

HIERARCHICAL CLUSTER ANALYSIS ON PEOPLE'S WELFARE IN SOUTHEAST SULAWESI PROVINCE

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ABSTRACT

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Problems with people's welfare typically result from the government's development efforts in a region not being done properly or equally. Consider grouping and defining the traits of each region's degree of welfare as a potential answer to ensure that development policies and strategies are well-targeted. This study aims to classify 17 regencies/cities in Southeast Sulawesi province based on several indicators of people's welfare. The method used is hierarchical cluster analysis with several approaches, including Single Linkage, Complete Linkage, Average Linkage, and Ward's. The data used in this study is secondary data obtained from the publication of the Central Agency of Statistics (CAS) of Southeast Sulawesi Province. Based on the evaluation results, the best method used is Ward's, which produces three clusters. The first cluster consists of 9 regencies, namely Buton, North Buton, South Buton, Central Buton, Muna, West Muna, Wakatobi, Konawe Islands, and East Kolaka, the majority of which come from the archipelago. Some of the problems in these areas are the relatively high poverty rate and the low average length of schooling and life expectancy. The same thing happened to the second cluster, which consisted of 6 regencies, namely Konawe, South Konawe, North Konawe, Bombana, Kolaka, and North Kolaka, with problems of poverty, the average length of schooling, and relatively low sources of proper drinking water when compared to other clusters. The third cluster consists of 2 urban areas: Kendari City and Baubau City. The problems are the relatively high unemployment rate and population density. The government ought to offer more initiatives to handle issues with poverty, education, and health in regions in clusters 1 and 2. While in cluster 3, the government should offer more initiatives to combat jobless issues and prepare for rising population densities.



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1. INTRODUCTION

People's welfare is the main goal in the development of a country. In Indonesia, people's welfare is one of the goals of the state, as stated in the fourth paragraph of the Preamble to the 1945 Constitution, that the goal of national development is to educate the life of the nation and promote the general welfare. People's welfare is a condition whose form is dynamic, and quantitatively it will never stop because it will continue to change along with the development of the needs of human life [1]. People's welfare has very broad and complex dimensions. The Central Agency of Statistics (CAS) measures people's welfare from various specific aspects, namely population, health and nutrition, education, employment, consumption levels and patterns, housing and the environment, poverty, and other social references in efforts to improve quality of life [2].

Southeast Sulawesi is one of the provinces that participate in the state's goals of improving people's welfare. Based on The Central Agency of Statistics data in 2021, the population of Southeast Sulawesi Province is 2.659 million people, with a total population density of around 69.85 people per square kilometer [3]. The population of Southeast Sulawesi Province continues to increase every year. When the population continues to increase, the government must also increase the number of living facilities to meet the decent living needs of the community [4]. Apart from the population aspect, indicators of people's welfare can also be measured from the poverty rate and unemployment rate. According to The Central Agency of Statistics data, the number of poor people in Southeast Sulawesi in 2021 will reach 318.7 thousand people or 11.66%. This shows that the percentage is still higher than that of the poor national population, 10.14%. Meanwhile, the open unemployment rate in Southeast Sulawesi Province in 2021 will reach 3.92%. If there is no change in strategy to overcome these problems, the result is that the poverty rate and unemployment rate will continue to increase every year.

People's welfare problems generally occur because the development carried out by the government in an area is not on target. In carrying out development programs, one of the solutions that can be applied is to identify the characteristics of the level of welfare of the people in each region so that in making development policies and strategies, they can be on target and effective [5]. One of the prerequisites for the success of development programs is highly dependent on the accuracy of identifying target groups and target areas [6]. Therefore, it is crucial to consider the grouping and know the characteristics of the 17 regencies/cities in Southeast Sulawesi Province based on indicators of people's welfare. One of the statistical methods that can be used for clustering is cluster analysis. Cluster analysis aims to group observation objects based on similar characteristics. The cluster analysis used is hierarchical cluster analysis with agglomerative techniques. The method with this technique begins by assuming that each object is a cluster. Then the two objects with the closest distance are combined into one cluster. The process continues so that a cluster consisting of all objects will be formed [7].

The research on district/city cluster analysis in Southeast Sulawesi Province based on indicators of people's welfare has been carried out by Tenriawaru (2018) using the k-means algorithm (non-hierarchical cluster). Previous research used 12 districts/cities with 7 indicators, producing 3 clusters [8]. Some differences between previous research and this research are the cluster analysis method used, the number of observation units, and the number of indicators. In this study using hierarchical cluster analysis with agglomerative techniques, several methods include Single Linkage, Complete Linkage, Average Linkage, and Ward's. The observation units used are 17 districts/cities and use 9 indicators of people's welfare. The advantage of this research is that it uses several hierarchical cluster analysis methods so that there is an evaluation of the selection of the best method used. In Indonesia, several other researchers have carried out district/city clustering based on indicators of people's welfare, including Yulianto and Hidayatullah (2014) produced 3 groups (clusters) from 35 districts/cities in Central Java Province using the average linkage method [6]. Alwii and Hasrul (2018) also produced 3 clusters from 24 Regencies/Cities in South Sulawesi Province using the average linkage method [1]. Pratama and Nasrudin (2022) used several hierarchical and non-hierarchical methods for 28 districts/cities in Papua Province, with the best method being Ward's, which produced 4 clusters [9]. Likewise, Wahyuni and Wulandari (2022) resulted in 4 clusters from 38 regencies/cities in East Java Province, with the best method being the complete linkage [10]. In addition, there was also research conducted by Zmuk (2015) to identify groups of European countries based on indicators of quality of life using hierarchical cluster analysis, the results of 3 clusters were obtained using Ward's method [11]. Another study was conducted by Ríos-Vásquez and de la Fuente-Mella (2023). One of the goals was to classify Quality of Life in the City Councils of Chile using hierarchical and non-hierarchical cluster analysis, resulting in 4

similar clusters [12]. In all cases, the results are suggestions to support decision-making in social welfare development and to identify the characteristics of the various districts/cities.

2. RESEARCH METHODS

The data used in this study is secondary data obtained from the publication of the Central Agency of Statistics (CAS) of Southeast Sulawesi Province on the website (<https://sultra.bps.go.id/>). The data used indicates people's welfare in 2021 with observation units of 17 regencies/cities in Southeast Sulawesi Province. The variables used are Gross Domestic Product at the national level and Gross Regional Domestic Product (GRDP) (X1), Population Density (X2), Percentage of Poor People (X3), Unemployment Rate (UR) (X4), Labor Force Participation Rate (LFPR) (X5), expenditure riil per capita per month of the poor (X6), life expectancy at birth data (X7), Mean years schooling (X8), and Percentage of Household that have an adequate source of drinking water (X9).

The analysis technique used in this research is cluster analysis. Cluster analysis is an analytical method that aims to classify items where some group members are homogeneous (similar), and others are heterogeneous (different) [13]. The greater the similarity within a group, the greater the differences among other groups. Methods in cluster analysis are divided into two, namely hierarchical and non-hierarchical methods. In this study, the method used is the hierarchical method. The grouping process in the hierarchical method begins with a combination of two or more objects with the same characteristics. Proceed to the next closest object and repeat the process. As a result, a tree is formed with a hierarchy or levels ranging from the most similar to the least similar [13]. One technique in the formation of hierarchical method groups is the agglomerative hierarchy technique. In agglomerative clustering, clustering starts with a group of as many observations and combines them one by one until only one group contains all the observations. The closer the clusters are to each other, the sooner they merge. The researcher's task is to identify a set of clusters that can be interpreted in a meaningful and useful way. The method does not imply a clear procedure for selecting the number of clusters [14]. The agglomerative hierarchical method used in this study includes Single Linkage, Complete Linkage, Average Linkage, and Ward's.

The steps of analysis in this study are as follows.

1. Conduct descriptive analysis to provide an overview of people's welfare in each district/city in Southeast Sulawesi Province.
2. Standardize data to eliminate large unit differences.
3. Determine the size of the distance to be used. The distance to be used is the Euclidean distance for cluster analysis using the Single Linkage, Complete Linkage, and Average Linkage methods. Meanwhile, Ward's method is the squared Euclidean distance. Suppose there are two objects with $\mathbf{x} = (x_1, x_2, \dots, x_n)$ and $\mathbf{y} = (y_1, y_2, \dots, y_n)$, then according to Spath (1982) the Euclidean distance between the two objects is [15].

$$d(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} = \sqrt{(\mathbf{x} - \mathbf{y})^T (\mathbf{x} - \mathbf{y})} \quad (1)$$

4. Cluster analyze of the hierarchical method viz Single Linkage, Complete Linkage, Average Linkage dan Ward's. According to Johnson and Wichern (2007), the formula is [15]:

- a. Single Linkage

The distance between two clusters (uv) with w using single linkage is determined by:

$$d_{(uv,w)} = \min\{d_{(uw)}, d_{(vw)}\} \quad (2)$$

- b. Complete Linkage

The distance between two clusters (uv) with w using complete linkage is determined by:

$$d_{(uv,w)} = \max\{d_{(uw)}, d_{(vw)}\} \quad (3)$$

- c. Average Linkage

The distance between two clusters (uv) with w using average linkage is determined by:

$$d_{(uv,w)} = \frac{n_u d_{uw} + n_v d_{vw}}{n_u + n_v} \quad (4)$$

- d. Ward's

The distance between two clusters (uv) with w using ward's is determined by:

$$d_{(uv,w)} = \frac{(n_u + n_w) d_{uw} + (n_v + n_w) d_{vw} - n_w d_{uv}}{n_u + n_v + n_w} \quad (5)$$

The results of calculations using the formula above will produce clusters which will be visualized through a dendrogram.

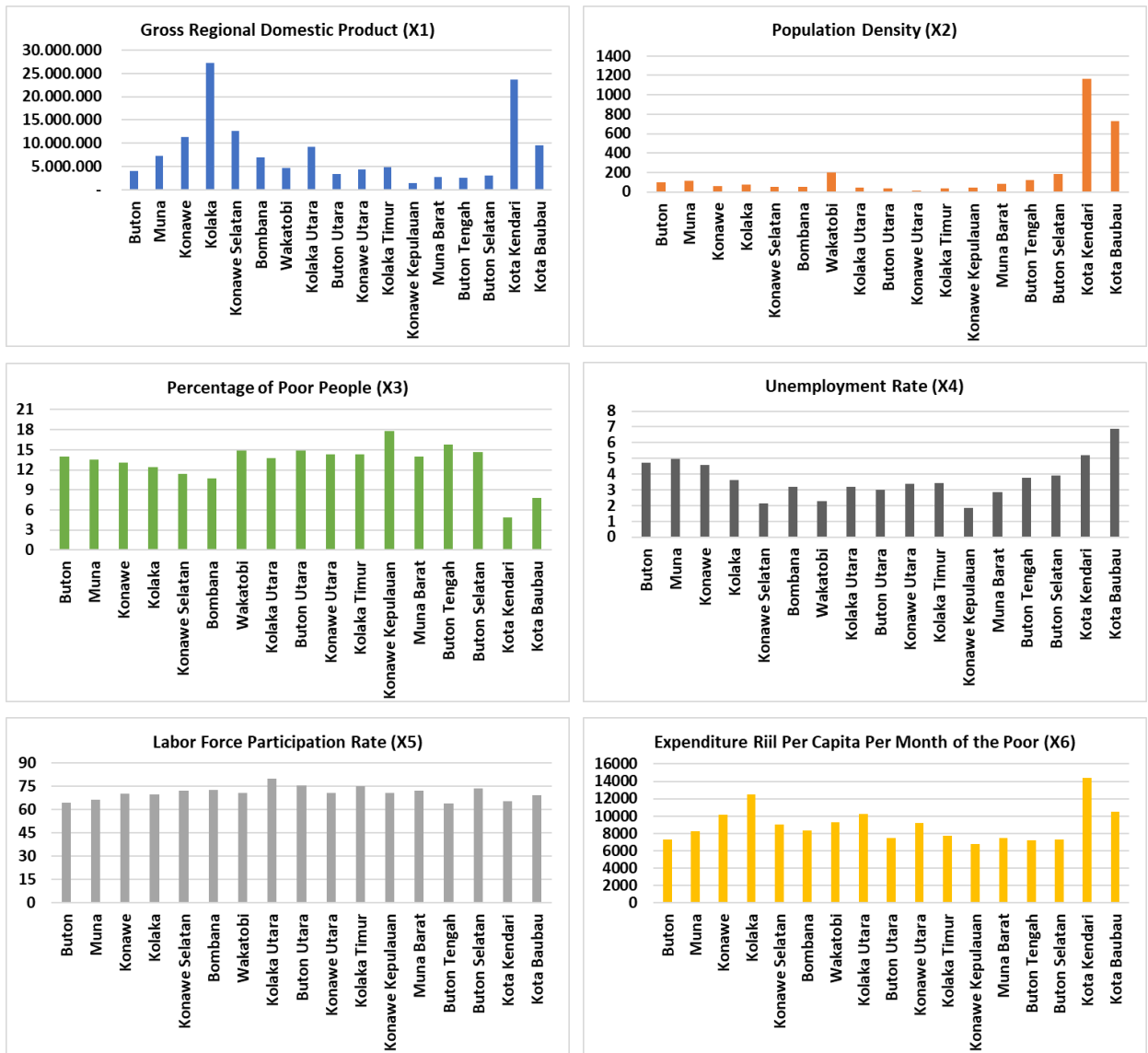
5. Selecting the best method and conducting cluster profiling. The selection of the best cluster method will be based on the ratio of the inter-cluster standard deviation (s_w) to the inter-cluster standard deviation (s_b) [16]. The smaller the value of the standard deviation ratio obtained, the better the cluster produced by a cluster method. The formula used is:

$$rasio = \frac{s_w}{s_b} \tag{6}$$

3. RESULTS AND DISCUSSION

3.1 Overview of Regional Welfare in Southeast Sulawesi Province in 2021

The results of descriptive statistical analysis to describe the welfare of regencies/cities in Southeast Sulawesi Province can be presented in **Figure 1** and **Table 1** below.



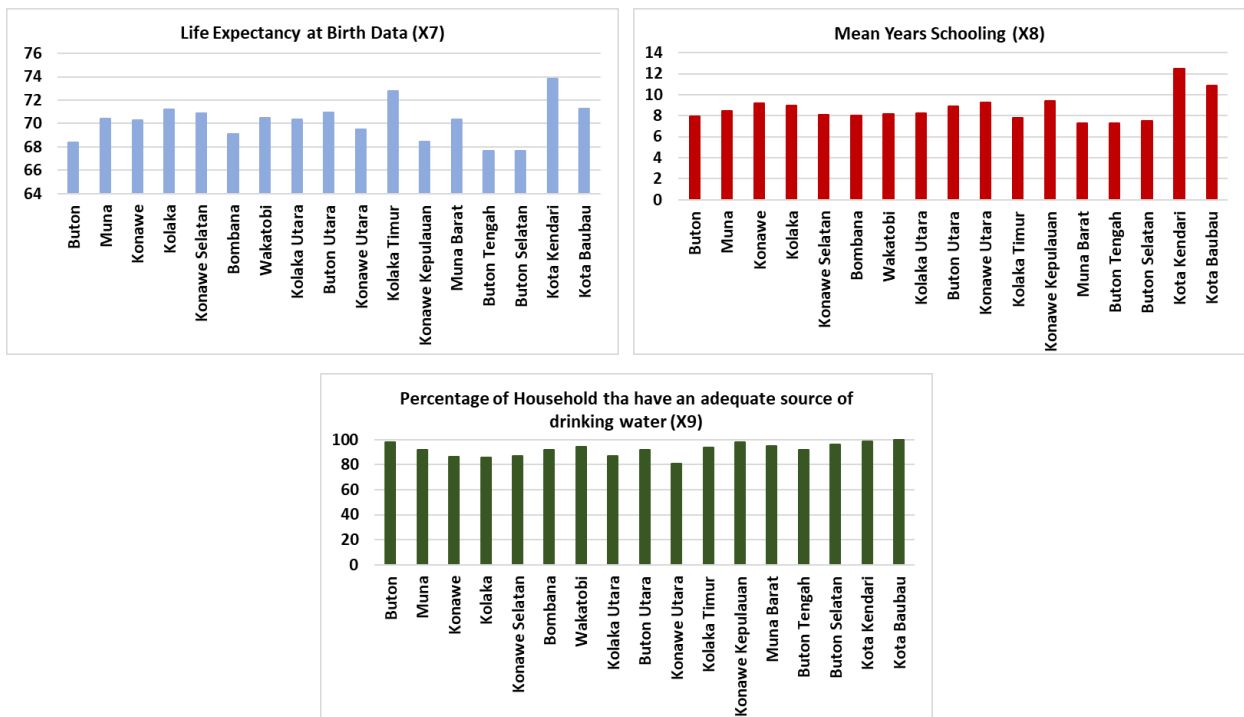


Figure 1. Overview of Regional Welfare in Southeast Sulawesi Province in 2021

Table 1. Results of Descriptive Statistical Analysis

Variables	Min	Max	Mean	Deviation Standard
X1	1469806.83	27327998.36	8173133.77	7304984.72
X2	13.51	1164.10	182.54	302.30
X3	4.87	17.81	13.07	3.05
X4	1.83	6.87	3.70	1.27
X5	63.93	79.76	70.66	4.14
X6	6738	14356	9009.59	2053.60
X7	67.69	73.83	70.21	1.66
X8	7.30	12.51	8.72	1.34
X9	81.06	99.67	92.29	5.31

Figure 1 and Table 1 show an overview of district/city welfare in Southeast Sulawesi Province with nine dimensions. It can be explained that the highest per capita GRDP in Southeast Sulawesi Province is Kolaka, followed by Kendari City, while the lowest is Konawe Islands. In terms of population density, urban areas, namely Kendari City and Baubau City, are areas with the highest population density.

From an economic perspective, the highest percentage of poor people is Konawe Islands and the lowest is in Kendari City. The majority of regions have a percentage of poor people above the average of 13.07%. These areas are Konawe Islands, Central Buton, Wakatobi, North Buton, South Buton, East Kolaka, North Kolaka, West Muna, Buton, North Kolaka, and Muna. The average per capita real expenditure adjusted for each region in Southeast Sulawesi Province is 9,009.59 (thousand rupiahs).

In terms of the unemployment rate, the urban area, namely Baubau City, has the highest percentage, followed by Kendari City. Meanwhile, other regions that have an unemployment rate above the average of 3.7% are Muna, Buton, Konawe, South Buton, and Central Buton. The Labor Force Participation Rate (LFPR) for all regions in Southeast Sulawesi Province has exceeded 60%. The area with the highest LFPR is North Kolaka.

The highest life expectancy rate in Southeast Sulawesi Province is Kendari City, followed by East Kolaka, while the lowest is Central Buton and South Buton. Education attainment between regencies/cities on average is 8.72 years. The highest mean years of schooling is Kendari City, and the lowest are West Muna and Central Buton. The percentage of households that have an adequate source of drinking water in every region in Southeast Sulawesi Province has exceeded 80%.

3.2 Cluster Analysis

The dendrogram of cluster analysis results using the Single Linkage, Complete Linkage, Average Linkage, and Ward's methods is shown in **Figure 2**. It can be seen that overall, these methods produce the same cluster members when using two classes. In this case, it is divided into 15 regencies for the first cluster and 2 cities for the second cluster. Using three clusters will produce different members in each cluster. Meanwhile, if it is divided into four clusters, the analysis using Single Linkage and Average Linkage will produce the same cluster members.

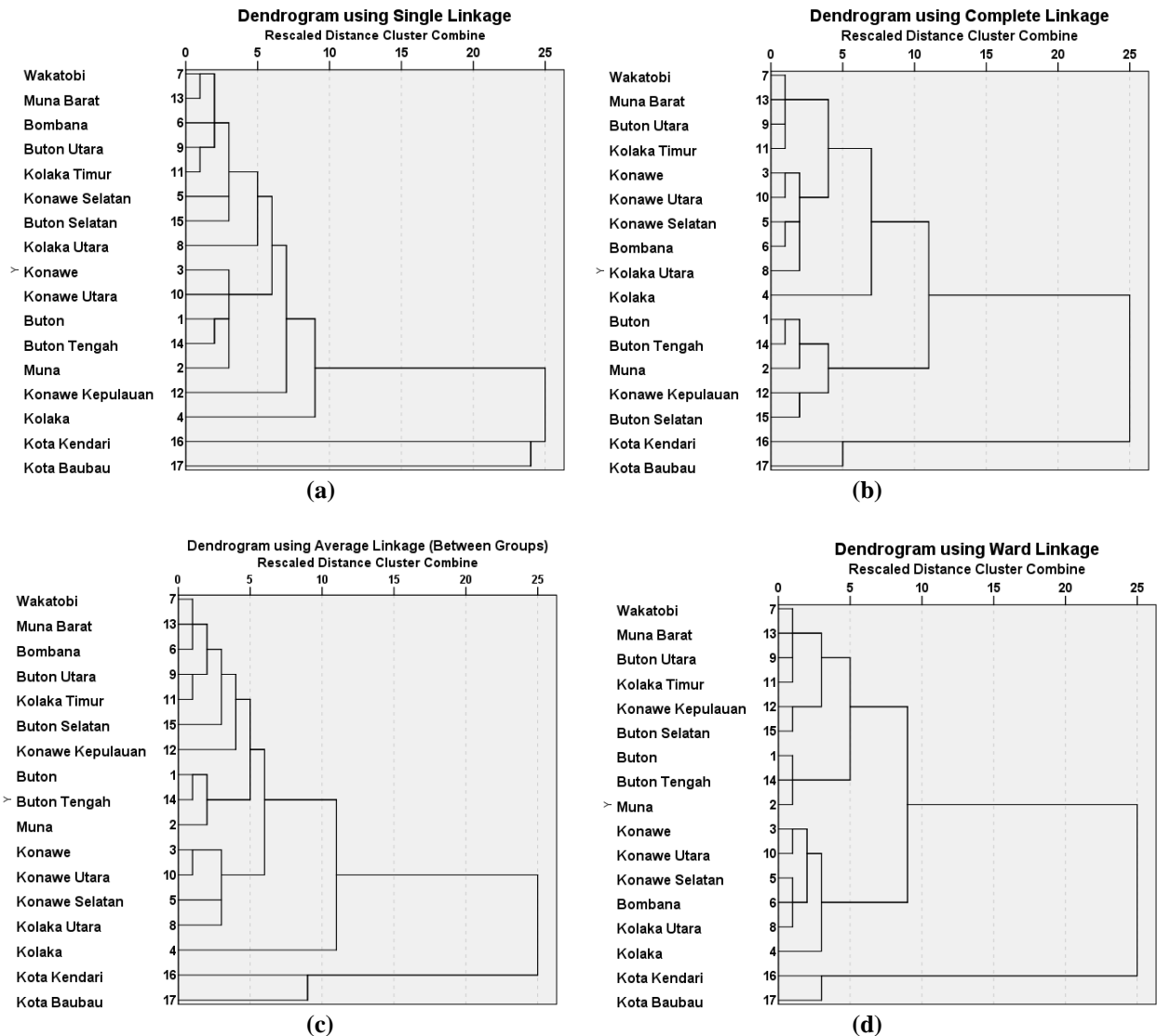


Figure 2. Dendrogram of cluster analysis results
 (a) Dendrogram using Single Linkage, (b) Dendrogram using Complete Linkage, (c) Dendrogram using Average Linkage, (d) Dendrogram using Ward Linkage

3.3 Selection of the Best Method

Selecting the best cluster method is based on the ratio between the intracluster standard deviation (s_w) and the intercluster standard deviation (s_b). A good clustering result is one that produces the minimum ratio value. The smaller the value of the resulting ratio, the better the homogeneity in the cluster. The following is the ratio calculation result obtained.

Table 2. The sw/sb ratio of the cluster linkage method

Method	k	S _w /S _b
Single linkage	2	1.903
	3	2.165
	4	2.431
Complete linkage	2	1.903
	3	2.072
	4	2.414
Average linkage	2	1.903
	3	2.511
	4	2.431
Ward linkage	2	1.903
	3	2.059
	4	2.184

Table 2 shows the four methods produce the same minimum ratio value when using two clusters, namely 1.903. The two clusters are divided into 15 regencies for the first cluster and 2 cities for the second cluster. Based on the examination of the cluster form, the researchers did not use the 2 clusters because they were only divided by regency and cities in Southeast Sulawesi Province. Thus, this study will use the Ward linkage method, which produces the minimum ratio value when using three clusters, namely 2.059. It can be seen that the results of the clusters formed are good, and the cut-off boundaries are clear by dividing 9 regencies for the first cluster, 6 regencies for the second cluster, and 2 cities for the third cluster.

3.4 Cluster Profiling

Based on the previous selection of the best cluster method, Ward's method was obtained with a three-cluster cut-off. The next process is profiling based on the average of each indicator in each cluster. Each cluster can be compared based on the dominant identifying indicators of each cluster. The average of each indicator in each cluster is shown in **Table 3**.

Table 3. The average of each variable based on Ward's method clustering

K	GRDP	Population Density	Percentage of Poor People	UR	LFPR	Expenditure Riil per capita	Life Expectancy at Birth data	Mean Years Schooling	Adequate Source of Drinking Water
1	3781348.21	101.92	14.87	3.42	70.22	7648.22	69.69	8.10	94.58
2	11937565.80	48.61	12.61	3.34	72.49	9911.67	70.23	8.65	86.52
3	16642872.69	947.11	6.33	6.03	67.15	12429.50	72.54	11.71	99.26

Cluster 1 is the majority of the Southeast Sulawesi archipelago, which consists of the Regencies of Buton, North Buton, South Buton, Central Buton, Muna, West Muna, Wakatobi, Konawe Islands, and East Kolaka. Only East Kolaka Regency is part of the Sulawesi mainland. Some of the problems in these areas are the relatively high poverty rate and the low average length of schooling and life expectancy. However, in terms of the labor force participation rate, it has shown a fairly high percentage likewise for the dimensions of the availability of proper drinking water sources.

Cluster 2 is a cluster that has the lowest population density compared to other clusters. The majority of areas in cluster 2 are regions originating from mainland Sulawesi, which consists of Konawe, South Konawe, North Konawe, Bombana, Kolaka, and North Kolaka Regencies. Some of the problems in these areas are the relatively high poverty rate, the low average length of schooling, and the relatively low supply of proper drinking water. However, in terms of the labor force participation rate, it shows the highest percentage when compared to other clusters.

Cluster 3 is a cluster that has relative advantages in the dimensions of GRDP per capita, poverty, life expectancy, the average length of schooling, and adequate drinking water sources when compared to other clusters, but there are also problems with open unemployment and population density. Cluster 3 is an urban area in Southeast Sulawesi which consists of Kendari City and Baubau City. Welfare from the poverty dimension in this cluster is better than in other clusters. This is following **Table 3**, which shows that the

percentage of poor people is lower than in other clusters. Poverty is a reflection of economic well-being. Areas with a low percentage of poor people will be economically prosperous. In addition, the welfare of the education dimension in cluster 3 is also much better. This means that the average length of education of the population aged fifteen and over in cluster 3 is higher than in the other clusters. The problem in cluster 3 occurs in the labor dimension. The open unemployment rate in this cluster reached 6.03%, the highest compared to other clusters. This scenario must be balanced with the availability of employment to satisfy the population to prevent other problems, such as rising poverty.

4. CONCLUSIONS

The study's findings support the hypothesis that inequality will continue in Southeast Sulawesi Province's welfare condition in 2021, particularly in regency and urban areas. The most severe inequality occurs in the dimensions of poverty, education, and other social dimensions. The best clustering method is Ward's method which produces three clusters. The first cluster consists of 9 regencies, namely Buton, North Buton, South Buton, Central Buton, Muna, West Muna, Wakatobi, Konawe Islands, and East Kolaka, the majority of which come from the archipelago. Some of the problems in these areas are the relatively high poverty rate and the low average length of schooling and life expectancy. However, in terms of the labor force participation rate, it already shows a fairly high percentage, as well as the dimensions of the availability of proper drinking water sources. The second cluster consists of 6 regencies, namely Konawe, South Konawe, North Konawe, Bombana, Kolaka, and North Kolaka, with the problems of relatively high poverty rates, a low average length of schooling, and low sources of proper drinking water. However, when compared to other clusters, the second cluster exhibits the greatest percentage in terms of labor force participation. In the third cluster, which consists of the cities of Kendari and Baubau, there are issues with population density and a comparatively high unemployment rate.

The best advice that can be provided is that the government should implement appropriate policies based on welfare issues in each region to ensure that everyone's needs are met and the inequality issue is resolved. The government ought to offer more initiatives to handle issues with poverty, education, and health in regions in clusters 1 and 2. While in cluster 3, the government ought to offer more initiatives to combat jobless issues and prepare for rising population densities.

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