Integration of K-Means clustering and fuzzy AHP to establish development strategy on cassava chips produced by SMEs

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Abstract. Malang Regency is an area that has potential to be developed on agricultural sector, with one most superior commodity is cassava chips. Main issue remains in the cassava chips SMEs is the partial or individual work condition in among SMEs. This research objective is to establish an industrial cluster using K-Means Clustering, and to determine the cluster’s development strategy using Fuzzy AHP. Respondents involved in this research are five SMEs’ owners and three experts from government and SMEs experts. Results showed that there are two clusters established. Cluster 1 belongs to small scale business with between 6 to 19 workers involved (SMEs of Dua Bawang, UD Wijaya, Pokmas Mandiri, and UD Langgeng Jaya Abadi). Cluster 2 belongs to medium scale business with 20 to 99 workers involved (SMEs of UD Pondok Tua). SME in cluster 2 has above average value of production capacity compared to cluster 1. Development strategy for cluster 1 could be done by implementing quality improvement and product standardization, as well as improving capital access. Development strategy for cluster 2 could be done by implementing quality improvement and product standardization, as well as training to improve the workers’ skill and performance.

1. Introduction
Malang Regency is one of the regencies in East Java Province being the second largest regency after Banyuwangi Regency, covering an area of 3,534.86 km². Moreover, Malang Regency is also well known as an area which is rich in its potentials including agricultural sector. One of the flagship commodities of Malang Regency is cassava. According to BPS (Central Bureau of Statistics) data in East Java Province in 2015, the total cassava production reached 3,161,573 tons with harvest area of 168,194 hectares, as well as harvested area and productivity level of 214 quintals per hectare. While the total production for Malang (City and Regency) in 2013 reached 335,980.16 tons with a harvested area of 12,989.00 hectares and the level of productivity reached 258.67 quintal per hectare [1].

The large amount of cassava production increases the attractiveness of the community to use cassava as a raw material for food products, one of which is cassava chips. In Malang Regency there are 5 SME of cassava chips scattered in Kalipare sub-district (Pokmas Mandiri and UD Langgeng Jaya Abadi), Singosari (UD Wijaya and Dua Bawang), to Turen (UD Pondok Tua). In Malang Regency there are a number of community groups which accommodate processed products from SMEs from various sub-districts, but not all cassava chips SMEs become members of the existing community. This condition is due to the fact that the nature of cassava chips SMEs are still partial or individual which posses limited knowledge in the development of product marketing. Development of
connecting institutions, the use of interpersonal communication, and information transfer through individuals are crucial for expansion and innovation [2]. Furthermore, accessing important resources and information in a cluster and realizing the potentials of economic benefits offered by the cluster can be established by locally connecting the firms [3]. One strategy to reduce partial conditions and strategies in describing and providing effective solutions to existing problems is to form industrial clusters, becoming a prerequisite for innovation and enabling firms to apply new knowledge to production. In addition, competitive advantage also depends on the interactions within the technological community which encourages local innovation and knowledge [2]. The formation of industrial clusters in cassava chips SMEs can improve the competitiveness of cassava chips products in Malang Regency and can be used to determine SME development strategies based on clusters which can facilitate strategic policy making. By forming a cluster, firms can cultivate professional labor, create spillover effects of techniques and knowledge, and enhance competitiveness [4-6].

Cluster analysis aims to classify n-objects based on p-variation which have similar characteristics between existing objects. The object will be classified into one or more clusters or groups. One method for clustering is to use the K means method. K-means method is a partitioning clustering method which separates data into different groups. It posses some advantages, fast and quite efficient for the grouping process in large amounts of data [7]. The decision-making process involves many criteria, the Fuzzy AHP method can be used to determine the priority weight on each criterion becoming the basis for the right decision analysis. The advantage of Fuzzy AHP method is that it can cover the weaknesses in the AHP method, namely the problem on criteria which has more subjective values. The purpose of this study was to form industrial clusters using K Means Clustering method and determine cluster development strategies using Fuzzy AHP method.

2. Research Method
Cluster analysis with the K-means clustering method becomes the most widely used method in data grouping in industrial fields. The first step that must be conducted in grouping employing K-means clustering method is to determine the number of clusters (k) and determine the centre value (centroid). After clusters are formed, the next step is build the Fuzzy AHP process, with steps analysis are as follows:
1. Identifying the occurring problems
2. Identifying objectives
3. Developing hierarchical structure
4. Determination of Weight
   a. Calculating the value of fuzzy synthetic extent, this value will affect the object, namely criteria, sub criteria and i-alternative. The value calculation of fuzzy synthetic extend can be conducted with the following formula:
   \[
   \sum_{i=1}^{m} \frac{1}{M_i} \sum_{j=1}^{m} \frac{1}{M_j} = \left( \sum_{i=1}^{m} u_i \sum_{j=1}^{m} m_j \sum_{i=1}^{m} l_i \right)
   \]
   Where:
   \[M = \text{triangular Fuzzy number} \]
   \[j = \text{column} \]
   \[i = \text{row} \]
   \[l = \text{lower value} \]
   \[m = \text{medium value} \]
   \[u = \text{upper value} \]
   b. Calculating the comparison of the probability levels between fuzzy numbers
   c. Calculating the probability level for fuzzy numbers
   d. Determining the weight vector, in the form of a fuzzy number then normalized by the equation:
3. Results and Discussion

The data on the profile of cassava chips SMEs in Malang Regency can be seen in Table 2.

| SME                      | Production capacity (kg/m) | Operating length (years) | Average sales (IDR/month) | Investment (IDR) | No. of workers |
|--------------------------|----------------------------|--------------------------|---------------------------|------------------|---------------|
| UD Wijaya                | 3,000                      | 30                       | 90,000,000                | 100,000          | 13            |
| Dua Bawang               | 700                        | 22                       | 21,000,000                | 200,000          | 6             |
| Pokmas Mandiri           | 16,000                     | 13                       | 200,000,000               | 100,000          | 19            |
| UD Langgeng Jaya Abadi   | 30,000                     | 12                       | 72,000,000                | 200,000          | 10            |
| UD Pondok Tua            | 3,000,000                  | 16                       | 900,000,000               | 500,000          | 99            |

Source: Data analysis (2017)

The initial investment or capital at the beginning of the cassava chips SMEs in Malang Regency still uses personal funds from the respective business owners. This is a problem challenged by the cassava chips SMEs. Inadequate capital is as one of the few small-scale enterprises’ problems [9]. Based on Table 2, the sales value of the five cassava chips SMEs ranging from IDR 21,000,000 to IDR 900,000,000. The initial capital investment or SMEs ranges between IDR 100,000 to IDR 500,000. The average monthly production capacity of cassava chips in Malang Regency is 700 - 3,000,000 kg with a total workforce of 6 to 99 people.

3.1. Cluster Analysis (K-Means Clustering)

The number of clusters formed in this study was 2 clusters. Cluster 1 has 4 SME members and Cluster 2 has 1 SME member of as shown in Table 3. Based on the number of access samples of 5 SMEs, the formation of 2 clusters is the best choice due to similar cluster member goals included in one cluster and significantly different from other cluster members. The results of data processing using SPSS show that the results of K-means clustering are optimal in the 2nd iteration with the minimum distance between cluster centres is 4.921. K-means uses the mean value as a cluster centre [10].
Table 3. Characteristics of each SME cluster.

| Characteristic                  | Cluster 1 (UD Wijaya, Dua Bawang, UD Langgeng Jaya Abadi, Pokmas Mandiri) | Cluster 2 (UD Pondok Tua) |
|---------------------------------|--------------------------------------------------------------------------|---------------------------|
|                                 | Cluster center | Minimum | Maximum | Cluster center | Minimum | Maximum |
| Production capacity (kg/m)      | 16,175         | 700     | 45,000  | 3,000,000      | 3,000,000 | 3,000,000 |
| Operating length (years)        | 18             | 8       | 30      | 16             | 16       | 16       |
| Average sales (thousand IDR/m)  | 95,740         | 21,000  | 200,000 | 900,000        | 900,000  | 900,000  |
| Investment (IDR)                | 150,000        | 100,000 | 200,000 | 500,000        | 500,000  | 500,000  |
| No. of workers                  | 12             | 6       | 19      | 99             | 99       | 99       |

Source: Data analysis (2017)

Cluster 1 is an SME cluster in the Fast Moving Enterprise group. Fast Moving Enterprise is an SME having an entrepreneurial spirit and will transform into a big business [11]. Cluster 2 has only 1 SME, namely Pondok Tua Trading because it is a type of medium business with 20 to 99 workers. Central Bureau of Statistics (BPS) classifies a business based on the number of workers, where medium businesses have 20 to 99 workers, and large businesses have at least 100 employees [1].

3.2. Strategy of cluster development

The analysis of development strategy in Cluster 1 SME was conducted for each expert, objective factors and alternative strategies. The results of filling out the questionnaire by experts were processed using AHP method and converted with Fuzzy Synthetic Extent calculation to obtain an effective development strategy. Fuzzy AHP utilizes fuzzy ratios called Triangular Fuzzy Numbers (TFN) and is used in fuzzification [12]. In more complex systems, human experience and judgment are often described in linguistic and unclear patterns. Therefore, a better picture can be developed into quantitative data using fuzzy theory. In this study, 2 hierarchies were formed which had the same alternative strategy, only the conditions of the 2 clusters were formed.

![Figure 1. Hierarchical structure of cluster 1 of cassava chips industrial cluster development.](image-url)
Figure 1a shows that the development of the cassava chips industry in Cluster 1 needs to prioritize the government factor with the value of 44.47%. Government is important to the development of the cluster of cassava chips industry due to voids often hindering entrepreneurial activities and innovation [13]. The priority goal is to increase product sales by 29.4%. Product sales affect the profits and development of a business. Increased production will in line with the improvement of production technology employed in order to meet production capacity. Volatile environments which are often found in developing country like Indonesia are also challenged with the lack of institutions and strategic market factors to support business and innovation [14]. Alternative strategies prioritized are improving quality and standardizing products. Product standardization will improve the quality of the product in the market.

Figure 2 presents the cluster development factor becoming a priority is the industrial cluster, accounted by 47.5%. SME development in accordance with industrial clusters will improve results rather than cluster-less development because its development being in accordance with the industrial cluster will be on target. Furthermore, it will also assist the government in determining appropriate and effective development strategies. The priority goal is to increase product sales with a 32% priority number. Cassava chips SMEs needs to reflect its market focus clearly. If not exporting their products, they should focus on developing new products to penetrate domestic markets. If they export, they should shift the focus, at least partially, to international markets [15]. All of the cassava chips SMEs in this research are marketing their product domestically. Therefore, they need to emphasize to reap benefits from up to indigenous demands in the domestic markets [16]. In this situation, the products offered by firms for domestic markets are critical in deciding product innovation and speed [15]. Alternative strategies prioritized are quality improvement and product standardization of 29.2%.

4. Conclusion
Clustering of five cassava chips SMEs in Malang Regency conducted with K-means clustering resulted in two clusters. Cluster 1 is cassava chips SMEs which included in the small scale businesses (UD Wijaya, Dua Bawang, UD Langgeng UD Jaya Abadi, and Pokmas Mandiri), while Cluster 2 is an SME categorized in medium scale business (UD Pondok Tua). Cluster 2 SMEs have very significant differences in several aspects of the research variables, so it only has 1 SME member. The strategy of developing cassava chips SME in Malang Regency conducted with Fuzzy Analytical Hierarchy
Process (FAHP). In SME members of Cluster 1, it is implemented by improving the quality and product standardization such as improving the quality of raw materials, clean production processes according production procedures and good packaging. The strategy of developing Cluster 2 is to improve the quality and standardization of products by using a more attractive packaging design.

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