# Clustering on Small-scale Food Manufacturing Industry in West Jakarta: a Fuzzy Analytical Hierarchy Process Approach

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**Abstract**. The small-scale food manufacturing industry has become the most dominant sector in Jakarta, in terms of number and manpower absorption. However, they are faced with slow growth rates, indicated by their inability to meet national demands. The Government believes that the small-scale food manufacturing industry in Jakarta are formed without comprehensive planning, they are spread throughout Jakarta. This study aims to cluster the small-scale food manufacturing industry, which is focused on the West Jakarta area as a pilot project. By employing the Fuzzy Analytical Hierarchy Process (Fuzzy AHP), five criteria were considered during the assessment: availability of land, suppliers, facilities and infrastructure, labor, and markets. As a result, area clustering map was proposed.
**Keywords:** small-scale industry, food manufacturing, clustering, fuzzy AHP.

## 1. Introduction

The small-scale food manufacturing industry is people-intensive. As a people-intensive industry, the quest for efficiency becomes a major concern. Small-scale industry competitiveness can be reflected by several indicators: the ability of the industry to create and produce high-quality products, the capacity of the industry to export high-quality products, and the propensity of the enterprises (SMEs) to sustain in the global economics [1]. The propensity of the small-scale industry to sustain in the current economics is considered as the most crucial indicator for most of the growing Asian countries.

The Ministry of Industry noted the investment in the manufacturing industry sector continues to grow significantly. In 2014, capital investment reached Rp195.74 trillion, then rose to Rp222.3 trillion in 2018. This increased investment boosted employment up to 18.25 million people in 2018, which contributed 14.72 percent of the total workforce national. The Government is targeting, throughout 2019 manufacturing industry growth can reach 5.4 percent. Subsectors that is expected to grow high include the food manufacturing industry [2].

Moreover, the Ministry of Trade of the Republic of Indonesia records that the total trade of Indonesian Processed Foods to Europe in 2018 was USD 981.9 million (surplus of USD 277.5 million). To date, 5 (five) main Indonesian processed food products are exported to Europe include Prep or Pres Fish (HS 1604), Crustaceans (HS 1605), Tobacco (HS 2401), Fruits (HS 2008), and Coconut (HS 2008) HS 0801). While the 3 (three) main destination countries for Indonesia's processed food exports are the Netherlands (USD 142.6 million), Germany (USD 98.9 million), and the UK (USD 78.2 million). Several countries in Europe have been identified as potential markets for Indonesian Processed Food

products including Spain (snacks), Germany (tea), Denmark (frozen seafood), and the European Union (coffee) [3].

The competitiveness of the Indonesian food industry, however, is highly contributed by medium and large enterprises. The lack of competitiveness for the small-scale industry is caused by several conditions: location, the government supports, human resources, and strategic partnership [4]. For the Indonesian context, the basic possible barrier is because of the lack of location planning. Thus far, small industries grow naturally, grouping by type of product. Industrial areas like this are known as industrial clusters. In general, industrial clusters are not formed based on certain considerations. According to industry service data, for example, the Capital City of Jakarta has several small-scale industrial clusters such as tofu/ tempeh, apparel, household appliance, *mukena*, and so forth. The cluster that has the most number of business units is the tofu/*tempe* cluster, consisted of 987 business units located in West Jakarta.

Thus, this paper aims to develop a clustering decision with a special focus on the small-scale food manufacturing industry in West Jakarta area.

### 1.1. Industrial Clustering

Clusters are formed because of the interconnectedness of institutions with similar needs and complement each other. Besides, clustering helps entrepreneurs to make decisions when there is an opportunity to do business [5]. Industrial clustering is quite beneficial for small and medium enterprises because each of the similar industries in one cluster can work together with each other, making it more effective and efficient in the production process [6]. Industrial clustering is one way to improve industrial competitiveness and can improve relations between similar entrepreneurs by doing business or cooperating, who have similar needs for capabilities, technology, and infrastructure [7].

The previous study recommends industrial development in strategic locations to building a good and competitive trade market [4, 8]. However, strategic location alone is not enough, industrial clustering at strategic locations is something that should be considered towards a competitive manufacturing industry. Previous studies implied several indicators to measure the potential competitiveness of manufacturing industry: skilful employee sourcing [4], suppliers' specialization [4, 7], facilities and infrastructure [6], production layout [6], quality of the product [6, 9], and delivery cost [9].

### 1.2. Criteria in Clustering Decision

There are several considerations in locating the appropriate industrial cluster. Some criteria should be considered [8, 10], such as characteristics and size of the population, availability of labor, proximity to production sources, promotion, economic base, compatibility with facilities, competitive situation, and convenience of a store location.

Another study used seven criteria in choosing the location of the processing industry: raw materials, land conditions, labor, marketing, spatial planning, supporting facilities, and adequate infrastructure [11]. For this study, five criteria were analyzed: land availability, infrastructures, labor source, suppliers, and market.

## 2. Methods

Five criteria were analyzed using the Fuzzy Analytical Hierarchy Process (Fuzzy AHP). Analytical Hierarchy Process (AHP) is a method of Multi-Criteria Decision Making (MCDM) developed by Saaty in the early 1970s. AHP is an analytical method used to create a problem-based model that has no structure and can be used to solve quantitative problems, and as well as problems that require opinions [12, 13].

Besides, AHP can also be used to solve problems in complex situations. AHP is a general theory of measurement used to find the ratio scale, both from discrete and continuous pair comparisons. These comparisons can be taken from actual measurements or a baseline scale that reflects the strength of feelings and relative preferences [12]. Further, fuzzy logic will deliver better results compared to conventional theories in general, because fuzzy logic develops existing theories by minimizing

deficiencies in previous theories, such as not being able to provide optimal results when research is subjective. Fuzzy logic has a role to minimize uncertainty. The uses of a triangular fuzzy number are one approach to minimize uncertainty in the AHP scale in the form of values.

For this study, three experts were involved as informants. The experts consist of a government official who has the experience and knowledge in a small industry, an industrial consultant who used to dealing with regional planning and development, and a higher education expert who has the concentration of research related to the industry, economic development, and regional development. Experts were given the freedom to assess the existing criteria with five priority weights of the AHP fuzzy method: EI (Equal Importance), MI (Moderate Importance), SI (Strong Importance), VSI (Very Strong Importance), EMI (Extremely More Importance) [13]. The assessment questionnaire was filled by filling in the available fields with a checkmark (V). The following table represents the fuzzy importance rating scale used in the questionnaire.

**Table 1.** Priority assessment scale

| Priority scale | Notes | Membership function |
| --- | --- | --- |
| 9 | Extremely more importance (EMI) | (8,9,10) |
| 7 | Very strong importance (VSI) | (6,7,8) |
| 5 | Strong importance (SI) | (4,5,6) |
| 3 | Moderate importance (MI) | (2,3,4) |
| 1 | Equal importance (EI) | (1,1,2) |

In processing data using the AHP method, it is necessary to calculate the consistency test, where the consistency test is useful to determine whether the pairwise comparisons produced are consistent or not. The measurement of consistency from a pairwise comparison matrix is based on the largest eigenvalue [12].

## 3. Results and Discussion

The assessment of the importance of each criterion was carried out by experts selected as informants in this study. In the questionnaire distributed several sub-districts became indicators, namely as follows, KL (Land Availability), SP (Facilities and Infrastructure), PM (Suppliers), TK (Labour), and PS (Market). The results obtained by filling out the questionnaire were comparisons between criteria. All questionnaire results can be arranged in the form of pairwise comparison matrices containing fuzzy number scales.

In assessing the relative importance of two elements, a reciprocal axiom applies, meaning that if the element in column one is given a value 4 times more important than the element in column two, then the element in column two must be equal to 1/4 times more important than the element in column one. Scale numbers that have been made on the paired matrix were then converted to the TFN (Triangular Fuzzy Number) scale. Fuzzy numbers are usually shown in the form of three numbers, i.e. (l, m, u). These parameters represent the smallest possible values, the most probable values, and the largest values that represent fuzzy problems.

Before defuzzifying the assessment matrix, the assessment matrix of respondent one, respondent two, and respondent three were combined into one assessment matrix, using the following formula: Let A1 = (l1, u1); A2 = (l2, u 2); A3 = (l3, u3). Then the combined assessment matrix is formulated as follows:

$$A_g(l,u) = \sqrt[3]{(l_1 * l_2 * l_3)},(u_1 * u_2 * u_3)$$ (1)

The combined matrix of criteria assessment is shown in Table 2.

**Table 2.** Criteria Assessment Combination Matrix

|      | KL |     | SP |      | PM |      | TK |      | PS |      |
|------|------|------|------|------|------|------|------|------|------|------|
| KL | 1 | 1.5 | 0.77 | 1.06 | 5.09 | 6.10 | 0.31 | 0.42 | 0.30 | 0.37 |
| SP | 1.09 | 1.51 | 1 | 1.5 | 3.44 | 4.51 | 0.43 | 0.51 | 0.33 | 0.40 |
| PM | 0.17 | 0.20 | 0.23 | 0.30 | 1 | 1.5 | 0.17 | 0.20 | 0.12 | 0.14 |
| TK | 2.77 | 3.68 | 1.98 | 2.33 | 5.09 | 6.10 | 1 | 1.5 | 0.24 | 0.30 |
| PS | 2.76 | 3.35 | 2.53 | 3.10 | 7.11 | 8.11 | 3.81 | 4.75 | 1 | 1.5 |

Defuzzification used in this study aims to convert fuzzy values into crisp values. The calculation of crisp values for the confidence level of $\alpha = 0.5$ is in Table 3.

**Table 3.** Combined Crisp Matrix

|       | KL | SP | PM | TK | PS |
|-------|------|------|------|------|------|
| KL | 1 | 0.91 | 0.37 | 0.36 | 0.33 |
| SP | 1.30 | 1 | 0.47 | 0.42 | 0.36 |
| PM | 0.18 | 0.26 | 1 | 0.16 | 0.13 |
| TK | 3.23 | 2.15 | 1.25 | 1 | 0.27 |
| PS | 3.06 | 2.81 | 4.28 | 2.87 | 1 |
| TOTAL | 8.77 | 7.14 | 7.36 | 4.81 | 2.10 |

C.R.'s calculation results obtained was 0.00. Therefore, it can be concluded that the paired matrix is consistent, and the results of the weighting of the criteria contained in the matrix can be used for further data processing. Table 4 shows the eigenvector calculation.

**Table 4.** Eigenvector calculation

|       | KL | SP | PM | TK | PS | weight | Rank |
|-------|------|------|------|------|------|--------|------|
| KL | 0.11 | 0.13 | 0.05 | 0.08 | 0.16 | 0.11 | 4 |
| SP | 0.15 | 0.14 | 0.06 | 0.09 | 0.17 | 0.12 | 3 |
| PM | 0.02 | 0.04 | 0.14 | 0.03 | 0.06 | 0.06 | 5 |
| TK | 0.37 | 0.30 | 0.17 | 0.21 | 0.13 | 0.24 | 2 |
| PS | 0.35 | 0.39 | 0.58 | 0.60 | 0.48 | 0.48 | 1 |

There were five fuzzy weighing scales used, namely STA (strongly not submitted), TA (not submitted), CA (simply submitted), A (submitted), SA (strongly proposed). Each weighing scale has different membership functions, such as STA (1,1,2), TA (2,3,4), CA (4,5,6), A (6,7,8), SA (8,9,10). The results of the performance evaluation of the type of industry in each district can be seen in Table 5.

Table 5. Performance evaluation based on industry types

| District | Tofu | Cake & Bread | Chili Sauce | Pudding | Wet Noodle | Dry Noodle | Seasoning | Jelly |
|---|---|---|---|---|---|---|---|---|
| Cengkareng | 56.24 | 76.66 | 64.36 | 100.00 | 59.55 | 29.75 | 26.10 | 51.27 |
| Grogol Pet. | 56.24 | 77.44 | 82.70 | 43.11 | 67.67 | 30.50 | 70.97 | 30.99 |
| Kalideres | 100.00 | 79.50 | 63.76 | 94.35 | 83.97 | 50.00 | 51.27 | 51.91 |
| Kebon Jeruk | 34.36 | 73.43 | 100.00 | 65.70 | 83.77 | 54.21 | 47.51 | 81.94 |
| Kembangan | 34.36 | 56.25 | 96.48 | 58.27 | 100.00 | 47.09 | 100.00 | 54.81 |
| Palmerah | 14.48 | 100.00 | 73.76 | 65.70 | 82.93 | 100.00 | 75.68 | 100.00 |
| Taman Sari | 14.48 | 66.17 | 49.25 | 27.09 | 41.33 | 25.56 | 34.70 | 11.94 |
| Tambora | 14.48 | 50.72 | 33.74 | 16.50 | 21.32 | 19.36 | 14.67 | 33.38 |

By combining with Simplex LP method, it is expected to find the optimal solution. The industry clustering optimization formulation is stated as follows:

**Max Z** $= 56{,}24\ x_{11}+76{,}66\ x_{12}+64{,}36\ x_{13}+100\ x_{14}+59{,}55\ x_{15}+29{,}75\ x_{16}+26{,}10\ x_{17}+51{,}27\ x_{18}+56{,}24\ x_{21}+77{,}44\ x_{22}+82{,}70\ x_{23}+43{,}11\ x_{24}+67{,}67\ x_{25}+20{,}50\ x_{25}+20{,}50\ x_{26}+70{,}97\ x_{27}+30{,}99\ x_{28}+100\ x_{31}+79{,}50\ x_{32}+63{,}76\ x_{33}+94{,}35\ x_{34}+83{,}97\ x_{35}+50\ x_{36}+51{,}27\ x_{37}+51{,}91\ x_{38}+34{,}36\ x_{41}+73{,}43\ x_{42}+100\ x_{43}+65{,}70\ x_{44}+83{,}77\ x_{45}+54{,}21\ x_{46}+47{,}51\ x_{47}+81{,}94\ x_{48}+34{,}36\ x_{51}+56{,}25\ x_{52}+96{,}48\ x_{53}+58{,}27\ x_{54}+100\ x_{55}+47{,}09\ x_{56}+100\ x_{57}+54{,}81\ x_{58}+14{,}48\ x_{61}+100\ x_{62}+73{,}76\ x_{63}+65{,}70\ x_{64}+82{,}93\ x_{65}+100\ x_{66}+75{,}68\ x_{67}+100\ x_{68}+14{,}48\ x_{71}+66{,}17\ x_{72}+49{,}25\ x_{73}+27{,}09\ x_{74}+41{,}33\ x_{75}+25{,}56\ x_{76}+34{,}70\ x_{77}+11{,}94\ x_{78}+14{,}48\ x_{81}+50{,}72\ x_{82}+33{,}74\ x_{83}+16{,}50\ x_{84}+21{,}32\ x_{85}+19{,}36\ x_{86}+14{,}67\ x_{87}+33{,}38\ x_{88}$

Constraints:

$$X_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18} = 3$$
$$X_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28} = 2$$
$$X_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38} = 987$$
$$X_{41}+x_{42}+x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{48} = 1$$
$$X_{51}+x_{52}+x_{53}+x_{54}+x_{55}+x_{56}+x_{57}+x_{58} = 2$$
$$X_{61}+x_{62}+x_{63}+x_{64}+x_{65}+x_{66}+x_{67}+x_{68} = 0$$
$$X_{71}+x_{72}+x_{73}+x_{74}+x_{75}+x_{76}+x_{77}+x_{78} = 0$$
$$X_{81}+x_{82}+x_{83}+x_{84}+x_{85}+x_{86}+x_{87}+x_{88} = 26$$

From the results of optimization using the SOLVER menu on MS-Excel, the overall performance score has increased from before clustering. The overall performance score before clustering was 99901, and after clustering the overall performance score was 100177. Figure 1 represents the proposed clustering for small-scale food manufacturing industries in the West Jakarta area. Area and Industry Clusters were named in Bahasa Indonesia and the picture was manually constructed based on performance evaluation scores.

Figure 1 can be explained as follows. An area which obtained a score of 100 shows a "strong" capability to serve as an industry cluster. Kalideres District, for example, was found very suitable for tofu industry. The lower the score, the less likely an area to be developed as an industrial cluster. In this case, Taman Sari District was identified as one area which was not suitable for almost all types of industries due to several possible reasons: less availability of land and high density of housing.
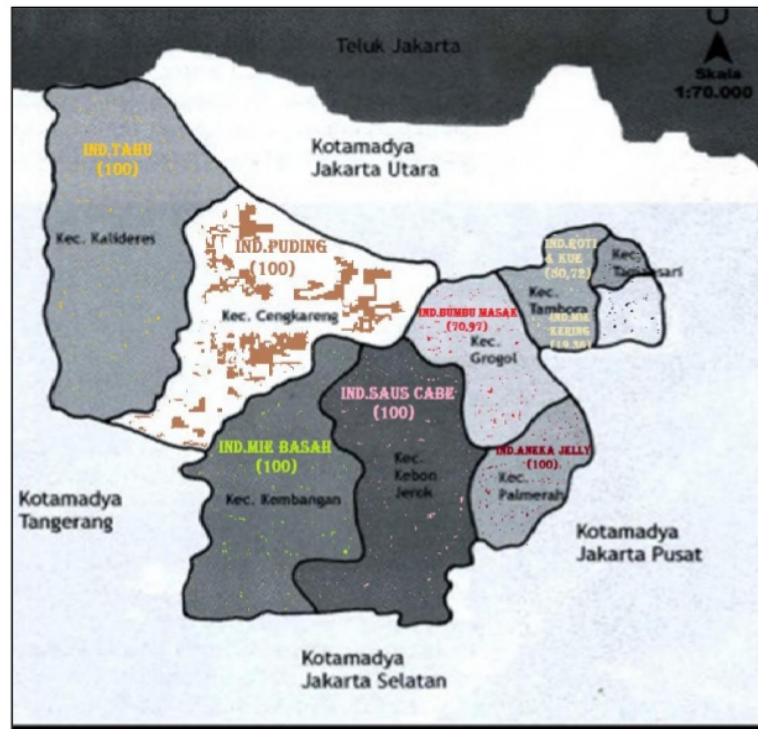
*Figure 1.* Proposed clusters

## 4. Conclusion

The fuzzy AHP approach showed that the "market" shown the greatest importance, followed by "labor", "facilities and infrastructure", "land availability", and "suppliers". The distribution of clusters was obtained as follows: tofu industry in Kalideres District, pudding industry in Cengkareng District, wet noodle industry in Kembangan District, chili sauce industry in Kebon Jeruk District, seasoning industry in Grogol District, various jelly industries in Palmerah District, bread & cake industry and the dried noodle industry in Tambora District. There is one sub-district which is not proposed at all to form an industrial cluster (Taman Sari District), due to the following conditions: the availability of land is quite minimal, and the density of housing is high.

This study could help the provincial government to better reallocating its industrial clusters. However, the outcome of this study could be more enriched. Three experts involved in this study were from government official, academician, and industrial consultant. Further study should incorporate views from business owners, since they would provide richer perspectives.

## References

[1]   World Economic Forum, "The inclusive growth and development report 2017", January 2017, accessed on 06 March 2019 from http://weforum.org.
[2]   The Ministry of Industry, "Investasi manufaktur diyakini semakin moncer seusai Pemilu", April 2019, accessed on 07 March 2019 from http://kemenperin.go.id.
[3]   The Ministry of Foreign Affairs, "American and European Market", May 2019, accessed on 06 June 2019 from https://pasaramerop.kemlu.go.id.

[4]    N.U. Handayani, H. Santoso, and A.I. Pratama, "Faktor-faktor yang mempengaruhi daya saing klaster mebel di Kabupaten Jepara," Jurnal Teknik Industri, vol. 13, no. 1, pp. 22–30, 2012.

[5]    M. Momeni, M. Mohseni, and M. Soofi, "Clustering stock market companies via K-means algorithm," Journal of Business and Management, vol. 59, no. 3, pp. 234-273, 2015.

[6]    M. Najib, H. Yagi, and A. Kiminami, "Competitiveness of Indonesian Small and Medium Food Processing Industry: Does the location matter?" International Journal of Business and Management, vol. 6, no. 9, pp. 57-67, 2011.

[7]    S. Lewis, M. Sundar, J. Jiang, and S. Lu, "Cluster analysis method for identification of failures in a manufacturing environment," Journal of Manufacturing Technology Management, vol. 56, no. 2, pp. 243-265, 2009.

[8]    M. Kirankabes and M. Arik, "Industrial clustering approach in regional development," Journal of Applied Business and Economics, vol. 16, no. 3, pp. 257-273, 2014.

[9]    C. Boja, "Clusters models, factors and characteristics," International Journal of Economic Practices and Theories, vol. 1, no. 1, pp. 34-43, 2011.

[10]   S. Zuliarni and R. T. Hidayat, "Analisis pertimbangan pebisnis restoran kelas kecil di lingkungan kampus Universitas Riau dalam pemilihan lokasi usaha," Jurnal Aplikasi Bisnis, vol. 3, no. 2, pp. 100-119, 2013.

[11]   N. G. Candy and A. Pamungkas, "Penentuan alternatif lokasi industri pengolahan sorgum di Kabupaten Lamongan," Jurnal Teknik ITS, vol. 2, no. 2, pp. 211-214, 2013.

[12]   M. Javanbarg, C. Scawthorn, J. Kiyono, and B. Shahbodaghkhan, "Fuzzy AHP-based multicriteria decision making system using Particle Swarm optimization," Journal of Manufacturing Technology Management, vol. 54, no. 2, pp. 245-274, 2012.

[13]   T. Hartanto, M. Ginting, and O. Sunardi, "A Fuzzy Analytic Hierarchy Process approach for determining the criteria success factors of MRT parts' e-procurement: the case of Jakarta MRT project," IOP Conference Series: Materials Science and Engineering, vol. 528, no. 1, 012001, 2019.

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