



## Human Development Cluster Analysis in Banten Province: A Global Perspective on the Impact of the COVID-19 Pandemic

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**Abstrak:** *Human Development Index (HDI) adalah indikator jangka panjang yang membutuhkan kewaspadaan dalam interpretasinya. Selain itu, HDI adalah indikator pembentukan kemajuan pembangunan manusia yang dilihat berdasarkan kecepatan dan status HDI dalam suatu periode, sehingga pembangunan manusia sangat penting dalam strategi kebijakan nasional untuk pengembangan ekonomi dan sumber daya manusia secara merata di suatu wilayah. Oleh karena itu, penelitian ini bertujuan untuk mengkluster distrik/kota di Banten menggunakan algoritma pada k-means dan fuzzy c-mean dengan dikelompokkan ke dalam 4 cluster sekaligus. Untuk melihat cluster terbaik menggunakan tes validasi, dan sebagai sarana informasi dan input dalam hal peningkatan pengembangan secara merata di Provinsi Banten. Oleh karena itu, pengolahan data diperlukan untuk mendapatkan metode dan hasil cluster terbaik. Peneliti melakukan pemrosesan data menggunakan algoritma k-means dan fuzzy c-Means. Hasil tes validasi adalah 0,38 dan 0,78. Kemudian hal ini menunjukkan bahwa penggunaan algoritma fuzzy c-means pada indikator HDI lebih baik daripada nilai algoritma k-media, karena nilai validasi lebih dekat dengan 1. hasil clustering yang didapat pada kedua metode baik terutama dalam karakteristik anggota yang masuk kedalam cluster, dengan mengelompokkan 8 kabupaten/kota ke dalam 4 cluster dihasilkan pada k-means untuk cluster 1 beranggota kota Tangerang dan kota Tangerang Selatan, cluster 2 Kabupaten Lebak, cluster 3 kabupaten Tangerang, kota Serang, dan kota Cilegon dan cluster 4 kabupaten Pandeglang, dan kabupaten Serang. Sedangkan pada fuzzy c-means pada cluster 1 beranggota Kabupaten Tangerang, Kota Cilegon dan Kota Serang, cluster 2 kota Tangerang dan kota Tangerang Selatan, cluster 3 Kabupaten Pandeglang dan Kabupaten Serang, dan cluster 4 Kabupaten Lebak.*

**Kata kunci:** *Clustering, Fuzzy C-Means, Indeks Pembangunan Manusia, K-Means, dan Uji Validitas.*

**Abstract:** *The Human Development Index (HDI) is a long-term indicator that requires caution in its interpretation. Moreover, the human development index is an indicator of the formation of human development progress seen based on the speed and status of the HDI in a period, so human development is very important in the national policy strategy for the development of the economy and human resources evenly in a region. Therefore this study aimed to cluster districts/cities in Banten using algorithms on k-means and fuzzy c-means by being grouped into 4 clusters*

*at once. To view the clustering best using validation test, and as a means of information and input in terms of increasing development evenly in Banten province. Therefore, data processing is needed to get the best cluster methods and results. Researchers conducted data processing using k-means and fuzzy c-means algorithms. The results of the validation test were 0.38 and 0.78. Then this shows that the use of those fuzzy c-means algorithm on the HDI indicator is better than the value of the algorithm k-means because validation values are closer to 1. The clustering obtained on both the good especially in characteristics of members of entering the cluster, by grouping eight districts/cities to 4 cluster produced on k-means for cluster of 1 membered Tangerang and South Tangerang, cluster of 2 Lebak district, cluster of 3 Tangerang district, Serang and Cilegon city, and cluster of 4 Pandeglang and Serang district, while in fuzzy c-means consists cluster of 1 membered Tangerang, Cilegon and Serang city, cluster of 2 Tangerang and South Tangerang, cluster of 3 Pandeglang and Serang district, and cluster of 4 Lebak district .*

**Keywords:** *Clustering, Fuzzy C-means, Human Development Index, K-means, and Validation Test*

## **INTRODUCTION**

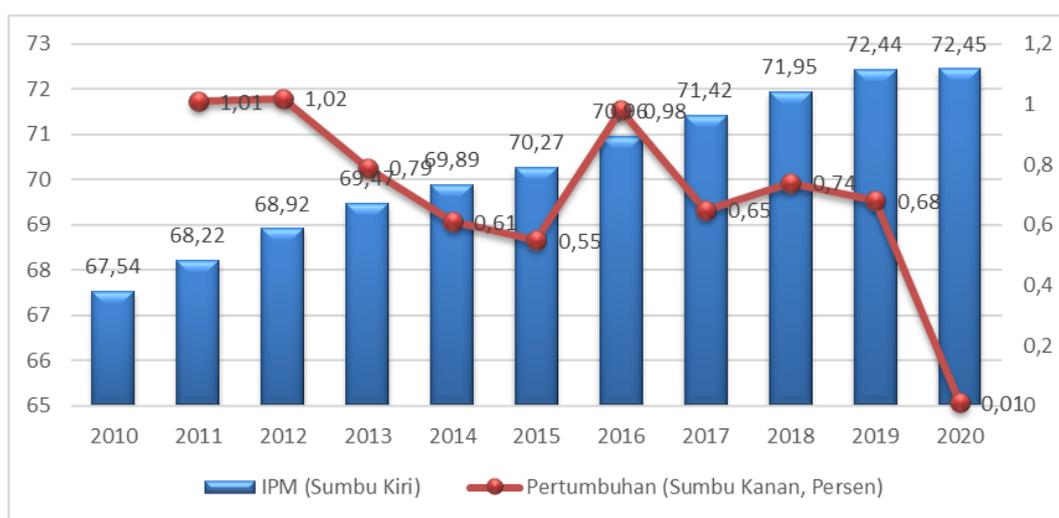
As the wealth of a nation, man has the basic capital of development. It makes man the ultimate goal of development. The primary priority of development can be focused on man, thus development has the main goal of creating an environment where people can enjoy a long life, have good health, and have a productive life. It sounds simple, but it is often forgotten from the short-term special life to accumulate quality and money.

Concerning the advancement of human development, the population must be made a priority or a focus of attention. It is meant to enable people to expand their choices, which includes not just increasing their incomes. Hence, the concept of human development is to be concentrated on all aspects of people, and not just an effort to enhance their own human capabilities, but an effort to improve human capacities optimally.

The quality of human development is crucial to the national policy strategy for economic development. Emphasis on the importance of the quality of human development becomes a must because high resources will create a better life in various aspects, both social and economic. So the quality acquired will have a major impact on the success of regional development management.

The Human Development Index (HDI) can be used as an indicator to measure the level of human development in a country. HDI covers three fundamental dimensions in the great role of improving the quality of human life, which include a long and healthy life, knowledge, and a decent standard of living. If the level of HDI is high, then its human resources will be assured to have a good quality of development.

The growth of human development in Banten Province over the course of the last ten years has continued to progress consistently. Banten's HDI rose from 67.54 in 2010 to 72.45 in 2020 (Figure 1).



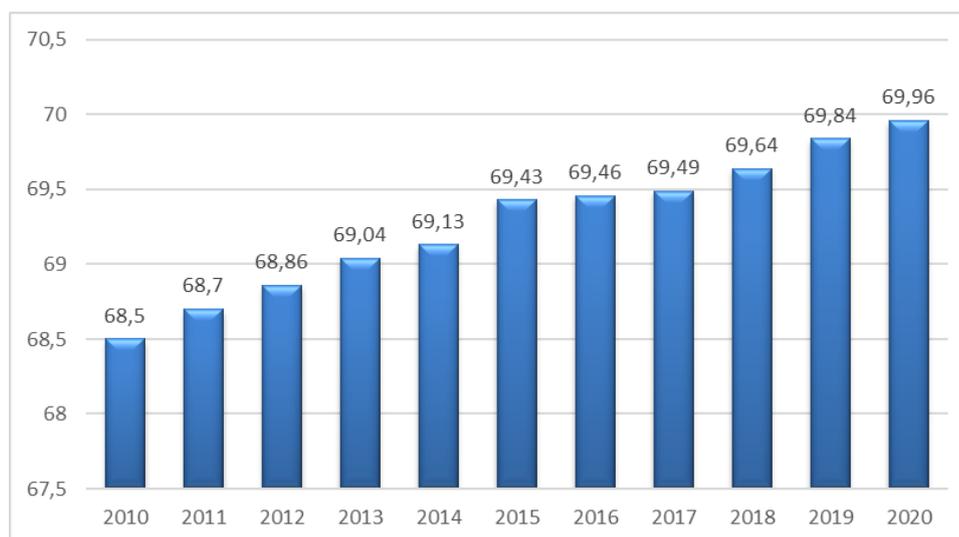
**Figure 1. Development of the Banten Human Development Index (HDI) 2010-2020**

Source: Central Statistical Agency of Banten Province, 2020

Unfortunately, the growth of this figure in 2020 has been declining due to the impact of COVID-19. It can be seen from the quality of human development that despite continuously increasing, the pace of its improvement turns out to be slowing down. This slowdown can be seen in its development, which is only 0.01 percent lower than its previous growth of 0.68 percent. This slower pace will produce effects in a slow time toward ideal development.

The growth in the HDI's forming indicators—life expectancy/ *Umur Harapan Hidup* (UHH), average school age/ *Rata-rata Lama Sekolah* (RLS), school age expectation/ *Harapan Lama Sekolah* (HLS), and per capita expenditure/ *Pengeluaran Per Kapita* (PPK), which only saw increases in 3 of the forming

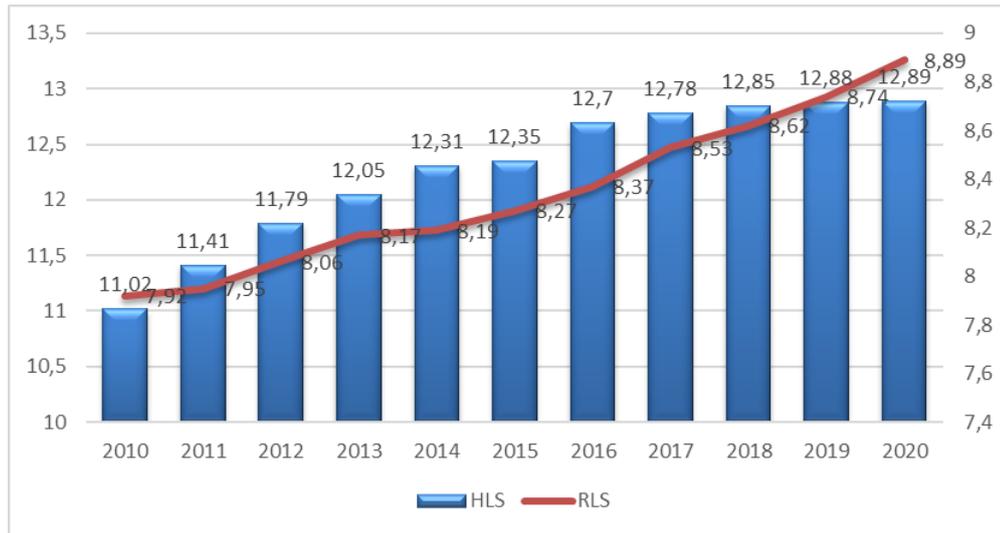
indicators—such as UHH, HLS, and RLS—marked the slowdown in the size of the HDI in Banten Province in 2020. While the indicators of living standards, represented by per capita expenditure, experienced a decrease in 2020 due to the impact of COVID-19, the three indicators of HDI formation that are still undergoing improvement, such as UHH, HLS, and RLS, and the development of UHH, can be observed based on the graph (Figure 2).



**Figure 2. UHH Development 2010-2020**

Source: Central Statistical Agency of Banten Province, 2020

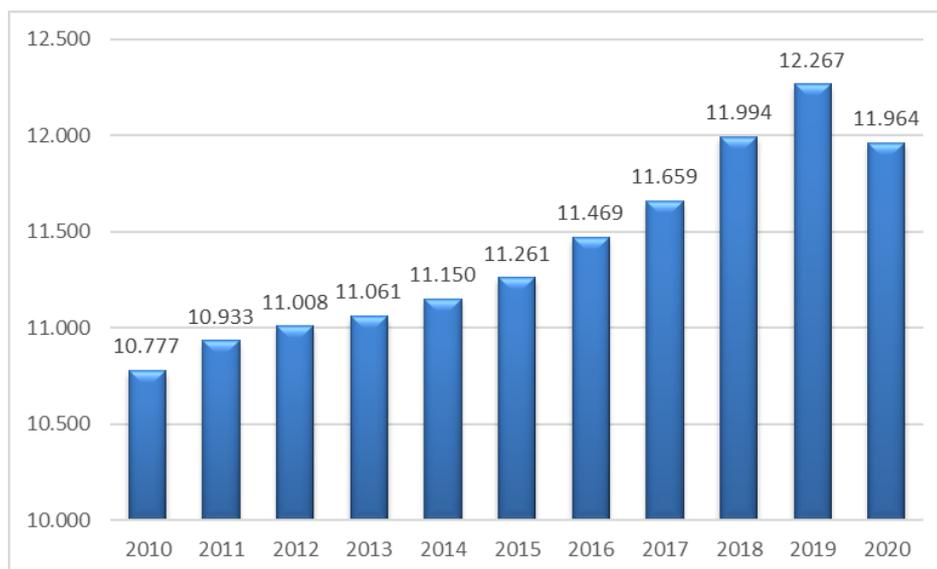
According to the results of UHH development, almost all year 2020, the COVID-19 pandemic attacked Banten. But generally, it hasn't affected the level of public health. Moreover, the percentage of people who have health complaints in 2020 is only 16.06 percent. (BPS, 2020b). As for the next formative indicator, education has two main formative components: old school expectancy (HLS) and average school age (RLS). Based on (Figure 3), the growth of HLS and RLS in the same period continues to increase. This could be a sign that the quality of education for the average population has improved and has also marked the improvement of the means and infrastructure as well as the level of public participation in the field of education. So the opportunities for the population to improve quality of life and level of well-being are becoming more open, which also signals that the Banten education system has gone in the right direction.



**Figure 3. Development of HLS and RLS in Banten 2010–2020**

Source: Central Statistical Agency of Banten Province, 2020

The growth of HLS and RLS in 2020 does not reflect any improvement in the quality of teaching. This is because the online learning that took place during the COVID-19 pandemic did not take place effectively, either in terms of learning time or the materials taught. Besides, not all students have internet access. While per capita spending is an indicator of a decent standard of living in the Banten province, which is experiencing a decline as a result of the COVID-19 pandemic, which has reduced the well-being of the population. It can be seen (Figure 4) based on the course of time during the years 2010–2019, which has been constantly increasing to reach 12.27 million rupiah. But by 2020, it had decreased to 11.96 million rupiah. While population expenditure is also lower when compared to 2018, it reached 11.99 million. Nevertheless, the size of spending in 2020 is well above the average spending of the Indonesian population, which is only 11,01 million rupiah.



**Figure 4. Development of per capita expenditure 2010–2020**

Source: Central Statistical Agency of Banten Province, 2020

The success of human development is measured not only by the magnitude and status of categorization but also by the acceleration of improvement in its construction. It is human development access in the HDI. The central government or even the region in its own development efforts, must not let up on high or low an HDI access. In 2020, the value of the HDI, in the province of Banten has slowed down from the previous year, but the construction category is still said to be “high” (BPS, 2020b).

Based on the problem, the researchers want to do a grouping on the HDI. In addition to the planning of the next program, the grouping has the same development role as a whole based on the district or town in the province of Banten. This clustering uses statistical tools based on cluster analysis, using K-means and Fuzzy C-Means (FCM) to analyze which clusters are the best on the Human Development Index indicator. Both of these methods have been done by several researchers, including Ramadan and Efendi (2017), on the grouping of user knowledge modeling data, where the cluster is grouped into 4 clusters. The comparison used is a validity-performance test. Where it is obtained that the use of methods on FCM is superior to K-Means because the validity of the result is close to 1.

Further with the research entitled “Comparison of the K-Means Algorithm with the Fuzzy C-Means (FCM) Algorithm in the GPS-based Mode of Transportation Clustering” by Syarif (Syarif, Furqon, and Adinugroho n.d). In this study, the K-Means algorithm at the center of the cluster obtained the smallest distance data mode of transportation, but on the FCM algorithm, the result grouping produced the greatest degree value on its membership. All performed as many as 10 tests, with averages of accuracy on K-means and fuzzy C-means in succession of 58,46154 and 70,86538. For silhouette coefficient values, both K-means and fuzzy-C-means successively obtained mean values of 0,4582670 and 0,440682. Then it can be said that the FCM algorithm is better used than K-means.

Further research is entitled “Analysis of the Performance of Fuzzy C-Means and K-Means Algorithms on Poverty Data” by Ulfah (Ulfah 2015). In this study, conducted in Girijati Purwosari Village, researchers grouped poverty data in the village into three clusters. Clustering phases, that is, by cleaning and transforming data before testing on both methods. Researchers found that the data from FCM and K-means were similar in terms of how they calculated poverty indicators. Data equality rates on FCM and K-Means with calculations of poverty indicators of 50% and 83.33%. Then for this research the K-Means algorithm is more suitable to be applied to the grouping of poverty data.

This research is different from previous research. The study identifies three major development-related issues in Banten Province by 2020. First, there is a significant slowdown in development, with the Human Development Index (HDI) growing by only 0.01 percent, compared to a growth of 0.68 percent in 2019. This condition indicates a developmental challenge that may be caused by various factors, and to be of particular concern in the planning of future development programs.

Second, despite an increase in HDI, the increase only occurred on three formative indicators, namely life health practice/*Umur Harapan Hidup* (UHH), average school age/, Rata-rata Lama Sekolah (RLS) and school age expectation/*Harapan Lama Sekolah* (HLS). The Serang district, in particular, recorded a significant increase in RLS indicators of 8.89 years, HLS of 12.89 years, and UHH

of 69.96 years. Further analysis of these patterns of improvement can provide important insights into the factors that support or hinder such development.

Third, there is a decrease in the per capita expenditure component that reflects a decent standard of living by 2020, with the value falling to 11.96 million rupiah. This decline is linked to the impact of the COVID-19 pandemic on the population or the labour force, highlighting the need for economic recovery strategies that focus on improving the well-being of communities amid uncertainty. Improvements in this dimension become essential to achieving sustainable and equitable development in the Banten Province.

Based on this, the researchers conducted a study in Banten Province with eight districts and cities based on HDI indicators with variables such as life expectancy (UHH), per capita expenditure/ Pengeluaran Per Kapita (PPK), average school age (RLS), and school life expectancy (HLS). Thus, the researchers are interested in conducting research on K-means and Fuzzy C-means algorithm analysis based on the Human Development Index indicators in Banten Province in 2020. The background of the above issues eventually brings this research to investigate further on "How is the picture obtained through the methods of K-means and C-fuzzy means against the indicator of human development index (HDI) of Banten province, as well as how is the spread mapping of the results of the HDI clustering and the comparison of the performance of the K-means and Fuzzy C-means based on validity tests? "

## ***METHODS***

This research uses quantitative research with the data presented in the form of statistical figures. The data used as secondary data is obtained from the results of information received from an institution that has been published. Secondary data available for this study was obtained from the Central Statistical Agency/*Badan Pusat Statistik* (BPS) of Banten Province, accessed through the website: <http://banten.bps.go.id>. Data was taken from the year 2020, which covers 8 districts and cities in Banten province. This research carries out procedures or basic measures in data collection according to the research required, as follows:

a. Library study

This data collection is carried out by collecting all sorts of r sources that can be used as references relating to research, which can be obtained through books, articles, or journals to obtain discussion on a problem.

b. Documentation techniques

Data collection using this technique, that is to say, is done by obtaining data through written documents as well as electronically received from institutions that correspond to the research problem. The collection of its own data is secondary data, which is obtained through the official website of the survey of the Central Statistical Agency (BPS) of Banten Province in 2020.

## ***RESULTS AND DISCUSSIONS***

This section will discuss the results of cluster analysis using the K-means and Fuzzy C-means methods against the Human Development Index (HDI) in Banten Province. This analysis aims to identify the characteristics of each cluster produced, understand the mapping spread of the grouping results, and present a comparison between the clusters produced by the two methods. This identification is an important foundation for a deep understanding of the variability of development in the region. By considering the differences and similarities between the results of the K-means and Fuzzy C-means clusters, readers can gain a more comprehensive insight into the dynamics of development at the district or city level in Banten Province. Furthermore, further discussions will explore the implications of these findings for more effective and sustainable development planning.

### **Identification of Cluster Characteristics**

In an attempt to deepen the cluster results produced by the K-means and fuzzy C-means methods, the next step leads to the identification of the respective cluster characteristics. The analysis of these characteristics becomes crucial in revealing the special nuances and differences hidden within each territory group. By detailing the main characteristics of each cluster, the author attempts to give a deeper picture of the factors that influence the rate of development in the district or towns in Banten Province. Through this identification, readers are invited to dive

into the diversity of development manifested in cluster outcomes, so that a more comprehensive understanding can open the door to more precise and effective policy recommendations.

The following are the results of K-means cluster characteristics (Table 1) and the characteristics of Fuzzy C-means clusters (Table 2). Tables 1 and 2 show the results from the identification of cluster features using the K-means and Fuzzy C-mean methods on the variables UHH (Life Health Effort), HLS (School Life Expectancy), RLS (Average School Age), and PPK (Per capita expenditure). This characteristic analysis gives an overview of the patterns and characteristics that appear in the division of the region into a particular cluster.

In Table 1, the cluster characteristic results of K-Means show that Cluster 1 and Cluster 3 have positive tendencies in UHH, HLS, and RLS variables, marked with a "+" symbol. Meanwhile, Cluster 2 and Cluster 4 have a negative tendency in the same variable, marked by a "-." These results indicate the existence of two major groups in the territorial division, which may reflect significant disparities in development conditions.

**Table 1. K-Means Method Cluster Identification**

Cluster	UHH	HLS	RLS	PPK
1	+	+	+	+
2	-	-	-	-
3	+	+	+	+
4	-	+	-	-

Source: Data processed by the author

Table 2 describes the cluster characteristic results of Fuzzy C-Means. Clusters 1 and 2 show positive tendencies in UHH, HLS, and RLS variables, which are different from clusters 3 and 4, which have negative tendencies. However, in the Fuzzy C-means method, there is an overlapping or uncertain membership, which is reflected in the symbol "+." This indicates a more soft or vague membership level, indicating a variation in the characteristics of each region.

**Table 2. Identification of Fuzzy C-Means Method**

Cluster	UHH	HLS	RLS	PPK
1	+	+	+	+
2	+	+	+	+
3	-	-	-	-
4	-	-	-	-

Source: Data processed by the author

Overall, comparisons between the K-Means and the Fuzzy C-Means (FCM) show differences in the rigidity of regionalization into clusters. K-Means tend to provide a more rigid and exclusive division, while the Fuzzy C-Means show a more vague and overlapping level of membership. This analysis provides a deeper understanding of the structure and variability characteristic of a clustered region, thereby guiding the formulation of a development policy that is more appropriate to the actual conditions.

Based on the results of both characteristics for clusters formed by the K-Means method, three characteristic shapes were obtained. The first characteristic with an overall value above average is found in cluster 1 with member cities Tangerang and South Tangerang, and cluster 3 with member districts Tangerang and Serang. However, based on the average value of each indicator in cluster 1, it is superior compared to cluster 3. The second characteristic is an above-average value for all indicators except for indicator HLS, but indicators UHH, HLS, and PPK are found in cluster 4 with member districts Pandeglang and Serang. The third characteristic was a value below the overall average that is found in cluster 2 with the representation of district Lebak.

In the cluster formed using the method of FCM, there are two characteristics. The first is a characteristic with the values found on the HDI indicator above the overall average, which occurs in cluster 1 that belongs to Tangerang District, Cilegon District, and Serang City, and cluster 2 that belongs to the City of Tangerang and South Tangerang. Whereas the second characteristic is characteristics with values below the total average that are found in Cluster 3, which

belongs to the districts of Pandeglang and Serang, and Cluster 4, which belongs to the districts of Lebak.

Based on the results of the overall characteristics formed by the K-Means and FCM methods. The city of Tangerang, along with the city of South Tangerang, is the most superior region, with cluster 1 on both the K-Means method and cluster 2 on the FCM method. District of Pandeglang, District of Lebak, and District of Serang, if we observe based on the size of per capita expenditure, the value of the height of the districts in Pandeglang, District of Lebak, and District of Serang has a smaller value than the other cities in the province of Banten. Although Tangerang experienced the greatest decline in 2020 due to COVID-19, according to the per capita expenditure indicator (PPK), the highest achievements on HLS and RLS belong to South Tangerang. If we look at education as an indication of the capacity and productivity of the labour force, then the decrease in the PPK indicator could not happen because of the education that happens in the city of Tangerang South was high. Therefore, it is hoped that not only formal education that has always been used as a reference but non-formal education that is a means of enhancing creativity should also be developed. In addition to the three districts, Pandeglang, Lebak, and Serang should continue to be paid more attention by the government of Banten Province in efforts to improve human development so that all experience an even improvement on all indicators of the formation of HDI.

By understanding the results of the clusters generated by the K-Means and Fuzzy C-Means methods, the next step is to identify the characteristics of each cluster. An in-depth analysis of the unique characteristics of each cluster will provide a more detailed insight into the developmental variations in the province of Banten. Through this identification, the author will detail the significant differences as well as the possible patterns or trends that can be observed in every cluster, forming the basis for policy recommendations that are more focused and tailored to the needs of each region.

### **Comparison of K-Means and Fuzzy C-Means Cluster Results**

Based on validation tests performed on both methods, K-Means used validation on silhouette index (SI), whereas Fuzzy C-Means used partition coefficient index (PCI) validation. The validation test on K-Means using silhouette

with the help of tools on RStudio obtained a value of 0.38. While the FCM method using the PCI validation test obtained a magnitude of 0.78, meaning that the validation value is close to 1, it can be said that the cluster result using FCM with PCI verification obtained excellent cluster results because it is closer to 1.

At the comparison stage of the cluster results between K-Means and Fuzzy C-Means, the authors conducted validation tests using methods relevant to each technique. K-Means were evaluated using silhouette index (SI), and validation results showed an SI value of 0.38. This assessment gives an overview of how cohesive membership is in a cluster and how separated clusters are. Although the SI value does not reach 1, a value of 0.38 indicates an acceptable degree of cohesion in the cluster result using K-Means.

On the other hand, Fuzzy C-Means was evaluated using the index partition coefficient (PCI), and the validation result showed a value of 0.78. In this validation, a value close to 1 indicates that cluster members have a high and homogeneously distributed membership rate. Therefore, a PCI of 0.78 on Fuzzy C-Means indicates a high level of homogeneity and strong membership.

A comparison between the SI value of K-Means and the PCI value of Fuzzy C-Means shows differences in the validation approaches used by both methods. Though K-Means provides an acceptable level of cohesion, Fuzzy C-Means stands out with a higher level of homogeneity and cluster membership. Therefore, in the context of this comparison, Fuzzy C-Means shows excellence in understanding the structure and distribution of membership within the cluster, which can provide a more in-depth insight into the characteristics of clustered territories.

## **CONCLUSIONS**

Based on the results of the analysis and discussion, it can be concluded that the results of using the K-Means and Fuzzy C-Means methods.

1. On the basis of the grouping results of each cluster on K-Means as well as FCM, it is obtained that both have the same members of the formed cluster, that are belonging to the City of Tangerang and the City of South Tangerang. Based on the results of this grouping, although Tangerang is a COVID-19-

spread city in this case, it can be said that both are superior to the others. This is not to be denied because South Tangerang City is the city with the highest increase in HLS (school age expectancy) and RLS (average school age). Then the fall in Banten's HDI in 2020, marked by a drop in PPK (per capita expenditure), should be minimized as higher education tends to increase the skills and productivity that it has.

2. The result of the obtained cluster is different when viewed based on the mapping spread of the number of members entering each cluster. Where cluster 1 on K-Means is 2 members of cluster with Tangerang City and South Tangerang City as members, on FCM cluster1 the members are the district of Tangerang, Cilegon City, and Serang City. Cluster 2 for K-Means the member is district Lebak, whereas FCM with members of district Pandeglang and district Serang. In cluster 4, K-Means with members of district Pandeglang and district Serang, while FCM the member is district Lebak. However, based on the members of the cluster formed, there are the same members on both methods: cluster 1 on the K-Means and cluster 2 on the FCM, with membership in the City of Tangerang and the South Tangerang City.
3. Based on the comparison results using a validation test, K-Means using validation on the silhouette index obtained a validation value of 0.38 using the tool RStudio. Whereas for the FCM using the validation at partition coefficient index and obtaining a result of 0.78 means the use of the FCM method is very good because validation results are closer to 1. It can then be concluded that the use of the Fuzzy C-Means method is better compared to the K- Means for the Human Development Index data.

Based on the conclusion, then the advice can be given in the effort to increase human resources, especially on the surface that occurs in 2020 on the value of the Human Development Index in the province of Banten that has experienced a slight slowdown, especially in the decrease in per capita expenditure due to the presence of COVID-19, so that a lot of their jobs are affected, thus it is expected that the government can more thoroughly review the job fields that correspond to the background of education. Because if we observe that South Tangerang City is the

city with the highest increase in HLS and RLS, then reviewing in terms of education is good. However, it is hoped that the education service will not only focus on formal but also non-formal education because it can also have an impact on the productive workforce. It is also expected that government aid can be used in the effort to develop non-formal education that is also more beneficial and able to train their creativity.

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