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Evaluation of East Java Province's Food Security Area Using Fuzzy C-Means (FCM) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

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Abstrak

Pangan memegang peranan penting dalam kehidupan manusia, terutama bagi pembangunan suatu negara, hal tersebut berpengaruh terhadap pembentukan generasi penerus bangsa yang berkualitas. Kemampuan suatu daerah untuk memenuhi kebutuhan pangan berbeda dengan daerah lain. Penelitian ini bertujuan untuk mengklasifikasi daerah di Provinsi Jawa Timur berdasarkan ketahanan pangan dan menentukan perangkingan daerah dengan ketahanan pangan terbaik dan terendah. Metode yang digunakan menggabungkan metode Fuzzy C-Means (FCM) dan TOPSIS. Metode FCM digunakan untuk mengelompokkan daerah ketahanan pangan berdasarkan kriteria sesuai dengan Indeks Ketahanan Pangan (IKP) yang disusun oleh Badan Ketahanan Pangan. Namun, banyaknya kriteria dan subkriteria membuat perhitungan menjadi rumit, sehingga untuk memeringkat daerah menggunakan Multiple Criteria Decision Making (MCDM), salah satu teknik yang paling populer adalah TOPSIS. Kelebihan metode TOPSIS adalah konsepnya sederhana dan mudah dipahami, menilai sisi kelemahan dari alternatif, bukan hanya kelebihannya. Hasil pengelompokan daerah menggunakan FCM, terpilih 3 klaster cluster terbaik untuk semua kriteria, kecuali aspek pemanfaatan pangan pada variabel kota menggunakan 5 cluster. Hasil perangkingan didapatkan, bahwa Kabupaten Magetan dan Kota Madiun terpilih sebagai daerah dengan ketahanan pangan terbaik. Sedangkan, ketahanan pangan terendah di daerah Kabupaten Probolinggo dan Kota Kediri.

Kata kunci— *Clustering, Fuzzy,FuzzyC-Means,Peringkat Ketahanan Pangan, MCDM, TOPSIS*

Abstract

The formation of quality human resources cannot be separated from food, as nutritional intake affects human performance and health. As time increases, the number of residents increases to increase food needs. The ability of a region to meet food needs in its territory is different from other regions. This study aims to classify regions in East Java Province based on food security and determine areas with the best and lowest food security. The method used is the Fuzzy C-Means (FCM) and TOPSIS methods. This research uses criteria based on the Food Security Index compiled by the Food Security Agency. The results of regional clustering using FCM selected the best cluster using three clusters for all requirements, except in food utilization in the city using five clusters. Furthermore, from the clustering results, clustering and cluster members use TOPSIS and produce Magetan regency and Madiun city as areas with the highest food security. At the same time, the lowest food securities are Probolinggo regency and Kediri city.

Keywords—*Clustering, Fuzzy, Fuzzy C-Means, Food Security Ranking, MCDM, TOPSIS*

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1. INTRODUCTION

One of the main areas of development is improving the quality of human resources. Food plays an essential role in human life, especially in developing a country, because it affects the formation of a quality generation as the nation's successor. As the population and food needs increase, food security needs must be the main focus [1]. Food security is a condition where nutrition is fulfilled for a country to the entire community, proven by the availability of good food from the amount, quality, quality, nutritional content, and food safety. So food security is essential because it concerns a country or region's economy, people's lives, and social stability [2] [3]. Limited food supplies that are not following needs can cause problems for economic stability [4]. So it is a duty for a country, including Indonesia, to maintain national food security sustainably [5].

So far, East Java province is known to have supported the needs of 15 other regions due to the abundance of food commodities, especially rice [6]. For Indonesia, rice is often identified as the leading staple food. But the problem is the diminishing agricultural land that has switched functions to housing, offices, and industrial areas. This condition harms the farming sector, which causes an increase in food prices and can harm all parties [7] [8]. A food security assessment needs to be done to determine how food conditions in East Java. Improving food conditions in East Java can positively impact other provinces.

Evaluating a country's food security requires smaller coverage to determine the condition of the regions in Indonesia. Therefore, the Food Security Authority of the Ministry of Agriculture compiles a food security index based on district or city-level data. Food security evaluation is needed to determine which areas should come first for special treatment to fulfill residents' food needs [9]. Regional food security is evaluated by mapping the territory and dividing the district or city area into the same characteristics. In the grouping process, criteria are needed that are used as assessments. The Food Security Index at the district level consists of three criteria and nine subcriteria. As for the city, there are only two criteria and eight subcriteria [1].

In classifying districts or cities with the same characteristics based on food security conditions, several methods can be used, one of which is the FCM method, a simple clustering algorithm that is easy to implement and can be used to cluster large amounts of data [10]. The FCM *method groups* food security areas based on criteria according to Food Security Index (FSI) [11]. However, the number of measures and subcriteria causes calculations to be complicated. A method is needed to accommodate all requirements and sub-criteria, a technique used, namely MCDM. MCDM is a technique used in decision-making that results in the best alternative to existing alternatives according to specific criteria [12]. One of the foremost celebrated procedures in MCDM is the TOPSIS. This study will rank the TOPSIS method based on an area's food security level. The advantage of the TOPSIS method is that it is conceptually simple and easy to understand. Still, the disadvantage of the alternative method is that it cannot be judged on its own merits [13] [14].

Several studies on the merger of clustering and TOPSIS methods have been conducted, including Swindiarto et al. [13], which combined FCM and TOPSIS methods for company performance evaluation at PT XYZ. Bai et al. [15] used the FCM-TOPSIS method to evaluate organizational performance. The results obtained in some of the above studies combining the FCM and TOPSIS methods are in a ranking format from highest to lowest, calculated based on the criteria provided. Puspitasari et al. [16] Used FCM to determine road repair priorities in Samarinda city by grouping road damage data for a year, obtaining 88.89% shows that FCM provides the right grouping results and calculations. Sari et al. [17] combine the AHP and TOPSIS methods as a decision support system for final article recommendations can optimize the weighting of criteria values that influence the results of more objective alternative rankings. Hidayat et al. [18] used FCM to determine the category of school loyalty to a university. It was found that of the 52 schools, only 71% can be categorized as loyal partners.

We referred to the various advantages of the FCM-TOPSIS method in previous studies. A few researchers focused on the FCM-TOPSIS method. There is not much research, and it is

limited to food security with such methods. Because no previous study has discussed food security with the application of FCM-TOPSIS methods, this research intends to use the FCM-TOPSIS method related to evaluating food security areas based on criteria determined by the Food Security Agency, Ministry of Agriculture. The cluster results using the FCM method can be used as a breeding system to order regions from high food security to low food security based on the food security of the Regency region or East Java city. Therefore, the purpose of this study is to cluster the Districts or Cities in East Java based on the FSI by the FCM method and apply the TOPSIS method to the food security field of the Districts or Cities in East Java province so that food security in communities and towns in the East Java region can be improved and help other sites that are still struggling in terms of food.

2. METHODS

2.1 Data

Data are from the Central Bureau of Statistics, Ministry of Agriculture, and East Java Provincial Health Department (in 2019), following the criteria and subcriteria set by the Food Security Agency (In Indonesia, namely BKP). The weight for each measure and subcriteria has also been developed by the BKP (shown in Table 2). Surrogate variables used in this study included 29 districts and 9 cities in East Java province. District criteria variables include availability, affordability, and food utilization. The criteria are divided into nine subcriteria for assessing district areas indicated in Table 1.

Table 1 Subcriteria Assessment of Region [19]

Subcryteria	
NCPR	The ratio of per capita baseline consumption to net grain availability
Pov	The proportion of persons living in poverty
Food	Percentage of households spending 65% or more of total spending on food
Elec	The proportion of households that do not have access to electricity
Water	The proportion of families that do not have access to safe drinking water
Life	At birth, life expectancy
Health	The population density level divided by the population per health worker
School	The average female school is more than 15 years old
Stunting	Percentage of toddlers with substandard height (stunting)

As for the city assessment, only two criteria are used, namely the aspects of affordability and food utilization. Subcriteria on municipal reviews are the same as county assessments; the only difference is the criteria used. The cause of this difference is that food availability in urban areas does not originate from the region but is based on trade between provinces. So, the food security assessment of districts and cities is carried out separately. Table 2 shows data on the weight of criteria and subcriteria in evaluating food security in communities and towns.

Table 2 Weight of Criteria and Subcriteria

Weight criteria and subcriteria regency						**Weight criteria and subcriteria of**			
Food		Food		Food Utilization		Food		Food Utilization	
NCPR	0.30	Pov	0.15	School	0.05	Pov	0.15	School	0.05
		Elec	0.075	Water	0.15	Elec	0.075	Water	0.15
		Food	0.075	Stunting	0.05	Food	0.075	Stunting	0.05
				Health	0.05			Health	0.05
				Life	0.10			Life	0.10

2.2 FCM

FCM is one of the clustering algorithms in which each data point in a cluster is based on the degree of membership [20]. The data in the cluster can be viewed depending on the degree of membership with the highest significant value. Jim Bezdek pioneered FCM in 1981. The determination of the cluster center was the original concept of FCM. The cluster's center represents the average location of each cluster. Initially, the cluster's center is still inaccurate. Each data point has a degree of membership in each cluster [18]. Because the cluster center is not precise, repeated changes to the cluster center and membership degree at each data point are required to progress toward the appropriate location. This process is repeated based on the minimization of objective functions, which represents the distance of the data point to the center of the cluster weighted by the degree of membership of the data [21]. From each data point, FCM produces a row of cluster centers and membership degrees [14]. The primary goal of the clustering process is to organize data with similar qualities into one cluster and data with dissimilar properties into other clusters [22], [23]. The FCM algorithm is depicted in the following manner:

Input data according to the criteria in matrix X with the size $n\ x\ m$, where n is a line that states the number of data samples, and m is a column that displays each data's properties. X_{ij} are data samples to-$i(i = 1,2, \dots, n)$ on attributes to-$j(j = 1,2, \dots, m)$.

Determining the amount *cluster* (c), weight (w), maximum iteration, *most minor* error, the initial objective function (P_0= 0), and early iterations (t = 1). Generate random values (μ_{ik}) where $i = 1,2, \dots, n$ and $k = 1,2, \dots, c$. The size of the matrix is indicated by nxc as the elements of the initial partition matrix U. Count how many columns there are:

$$Q_j = \sum_{k=1}^{c} \mu_{ik} \tag{1}$$

Calculate the value of the matrix element:

$$\mu_{ik} = \frac{\mu_{ik}}{Q_j} \tag{2}$$

Counting *cluster* centers (V_{kj}).

$$V_{kj} = \frac{\sum_{i=1}^{n}((\mu_{ik}{}^{w})X_{ij})}{\sum_{i=1}^{n}(\mu_{ik})^{w}} \tag{3}$$

Calculate objective functions (P_t).

$$P_t = \sum_{i=1}^{n}\sum_{k=1}^{c}\left(\left[\sum_{j=1}^{m}\left(X_{ij} - V_{kj}\right)^2\right](\mu_{ik})^{w}\right) \tag{4}$$

Calculate partition matrix changes (μ_{ik}).

$$\mu_{ik} = \frac{\left[\sum_{j=1}^{m}\left(X_{ij} - V_{kj}\right)^2\right]^{\frac{-1}{w-1}}}{\sum_{k=1}^{c}\left[\sum_{j=1}^{m}\left(X_{ij} - V_{kj}\right)^2\right]^{\frac{-1}{w-1}}} \tag{5}$$

Check for the stop condition: If $\left(\left|P_t - P_{(t-1)}\right| < e\right)$ Or $t > MaxIter$ Then stop, but if it does not meet, then $t = t + 1$ and the central calculation of the cluster is performed again.

2.3 Cluster Validation

A validity test is conducted against grouping with the concept that data can become a member of the entire cluster with the value of its membership degree [16]. The greater a cluster's degree of membership, the more data will enter the cluster. The determination of the number of clusters depends on the research carried out. Several methods can be used for cluster validation tests: the Partition Coefficient Index (PCI). PCI will calculate the value of the degree of membership in the data to determine the amount of overlap between groups [24]. The cluster quality is better if the PCI result is close to 1. The calculation is done by squaring the membership values in each cluster and then summing up as follows:

$$PCI = \frac{1}{n}\left(\sum_{i=1}^{n}\sum_{k=1}^{c}\mu_{ik}^{2}\right) \tag{6}$$

2.4 TOPSIS

TOPSIS is a multi-criteria decision-making system created by Yoon and Hwang in 1981. The core premise is that the optimal option is the one that is closest to the positive ideal solution and the furthest away from the perfect negative answer [25]. The sum of the best overall values obtained on each attribute or criterion yields the positive ideal solution [26]. In contrast, the perfect negative solution is the worst value achieved on each feature [17]. This method sorts existing alternatives by reference value. The following are the TOPSIS technique completion steps:

Create a decision matrix that is normalized (r_{ij}), where x_{ij} is criteria data or subcriteria.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^{2}}} \tag{7}$$

Define a weighted normalized decision matrix (y_{ij}). In each criterion or subcriteria. Weight indicates the level of importance of the requirements or subcriteria. Calculations are done by multiplying the weight value of standards or subcriteria (w_j) with r_{ij} i.e., normalized matrix.

$$y_{ij} = w_j . r_{ij} \tag{8}$$

Create a matrix of positive ideal solutions (A^+) and destructive ideal solution matrix (A^-).

$$A^+ = (y_1^+, y_2^+, \dots, y_m^+) \tag{9}$$

$$A^- = (y_1^-, y_2^-, \dots, y_m^-) \tag{10}$$

$$y_j^+ = \begin{cases} \max y_{ij}\,, if\ j\ is\ profit\ attribute \\ \min y_{ij}\,, if\ j\ is\ a\ cost\ attribute \end{cases}$$

$$y_j^- = \begin{cases} \min y_{ij}\,, if\ j\ is\ profit\ attribute \\ \max y_{ij}\,, if\ j\ is\ a\ cost\ attribute \end{cases}$$

The following conditions: The profit attribute is an attribute that provides an advantage for decision-makers, while the cost attribute is an attribute that offers expenses if the value is more significant.

Calculate the distance between alternate values (y_{ij}) using a matrix having positive and negative ideal solution matrices.

Distance to the optimal solution that is positive (S_i^+).

$$S_i^+ = \sqrt{\sum_{j=1}^{m} \left(y_i^+ - y_{ij}\right)^2} \quad (11)$$

Negative ideal solution distance (S_i^-).

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(y_{ij} - y_i^-\right)^2} \quad (12)$$

Calculate the alternative's relative proximity to the ideal solution, where T_i is the preference value.

$$T_i = \frac{S_i^-}{S_i^+ + S_i^+} \quad (13)$$

Sorting preference values from highest to lowest values is performed. The highest preference value indicates the highest ranking, and vice versa.

3. RESULTS AND DISCUSSION

3.1 Clustering with the FCM method

Clustering is performed on different Districts and Cities in East Java Province variables based on their criteria. The computations were performed on 29 communities and 9 cities. Before the clustering process, equalization of perception in the subcriteria is carried out first. This study found differences in perceptions in the subcriteria of the average length of girls' school and life expectancy. The more excellent the value, the more vulnerable the region to food in the other seven subcriteria. While in the two subcriteria, the opposite applies. The higher the value, the more food resistant the area. The Food Security Agency has demonstrated the process of equalizing perception on the guidelines for preparing food security criteria, and Table 3 displays the results.

Table 3 District Criteria Data

No	District	Food Availability	Food Affordability		⋯	Food Utilization
		NCPR	Pov	Food		Life
1	Pacitan	0.39	14.19	36.4	⋯	28.48
2	Ponorogo	0.24	10.36	32.24	⋯	27.57
3	Trenggalek	0.53	12.02	36.13	⋯	26.65
4	Tulungagung	0.56	7.27	24.61	⋯	26.26
5	Blitar	0.62	9.72	24.21	⋯	26.84
⋮	⋮	⋮	⋮	⋮	⋱	⋮
29	Sumenep	0.57	20.16	51.55	⋯	29.06

This also applies to city variables for the overall data used in the district clustering process shown in Table 3 above. This study determines the number of district and city variables clusters, namely c (cluster) = 3, 4, and 5. The clustering process is carried out only in affordability and food utilization because food availability consists of only one subcriteria. Only data sorting is carried out with the help of the Matlab program, obtained clustering results in the form of cluster centers and membership degrees that will be used in the following calculation process.

3.2 Cluster Validation using PCI

The best cluster results are calculated using the PCI method and selected values close to 1. Cluster validation results for district and city variables, Table 4 displays the results.

Table 4 Cluster Validation

District				City			
Food Affordability		Food Utilization		Food Affordability		Food Utilization	
Cluster	PCI	Cluster	PCI	Cluster	PCI	Cluster	PCI
3	0.7617	3	0.6916	3	0.8813	3	0.7412
4	0.7058	4	0.6304	4	0.8427	4	0.7091
5	0.6606	5	0.6115	5	0.7956	5	0.7279

Based on Table 4, the cluster quality district variable is better if the PCI value is close to 1. Based on the calculations that have been done, it can be seen that in the aspect of food affordability for cluster 3, the PCI result obtained is 0.7617, in cluster 4 is 0.7058, and in cluster 5, with a monetary value of 0.6606. Cluster 3 represents the most significant value closest to one based on these data. So that in the aspect of affordability of cluster food used is 3. Likewise, for food utilization, with the highest yield of 0.6916, which is cluster 3. In the city variable, The quality of the cluster is better if the PCI result is close to 1. In Table 4, the best cluster in food affordability is c = 3, with the validation result being 0.8813, and c = 5 in food utilization, with a validation result of 0.7279 so that the two clusters will be used next in the casting process with the TOPSIS method. To find out which areas are included in clusters 1, 2, and 3 can be seen based on the results of the membership degree. The highest degree of membership indicates that an area belongs to the cluster. Cluster results, along with membership degrees, are presented in Table 5 below.

Table 5 Clustering Results

No	District	Degree of Membership of Cluster data to-			Cluster		
		1	2	3	1	2	3
1	Pacitan	0.9037	0.0238	0.0455	√	-	-
2	Ponorogo	0.5631	0.0410	0.3959	√	-	-
3	Trenggalek	0.9696	0.0088	0.0215	√	-	-
4	Tulungagung	0.0354	0.0079	0.9566	-	-	√
5	Blitar	0.0077	0.0017	0.9906	-	-	√
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
29	Sumenep	0.0495	0.9344	0.0161	-	√	-

The result of the membership degree can be used to find an area included in clusters 1, 2, or 3. This is evident from the highest level of membership. For example, in Table 5, for the Pacitan district, the highest membership degree is in cluster 1, so the Pacitan district is a member of cluster 1, which is 0.9037. As for the Tulungagung regency, the highest membership degree is found in cluster 3, so the Tulungagung regency is a member of cluster 3, which is 0.9566. For the Sumenep regency, the highest membership degree is contained in cluster 2, so the Sumenep regency is a member of cluster 2, which is 0.9344 and applies to other districts.

3.3 Ranking with TOPSIS Method

The selected cluster based on the results of PCI calculations is then used in the casting process. Cluster members and general role-cutting are performed on variable data from districts and cities in East Java province using the TOPSIS approach. Cluster center data is derived from the outcomes of FCM calculations during cluster creation. The cluster that has been ranked shows the order of cluster levels based on food security. Clusters with the highest preference values indicate clusters with low levels of food security. After casting in the cluster, they raised members in each cluster to determine how the order of the district or city area is determined by the degree of food security. Table 6 shows the results of ranking clusters and cluster members of food affordability aspects:

Table 6 Cluster Casting Results and Regency Area Cluster Members

Cluster	T	Cluster Rank	Member of Cluster	T	Member Rank in Cluster
1	0.4592	2	Ngawi	0.86365	1
			Pacitan	0.77455	2
			Jember	0.70251	3
			Bojonegoro	0.59638	4
			Ponorogo	0.36417	5
			Tuban	0.32184	6
			Madiun	0.21739	7
			Trenggalek	0.16975	8
			Kediri	0.12372	9
			Pasuruan	0.10701	10
			Lumajang	0.0885	11
			Magetan	0.06158	12
			Jombang	0.03981	13
2	1	1	Bangkalan	0.85419	1
			Sumenep	0.57092	2
			Sampang	0.55565	3
			Nganjuk	0.53741	4
			Probolinggo	0.45694	5
			Bondowoso	0.1286	6
			Pamekasan	0.12787	7
			Situbondo	0.03024	8
3	0	3	Lamongan	0.94432	1
			Gresik	0.66663	2
			Banyuwangi	0.56615	3
			Tulungagung	0.48117	4
			Malang	0.38763	5
			Mojokerto	0.36269	6
			Sidoarjo	0.34242	7
			Blitar	0.33038	8

Cluster rank results use the TOPSIS method based on preference values on each cluster. The highest preference values indicate clusters with high food susceptibility, whereas the lowest values indicate regions with good food security. For example, the food affordability aspect consists of 3 clusters in the district variable. After cluster 1 is carried out, it has a preference value of 0.4592, then cluster 2 with a value of 1, and cluster 3 has a preference value of 0. So that when sorted from the highest value, it is obtained that the first ranking position is occupied by cluster 2 with a preference value of 1, then continued with cluster 1, and in the last class, there is cluster 3. As a result, Cluster 2 has the most vulnerable degree of food security, Cluster 1 has a moderate level of vulnerability, and Cluster 3 has the highest level of food security.

Based on the results of calculations that have been done, the cluster with the highest level of food affordability is cluster 3. So, cluster 3 is the group of regions with the best food affordability. Based on Table 6, Lamongan Regency is the area with the highest level of food affordability. For clusters with moderate affordability levels, namely cluster 1, in which Ngawi Regency is a district with medium food affordability. The cluster with the lowest food affordability level is cluster 2, where Bangkalan Regency is a district with the lowest food affordability. After cluster casting and cluster members, the TOPSIS method is also used to participate in all communities and cities of East Java Province obtained from the ranking results of each criterion. The highest preference value, the first order, states areas with increased food

security. In contrast, the areas with the lowest preference values were expressed as areas with low food security or high food vulnerability.

Obtained the results of cluster casting, the role of cluster members for each criterion, the slinging of each criterion, and the overall casting. For the results of the entire district, the district with the highest food security is Magetan Regency and the lowest is Probolinggo. As for the food security assessment in the city area, Madiun indicates the most elevated food simplicity, while Kediri indicates the most insufficient food security or increased food vulnerability. So that it can answer the goal of this study, the outcomes of clustering Districts or Cities in East Java province based on the FSI using the FCM technique and implementing the TOPSIS method in the food security area of the Districts or Cities in East Java province can be found out.

Based on these findings, it is possible to see food security in the districts and cities of East Java province. Table 7 compares the effects of assessments performed by the Food Security Agency to the results of calculations using the FCM-TOPSIS method for district variables.

Table 7 Comparison Results of the Highest and Lowest Food Security of Regencies

Highest Food Security		
Criterion	Rank FCM-TOPSIS	Rank BKP
Affordability Aspects	Blitar Sidoarjo Mojokerto	Sidoarjo Tulungagung Banyuwangi
Utilization Aspects	Gresik Sidoarjo Magetan	Gresik Sidoarjo Lamongan
Overall Aspects	Magetan Tuban Ponorogo	Gresik Magetan Lamongan
Lowest Food Security		
Affordability Aspects	Sampang Sumenep Bangkalan	Bangkalan Sumenep Sampang
Utilization Aspects	Trenggalek Jember Situbondo	Bondowoso Jember Probolinggo
Overall Aspects	Pamekasan Bangkalan Probolinggo	Pamekasan Sampang Probolinggo

Based on Table 7, for criteria for food affordability in districts, The district with the highest food affordability is Blitar Regency, whereas the district with the lowest is Bangkalan Regency. Food availability is tied to food production. At the same time, affordability is associated with the stability of food availability, prices, and management in food reserves. According to the food security agency, the district with the highest food affordability is the Sidoarjo Regency, while the lowest is the Sampang Regency. But based on the calculations that have been done, the district with the highest level of affordability is indicated by Blitar Regency, while the lowest is Bangkalan Regency. Estimates for the city's food security are done in the same step. In the overall assessment, the city with the highest food security is Madiun, and the city with the lowest food security is Kediri.

There are many disparities between the Food Security Agency assessment results and the food security evaluations of districts and cities in East Java Province utilizing FCM and TOPSIS techniques. Different calculation processes cause differences in calculations. The Food Security Agency performed the calculation process by multiplying the criteria data by the predetermined weight and then sorting it to determine the ranking results. In the meantime, before this

investigation's casting procedure, clustering was performed using the FCM approach. The clustering procedure takes the proximity of the data into account. So, districts and cities can be grouped by paying attention to the similarity of characteristics. Then the groups were ranked using the TOPSIS method to determine the food security level. In addition, casting is also carried out on members of these groups. Then it can be known the overall results of the harvest from the region with the highest to the lowest level of food security. Based on these results, the government can determine which areas need special treatment for food equalization in the East Java region.

East Java Province has strengthened its efforts to address the issue of food insecurity. East Java Province is rated food-vulnerable in a 2009 Food Security and Vulnerability Atlas of Indonesia (FSVA). From 2010 until 2014, the East Java regional government continued to make efforts to deal with the problem of food insecurity. During this period, the issue of regional food insecurity was resolved by 60.48 percent. Judging from the pillars of food availability, East Java is among the provinces with a cereal production surplus. East Java province has reasonable regulations and policies in almost all food security indicators and nutrition commitment with the highest commitment rating. From the budget dimension, East Java Province does not have enough budget to develop food security and nutrition. It is shown from the East Java commitment assessment results, which only reached 69. Although East Java Province has a relatively high commitment, it is still necessary to increase loyalty, mainly so that the obligations written in the development document can be implemented into work programs [9], [27]. In line with the research results, wherein the districts and cities of East Java Province still need to be revamped and concentrated for the entire region so that the improvement of food security areas does not occur very significantly increases.

The author wanted to make some suggestions after adopting the FCM-TOPSIS technique to improve food security in districts and cities throughout East Java Province. In general, this method can be used as a reliable performance evaluation. It is indicated by a ranking order that is not much different from the determination made by the government with other measurement methods, especially in the top and bottom ranking positions. But even so, there are still many ranking differences in different parts. For further research, you can use GIS to determine the distribution map of food security according to color differences. In addition, other MCDM methods can be used, such as PROMETHEE and ELECTRE methods.

4. CONCLUSIONS

This study combines two methods, FCM and TOPSIS, to evaluate food security in East Java. FCM is used to cluster districts or cities that have the same characteristics. TOPSIS, on the other hand, is used to determine food security in East Java Province districts/cities by rating clusters, cluster members, and overall rankings. The Food Security Agency has prepared the food security index as criteria and sub-criteria. According to the statistics, the Magetan district and Madiun City have the highest food security. Probolinggo area and Kediri City, on the other hand, have the lowest food security. According to the findings of this ranking, districts or cities with low rankings can be given special attention by local governments to avoid food shortages. On the other hand, regions with high food security can continue to be maintained and further improved to help districts or cities with low food security.

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