



Clustering of Sub-districts in Cilacap Regency Based on the Number of Health Facilities, Active KB Participants, and Population Growth Rate Using K-Means Cluster Analysis

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Abstract

This research examines clustering of sub-districts in Cilacap Regency based on the number of healthcare facilities, active family planning (FP) participants, and population growth rate using K-Means Cluster analysis. The study was conducted at the Cilacap Regency Statistics Bureau using 2023 data. The purpose of this research is to identify differences in each subdistrict's characteristics to support precise policy formulation. The analysis uses R 4.4.1 software and involves Euclidean distance measurement techniques and standard deviation to determine data similarity between sub-districts. Based on the results, five clusters with unique characteristics were identified. Clusters 1 and 2 have moderate levels of healthcare facilities and FP participants, while Cluster 3 represents sub-districts with the highest number of healthcare facilities and FP participants. Cluster 4 has a low population growth rate, while Cluster 5 includes sub-districts with the highest growth rate. This clustering provides critical information for the allocation of health resources and effective implementation of FP programs. Recommendations for further research include adding related factors to refine clustering results and provide deeper insights for decision-making in the regional health sector.

Keyword: Number Of Healthcare Facilities, Active FP Participants, Population Growth Rate, K-Means Clustering, Clustering.

1. Introduction

Health problems in society, especially in developing countries such as Indonesia, are influenced by two factors: physical and non-physical aspects. The physical aspect includes health facilities and disease treatment, while the non-physical aspect involves health-related issues such as human behavior in the form of knowledge, attitudes, and actions. Health services are a basic right of the people that must be fulfilled through health development. Health development is carried out to increase awareness, willingness, and the ability to live a healthy life for every individual in order to achieve the highest possible standard of public health.

Health facilities in Indonesia, particularly in Cilacap Regency, still need serious attention from the government. The lack of adequate health facilities in several districts within Cilacap Regency causes difficulties for the local population in maintaining a healthy life and accessing treatment. For instance, if people want to access contraceptive health services, they will face challenges if the necessary facilities are lacking.

High population growth can hinder development in various sectors, such as an increase in poverty rates. Therefore, efforts to control birth rates need to be implemented, one of which is through the Family Planning (FP) program. The National Family Planning Movement of Indonesia has been recognized globally as a successful program in significantly reducing birth rates. The FP program was initiated by the government alongside the establishment of the National Population and Family Planning Agency (BKKBN) in 1970. The FP program is regulated under Law No. 10 of 1992, with BKKBN as the overseeing body. This program includes the use of contraceptive devices to prevent or delay pregnancy.

According to data from the Indonesian Demographic and Health Survey (IDHS), the trend of Total Fertility Rate (TFR) has decreased since 1991: 3% in 1991, 2.9% in 1994, 2.8% in 1997, 2.6% in 2002, 2.6% in 2012, and

2.6% in 2017. This trend coincides with an increase in the Contraceptive Prevalence Rate (CPR): 49.7% in 1991, 54.7% in 1994, 57.4% in 1997, 60.3% in 2002, 61.4% in 2012, and 61.9% in 2017.

The available data on FP in the SICANTIK system has yet to provide optimal information. One way to maximize this data is through clustering. Clustering is a data analysis method used to solve data grouping problems (Handoyo, 2013). One clustering method is K-Means. K-Means has the ability to group large amounts of data with relatively fast and efficient computation time (Arai & Barakbah, 2007).

Khoirunnisa & Dzikkruallah (2020) used the K-Means method to cluster districts based on active FP contraceptive use in the Special Region of Yogyakarta. Their research resulted in 4 clusters based on the similarity of regional characteristics in terms of seven types of contraceptives: IUD, MOW, MOP, condom, implant, injection, and pills. Utami (2020) applied the K-Means method to form clusters of contraceptive users (case study at the FP Office of Yogyakarta City), resulting in 2 clusters based on regional characteristics related to user interest in MOW, MOP, implants, and pills.

The application of the K-Means method to analyze the spread of Covid-19 cases by province in Indonesia by Sari (2020) resulted in 5 clusters. The use of the K-Means method by Wati et al. (2019) for contraceptive method selection resulted in 3 clusters, and for predicting contraceptive supply (case study: Deliserdang Regency), 4 clusters were identified.

Based on these studies, this research aims to cluster the districts in Cilacap Regency that have health facilities, active FP participants, and population growth rates quickly and effectively.

2. Theoretical Foundation

Health problems in society, particularly in developing countries like Indonesia, are influenced not only by the availability of physical facilities but also by non-physical aspects such as public knowledge and behavior toward health (Notoatmodjo, 2012). Equitable health development is essential to ensure that the basic right of every citizen to access health services is fulfilled.

One of the key issues in public health development is controlling population growth. Uncontrolled population growth can lead to various social, economic, and health problems (Sukmana, 2015). Therefore, since 1970, the Indonesian government has initiated the Family Planning (FP) program, managed by the National Population and Family Planning Agency (BKKBN). This program aims to reduce birth rates through education and the use of contraceptives (BKKBN, 2020).

According to the Indonesia Demographic and Health Survey (IDHS), there has been a declining trend in the Total Fertility Rate (TFR), accompanied by an increase in the Contraceptive Prevalence Rate (CPR), indicating the effectiveness of the FP program over time (BPS, BKKBN, Ministry of Health, & ICF, 2017).

In the context of analyzing health and FP program data, *clustering* methods have been widely used to understand patterns and group regions based on specific indicators. One of the most popular clustering methods is K-Means, which is effective in grouping large datasets with relatively fast and efficient computation (Arai & Barakbah, 2007).

Khoirunnisa and Dzikkruallah (2020) used the K-Means method to cluster sub-districts based on active contraceptive types in the Special Region of Yogyakarta and successfully formed four clusters based on regional similarities in seven types of contraceptives. Another study by Utami (2020) also demonstrated the effectiveness of K-Means in clustering contraceptive users in Yogyakarta City into two clusters based on user preferences for MOW, MOP, implants, and pills.

Sari (2020) applied the K-Means method to analyze the spread of Covid-19 cases across Indonesian provinces and identified five clusters. Meanwhile, Wati et al. (2019) used K-Means for selecting contraceptive methods and predicting their stock in Deliserdang Regency, resulting in three and four clusters respectively. These studies indicate that the K-Means method holds great potential for data-driven decision-making in public health sectors.

3. Research Methodology

The research method used is a combination of Literature Study from various sources and Case Study. The data used includes the number of health facilities, active family planning (FP) participants, and population growth rate in Cilacap Regency from July 2024 to August 2024, obtained from the Cilacap Regency Central Bureau of Statistics (BPS).

4. Results and Discussion

The results of the Kaplan-Meier survival analysis using $\alpha = 5\%$ are summarized in the plot figure 4.1. The survival probability throughout years is calculated based on general Kaplan-Meier model of equation 2.2. Using the Surv() function, available in the survival() library in Rstudio software, we find out that employee who accept overtime are more likely to leave the company earlier than those who don't accept overtime as shown by the steeper drop in the

curve. The analysis was conducted using R 4.4.1 software. Steps taken to group or cluster Subdistrict in Cilacap Regency based on the number of health facilities, active KB participants, and population growth rate are as follows.

- 1) Data collection on the number of health facilities, active family planning participants, and population growth rate in Cilacap Regency in 2023.
- 2) Determining descriptive statistics from data on the number of health facilities, active family planning participants, and population growth rate in Cilacap Regency in 2023.
- 3) Standardization of data on the number of health facilities, active family planning participants, and population growth rate in Cilacap Regency in 2023.
- 4) Determine the number of clusters to be formed.
- 5) Allocate each object into a cluster.
- 6) Interpreting clusters.

4.1 Descriptive Statistics

Based on the data obtained, namely data on the number of health facilities, active KB participants, and population growth rate in Cilacap Regency in 2023, an analysis will be carried out by determining descriptive statistics from the data obtained. Based on the analysis output using R 4.4.1 software, descriptive statistics are obtained.

Table 1. Descriptive Statistics

	Number of health facilities	Active KB participants	Population growth rate per year 2020-2023 (%)
N	24	24	24
Min	10	1822	0.33
1 st Qu	61.75	7510	0.6675
Median	72	8768	1.08
Mean	75.04	9465	1.0396
3 rd Qu	90.5	11219	1.3425
Max	151	17937	1.86
Sd	30,9199	3849,928	0.423246
Mode	logical	logical	logical
False	24	24	24

In Table 1, the N value or the amount of data from the number of health facilities, active KB participants, and population growth rate is the same, namely 27. For the data on the number of health facilities, the minimum value is 10, the maximum value is 151, the average value is 75.04, the median value is 72, the first quartile value is 61.75, the third quartile value is 90.5 and the standard deviation value is 30.9199. Then for the data on active KB participants, the minimum value is 1822, the maximum value is 17937, the average value is 9465, the median value is 8768, the first quartile value is 7510, the third quartile value is 11219 and the standard deviation value is 3849.928. Then for the population growth rate data, the minimum value is 0.33, the maximum value is 1.86, the average value is 1.0396, the median value is 1.08, the first quartile value is 0.6675, the third quartile value is 1.3425 and the standard deviation value is 0.423246. The data used consists of numeric data and name data. Subdistrict. Since the numeric data is located in the second to third columns, the missing value check is only performed in the second to third columns. Based on the output of the R 4.4.1 software, it turns out that the data on the number of health facilities, active KB participants, and population growth rate in Cilacap Regency do not have missing values.

4.2 Data Standardization

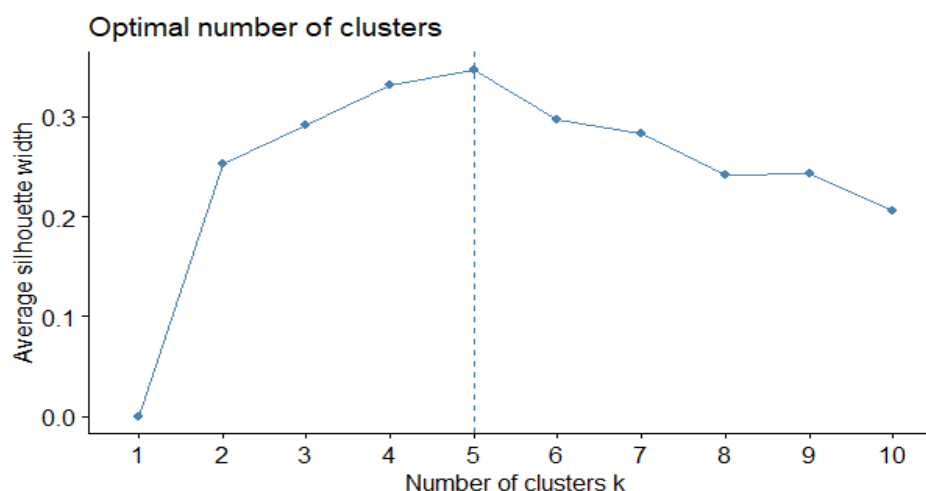
Standardizing data can be done by using the Z-score value. The Z-score value can be calculated by subtracting the average and then dividing it by the standard deviation for each variable. Data standardization serves to ensure that all variables have the same scale before the grouping process is carried out. A negative number means that the data is below the average of all data on the variable. A positive number means that the data is above the average of all data on the variable. The higher the Z-score value, the further the data is from the average. To speed up the calculation, it can be done using R 4.4.1 software, the following is the output result of data standardization using R 4.4.1 software.

Table 2. Data Standardization

No.	Subdistrict	Number of health facilities	Active KB participants	Population growth rate per year 2020-2023 (%)
1.	The Day of the Blessed	-0.32476	-0.9437	-1.67653
2.	Wanareja	-0.45413	1.88233	-1.10948
3.	The Majestic	1.098268	1.526739	-0.96772
4.	The Cimanggu	0.54846	0.911402	-0.84958
5.	The Coral Reef	-0.06603	-0.05667	-0.70782
6.	Cipari	0.451435	-0.40265	0.733419
7.	Sidareja	-0.29242	-0.6398	-0.14078
8.	The Village	-0.51881	-0.11615	0.638911
9.	The Patimuan	-1.68311	-0.93902	-0.66057
10.	The Gandrungmangu	-0.29242	0.703347	0.709792
11.	Bantarsari	-2,10355	-0.31096	0.662538
12.	The Land of the Rising Sun	-0.09837	-0.05069	0.331761
13.	Sea Village	-1.61843	-1.98528	0.638911
14.	Orange	0.483777	-0.22758	1.938391
15.	Pleasure	2.456617	1.524141	0.922434
16.	Adipala	1,292318	0.062815	1.064195
17.	Maos	-0.1954	-1.3302	-0.96772
18.	Lacquer	0.257386	-0.89331	-0.11715
19.	Crocodile	1.615734	2,200518	0.166373
20.	Binangun	0.580802	-0.32369	1.253211
21.	The Greatness of the Nation	-0.42179	-0.46369	1.276838
22.	South Cilacap	0.063336	-0.36602	-1.6529
23.	Central Cilacap	-0.09837	0.372951	-1.51114
24.	North Cilacap	-0.68052	-0.13485	0.024611

4.3 Determining the number of clusters

To determine the number of k clusters, you can use the Silhouette method. Using R 4.4.1 software, the following output is obtained.

**Figure 1.** Number of Clusters

Based on the output above, it can be seen that the optimal number of clusters is 5 or $k = 5$. So that clusters will be formed for the number of health facilities, active KB participants, and population growth rates in 5 clusters.

4.5 Clustering

It has been known in the previous point, that the optimal number of clusters is 5. By using R 4.4.1 software, it can be seen that the number of Sub-districts in the first cluster is 6 Sub-districts, the second cluster is 6 Sub-districts, the third cluster is 2 Sub-districts, the fourth cluster is 6 Sub-districts and the fifth cluster is 4 Sub-districts. The following is clustering based on the output of R 4.4.1 software.

	Jumlah.sarana.Kesehatan	Pengguna.KB.aktif	Laju.pertumbuhan.penduduk.per.tahun.2020.2023....	final.cluster
1	-0.31792603	-0.92382785	-1.64122702	4
2	-0.44456876	1.84269732	-1.08612029	1
3	1.07514403	1.49459319	-0.94734361	1
4	0.55891242	0.89221285	-0.83189637	1
5	-0.06464058	-0.05547459	-0.69291969	1
6	0.44193037	-0.39417051	0.71797659	5
7	-0.28626534	-0.62632469	-0.13781296	4
8	-0.50789013	-0.11370385	0.62545880	2
9	-1.64767472	-0.91925088	-0.64666079	4
10	-0.28626534	0.68853760	0.69484714	2
11	-2.05926360	-0.30441100	0.64858825	2
12	-0.09630124	-0.04962624	0.32477599	2
13	-1.58435335	-1.94547546	0.62545880	4
14	0.47359105	-0.22278834	1.89757840	5
15	2.4124	-0.09630124 -0.68853760	0.3010226 0.13031171	3
16	1.26510813	0.06149246	1.04178885	5
17	-0.19128329	-1.30219086	-0.94734361	4
18	0.25196627	-0.87449827	-0.11468351	4
19	1.58171496	2.15418568	0.16286986	3
20	0.56857310	-0.31687054	1.22682443	5
21	-0.41290808	-0.45392542	1.24995388	2
22	0.06200217	-0.35833756	-1.61809758	1

Figure 2. Clustering

Based on the output above, a clustering table can be formed as follows.

Table 3. District Clustering

Cluster	Amount	Subdistrict
1	6	Wanareja, Majenang, Cimanggu, Karangpucung, South Cilacap, and Central Cilacap
2	6	The area of Kedungreja, Gandrungmangu, Bantarsari, Kawunganten, Nusawungu, and North Cilacap
3	2	Riches and Kroya
4	6	Dayeuhluhur, Sidareja, Patimuan, Sea Village, Maos, and Sampang
5	4	Cipari, Jeruklegi, Adipala, and Binangun

Based on the above clustering, sub-district plot clusters can be created as follows.

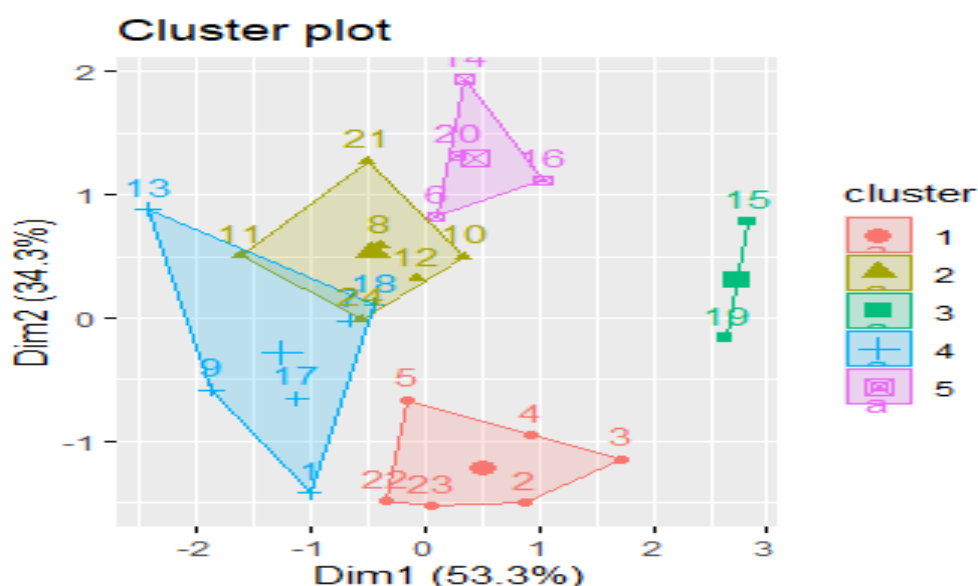


Figure 3. Cluster Plot

To interpret each cluster result, descriptive statistics can be used on each cluster. Based on the output of R 4.4.1 software, the descriptive statistics of each cluster are obtained as follows.

Table 4. Minimum, Maximum, Mean and Standard Deviation Values for Each Cluster of Health Facilities

	Cluster(Number of Health Facilities)				
	1	2	3	4	5
Minimum	61	10	125	23	89
Maximum	109	72	151	83	115
Mean	80.67	53.83	138	55.17	96.75
Standard Deviation	15,627	20,383	13	22,821	10,639

Table 5. Minimum, Maximum, Mean and Standard Deviation Values of Each Active KB Participant Cluster

	Cluster(Active KB participant)				
	1	2	3	4	5
Minimum	8056	7680	15333	1822	7915
Maximum	16712	12173	17937	7002	9707
Mean	12206	9226	16635	5146	8608
Standard Deviation	3120,252	1421,049	1302	1677,176	678,183

Table 6. Minimum, Maximum, Mean and Standard Deviation Values of Each Cluster Population Growth Rate Per Year 2020-2023

	Cluster(Population Growth Rate Per Year 2020-2023)				
	1	2	3	4	5
Minimum	0.34	1.05	1.11	0.33	1.35
Maximum	0.74	1.58	1.43	1.31	1.86
Mean	0.56	1,297	1.27	0.8333	1,567
Standard Deviation	0.145	0.162	0.16	0.309	0.186

From the table above, each cluster will be interpreted. The interpretation of each cluster will be based on the cluster of the number of health facilities, active KB participants, and the population growth rate cluster. Before interpreting the results of each cluster, the limits or grouping of the number of health facilities, active KB participants, and population growth rates in each cluster will be defined first.

Cluster interpretation based on the number of health facilities

a. *Cluster1*

Cluster 1 consists of 6 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 1 has characteristics including having a difference in the number of health facilities of 48, having an average value of 80.67 and having a standard deviation value of 15.627. Thus, it can be concluded that cluster 1 is a grouping of sub-districts with an average the number of health facilities is the third highest in the other five clusters.

b. *Cluster2*

In cluster 2 consists of 6 Subdistrict in Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 2 has characteristics including having a difference in the number of health facilities of 62, having an average value of 53.83 and having a standard deviation value of 20.383. Thus, it can be concluded that cluster 2 is a grouping Subdistrict with the lowest average number of health facilities among the other five clusters.

c. *Cluster3*

In cluster 3 consists of 2 Subdistrict in Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 3 has characteristics including having a difference in the number of health facilities of 26, having an average value of 138 and having a standard deviation value of 13. Thus, it can be concluded that cluster 3 is a grouping Subdistrict with the highest average number of health facilities among the other five clusters.

d. *Cluster4*

In cluster 4 consists of 6 Subdistrict in Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 3 has characteristics including having a difference in the number of births of 60, having an average value of 55.17 and having a standard deviation value of 22.821. Thus, it can be concluded that cluster 4 is a grouping Subdistrict with an average number of health facilities ranked fourth from the highest in the other five clusters.

e. *Cluster5*

Cluster 5 consists of 4 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 5 has characteristics including having a difference in the number of health facilities of 26, having an average value of 96.75 and having a standard deviation value of 10.639. Thus, it can be concluded that cluster 5 is a grouping of sub-districts with the second highest average number of health facilities in the other five clusters.

Cluster interpretation based on active KB participants

a. *Cluster1*

Cluster 1 consists of 6 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 1 has characteristics including having a difference in active KB participants of 8656, having an average value of 12206 and having a standard deviation value of 3120.252. Thus, it can be concluded that cluster 1 is a grouping of sub-districts with the second highest average of active KB participants in the other five clusters.

b. *Cluster2*

Cluster 2 consists of 6 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 2 has characteristics including having a difference in active KB participants of 4493, having an average value of 9226 and having a standard deviation value of 1421.049. Thus, it can be concluded that cluster 2 is a grouping of sub-districts with an average of active KB participants in the third highest order in the other five clusters.

c. *Cluster3*

Cluster 3 consists of 2 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 3 has characteristics including having a difference in active KB participants of 2604, having an average value of 16635 and having a standard deviation value of 1302. Thus, it can be concluded that cluster 3 is a grouping of sub-districts with the highest average number of active KB participants among the other five clusters.

d. *Cluster4*

Cluster 4 consists of 6 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 4 has characteristics including having a difference in active KB participants of 5180, having an average value of 5146 and having a standard deviation value of 1677.176. Thus, it can be concluded that cluster 4 is a grouping of sub-districts with the lowest average number of active KB participants among the other five clusters.

e. *Cluster5*

Cluster 5 consists of 4 sub-districts in Cilacap Regency. Sub-districts included in this cluster generally have the same characteristics. Cluster 5 has characteristics including having a difference in active KB participants of 1792, having an average value of 8608 and having a standard deviation value of 678.183. Thus, it can be concluded that cluster 5 is a grouping of sub-districts with an average of active KB participants ranked fourth from the highest in the other five clusters.

Cluster interpretation based on population growth rate

a. *Cluster1*

In cluster 1 consists of 6 sub-districts in Cilacap Regency. The sub-districts included in this cluster are generally have the same characteristics. Cluster 1 has characteristics including having a difference in population growth rate of 0.4, having an average value of 0.56 and having a standard deviation value of 0.145. Thus, it can be concluded that cluster 1 is a groupingSubdistrictwith the lowest average population growth rate among the other five clusters.

b. *Cluster2*

In cluster 2 consists of 6Subdistrictin Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 2 has characteristics including having a population growth rate difference of 0.53, having an average value of 1.297 and having a standard deviation value of 0.162. Thus, it can be concluded that cluster 2 is a groupingSubdistrictwith an average population growth rate that is the second highest in the other five clusters.

c. *Cluster3*

In cluster 3 consists of 2Subdistrictin Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 3 has characteristics including a difference in population growth rate of 0.32, an average value of 1.27 and a standard deviation value of 0.16. Thus, it can be concluded that cluster 3 is a groupingSubdistrictwith an average population growth rate of the third highest in the other five clusters.

d. *Cluster4*

In cluster 4 consists of 6Subdistrictin Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 4 has characteristics including a difference in population growth rate

of 0.98, an average value of 0.8333 and a standard deviation value of 0.309. Thus, it can be concluded that cluster 4 is a grouping Subdistrict with an average population growth rate of the fourth highest in the other five clusters.

e. *Cluster 5*

In cluster 5 consists of 4 Subdistrict in Cilacap Regency. The sub-districts included in this cluster generally have the same characteristics. Cluster 5 has characteristics including a difference in population growth rate of 0.51, an average value of 1.567 and a standard deviation value of 0.186. Thus, it can be concluded that cluster 5 is a grouping Subdistrict with the highest average population growth rate among the other five clusters.

5. Conclusion

Based on the results and discussion, it can be concluded that the data used can be grouped into five clusters. There are three types of clusters, namely clusters for the number of health facilities, clusters for active family planning (FP) participants, and clusters for population growth rate. Based on this grouping, it can be seen that the sub-district with the highest number of health facilities is Kesugihan Sub-district, or in other words, the cluster with the highest number of health facilities is Cluster 3. The sub-district with the highest number of active FP participants is also Kesugihan Sub-district, meaning that the cluster with the highest number of active FP participants is Cluster 3. The sub-district with the highest population growth rate is Jeruklegi Sub-district, or in other words, the cluster with the highest population growth rate is Cluster 5.

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