SM (21%).
11. The estimated number of members in PRM is less than 100 (75%).

Based on those characteristics, the differences between each cluster can be seen. Cluster_0 with the largest number of PRMs turns out to have the least AUM. The composition of mosque or prayer room ownership also differs across clusters. The type of branch within each cluster varies between rural and urban areas, although the majority is rural. These characteristics can differentiate the types of organizations and their growing da'wah.

When compared to the categorization in the Sicara application shown in Fig. 5, it is found that each category exists in each cluster. Cluster_3 is predominantly in the vacuum category, Cluster_2 is predominantly in the "active" category and Cluster_7 is predominantly in the "less active" category. This clustering can group PRMs not only based on scoring but also on their characteristics.

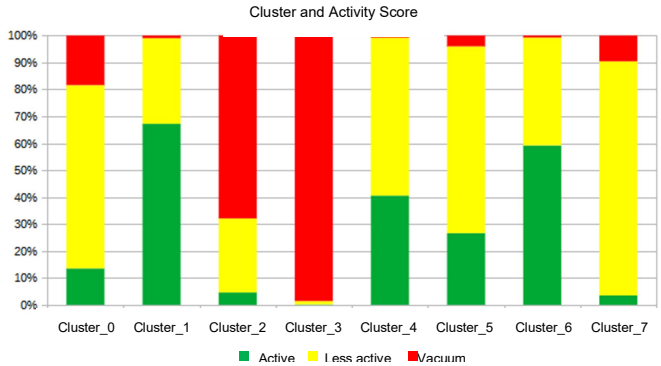

Fig. 5. Clusters and scoring of speech

IV. CONCLUSION

Based on the clustering results and comparison with the scoring-based PRM categorization, this method is more effective in grouping PRM based on organizational characteristics. The eight clusters formed, each with distinct characteristics, can serve as a guide for organizational improvement or mentoring.

In future research, more data could be used to test the number of clusters formed. Comparability of cluster selection methods could also be improved by using multiple methods to more reliably determine the number of clusters.

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