Sustainable production performance index measurement in small scale chicken slaughtering

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Abstract. The concept of halalan thoyiban, which is in line with sustainable production, has become the needs of industry and consumers, one of which is chicken slaughtering. The methods to measure sustainable production for small scale chicken slaughtering has not been well formulated. This study aims to measure the performance index of sustainable production in small scale chicken slaughtering. In this study, the instrument for measurement was developed in the form of Key Performance Indicators (KPI). The method used to calculate KPI is the Composite Index (CI), so the Sustainable Production Performance Index (SPPI) is obtained. SPPI was calculated in 16 KPI. This method consists of four stages, i.e., measuring the actual value of KPI, normalizing the KPI, weighing the KPI using Analytical Hierarchy Process (AHP), and an aggregation method. This study's results in two small scale chicken slaughtering obtained SPPI values in the economic aspects of 0.5066 and 0.4383, the environmental aspect of 0.4941 and 0.8584, and social aspects of 0.3329 and 0.4205. This result indicates that the lowest performance index is in a social aspect. Overall SPPI of the two small scale chicken slaughtering is 44.45% and 57.24%. Based on the rating standard, both of the SPPI is categorized as 'fair.' Two chicken slaughtering are owned by the public and require training and surveillance from the local government. The improvement strategy for small scale chicken slaughtering is to increase the awareness to implement sustainable production by try to apply halal certification.

1. Introduction
Most of Indonesia's population is Muslim. The Pew Forum on Religion & Public Life [1] wrote that the Muslim community in Indonesia is 88%. Based on this, the necessity to fulfil qualified and halal food is essential. Industries are now aware that the halalan thoyiban principle needs to be applied to ensuring the sustainability of production. Sustainable production is also a development commitment that combines and balances environmental, social and economic goals [2]. This condition indicates that sustainable production, which is parallel with the concept of halalan thoyiban needs to be applied in the industry. Chicken meat is one of the most critical food products in the halal process. Many food industries in
Indonesia have implemented Halal and safety, expect the small scale industries, as they mostly do not have the halal certification yet, so the guarantee of halal is still uncertain. The level of sustainable production is seen from the three bottom line concept, i.e., economic, social, and environmental performance, to perceive sustainable production performance, then the measurements should be done.

Several studies on the measurement of sustainable performance were using Analytic Hierarchy Process (AHP) model to [3-6]. AHP was used mostly for weighting the indicators in performance measurement. A framework was developed for measuring sustainable performance with the Composite Index (CI) approach [6]. CI consists of four steps, i.e., measuring the actual value, normalization method, indicator weighting, and linear aggregation method. Research conducted by [6] using the CI method can measure the performance by calculating the historical and qualitative data so that the final result of the measurement is the sustainability score. Performance measurement indicators are commonly called Key Performace Indicators (KPI). KPI are financial and non-financial indicators used to estimate the level of efficiency and effectivity and aim to reach sustainability on an ongoing basis [7]. This study adopted the CI to measure the sustainable production performance index in chicken slaughtering, which includes four steps, namely measuring the actual value of the KPI, normalizing the KPI, weighing the KPI with AHP and linear aggregation methods to obtain the Overall Sustainability Production Performance Index (SPPI). Therefore, this study aims to measure the SPPI in small scale chicken slaughtering. The research was conducted on two small scale chicken slaughtering.

2. Research Methods
   The methodology consists of two main stages. First, select the KPI for SPPI measurement. The KPI was identified and derived from the literature. Second, SPPI measurement was developed using CI. The details are the following sections.

2.1. Identification of KPI
   The KPI for SPPI measurement was developed through a literature review. The selected KPI has been constructed by adopting the sustainability concept consisting of economic, environmental, and social aspects. Economic aspects include manufacturing cost [6], on-time delivery [6], productivity [6], scrap [7] and defect-free products [8]. Environmental aspects consist of energy use [6], water use [6], electricity use [6], waste minimization [6], hygiene and sanitation [9], and halal production practices [10]. The social aspect consists of customer complaints [6], injuries and illness [6], employment rate [6], internal halal management employees [11], and halal training [11].

2.2. Composite index
   Composite Index (CI) is an innovative approach to evaluating sustainable development; the aggregation method is the most commonly used method of forming indexes [12]. An index can be easily weighted depending on its purpose. The CI has been widely used to incorporate individual indicators in performance measurement [13]. The developed CI by Sopadang et al. [6] has the advantage of measuring the performance based on historical data and qualitative assessment from experts so that the final result of the measurement is the sustainability score per company. CI consists of four stages, i.e., the measure of the actual value, normalization method, weighting of indicators, and linear aggregation method.

2.2.1. Measuring the actual value of KPI
   Measuring the actual value of each KPI uses a formula. The actual value result will be categorized into standard sizes on a scale of 1 = minimum to 5 = maximum. The standard measurements are shown in Table 1. The formula for calculating the actual value was shown in Table 2.
2.2.2. **Normalization of KPI**

Normalization is used to convert different units of measurement into a standard measure. The standard size was defined through a literature review in Table 1.

| Aspects         | KPI                                      | Level of measurement (%) |
|-----------------|------------------------------------------|--------------------------|
|                 |                                           | 1 | 2   | 3   | 4   | 5   |
| **Economics**   | Manufacturing cost [6]                    | >75| 70-75| 60-69| 50-59| <50 |
|                 | On-time delivery [14]                     | <90| 90-95| 95-97| 97-99| 100 |
|                 | Productivity [14]                         | 0-39| 40-59| 60-79| 80-89| 90-100 |
|                 | Scrap [15]                                | >50| >30-45| 10-30| 6-10| <5  |
|                 | Defect-free products [16]                 | ±95| 96    | 97    | 98    | 99-100 |
| **Environmental** | Energy use [14]                          | >80| 64-79| 48-63| 32-47| <32 |
|                 | Water use [14]                            | >80| 64-79| 48-63| 32-47| <32 |
|                 | Electricity use [14]                      | >80| 64-79| 48-63| 32-47| <32 |
|                 | Waste minimization [6]                    | 81-100| 61-80| 41-60| 21-40| 0-20 |
|                 | Hygiene and sanitation [17]               | 0-20| 21-25| 26-30| 31-35| 36-100 |
|                 | Halal production practices                | 60-80| 85    | 90    | 95    | 99-100 |
| **Social**      | Customer complaints [6]                   | >10| 8-9   | 6-7   | 4-5   | 1-3  |
|                 | Injuries and illness [6]                  | >30| 15-29| 6-14 | 1-5   | 0    |
|                 | Employment rate [6]                       | <19| 20-49| 40-59| 60-79| >80  |
|                 | Internal halal management                 | <1| 1-3   | 4-6   | 7-9   | >10 |
|                 | employees                                 |                 |   |   |   |
|                 | Halal training                            | <10| 20-30| 40-50| 60-70| 80-100 |

2.2.3. **Weighting the KPI using AHP**

AHP has become one of the most widely used methods for multiple criteria decision making (MCDM) problems. It is a decision approach designed to aid in making the solution of complex multiple criteria problems to several application domains [18]. In this study, the AHP-based model was used to weight the KPI. First, the proposed KPI of SPPI measurement is used in constructing a hierarchy. The hierarchy is depicted in Figure 1. Second, if the hierarchy has been constructed, the next step is to calculate the weight of the KPI. AHP pairwise comparison questionnaire was then designed. The respondents from the small scale chicken slaughtering were consulted to give their preferences on the KPI. Those respondents were selected based on their experience in chicken slaughtering.

Normalized value was calculated using the following formula.

\[
\text{Normalized value} = \frac{g}{(1)}
\]

The pairwise comparisons were in indicators within each factor of the KPI. A Saaty’s scale of 1 to 9 (1= equally, 3= moderate, 5= strong, 7=very strong, 9= extreme) was used to reflect these preferences [18]. The Consistency Ratio (CR) was used to check the consistency of the pairwise comparisons for each expert. The CR values should be less than 0.1, which means it consistent. If it is not yet consistent, the comparison has to be repeated.
| No. | KPI | Actual Value Formula | Chicken Slaughtering A | Chicken Slaughtering B |
|-----|-----|----------------------|------------------------|------------------------|
|     |     |                      | Measured value | Rating scales | Normalized value | Weights | Results | Measured value | Rating scales | Normalized value | Weights | Results |
| 1.  | Manufacturing cost [6] | \( \frac{\text{Manufacturing Cost per unit product}}{\text{Total Cost per unit}} \times 100 \% \) | 98.88 | 1 | 0.0448 | 0.2333 | 0.0104 | 99.64 | 1 | 0.0144 | 0.2307 | 0.0033 |
| 2.  | On-time delivery [6] | \( \frac{\text{Total of on-time delivery}}{\text{Total of purchased orders}} \times \frac{\text{Production hours}}{100} \) | 100 | 5 | 1 | 0.2333 | 0.2333 | 0.0485 | 94.12 | 2 | 0.608 | 0.2307 | 0.1402 |
| 3.  | Productivity [6] | \( \frac{\text{Total score available for productivity}}{\text{Actual usage}} \times \frac{\text{Production hours}}{100} \) | 20.83 | 1 | 0.2083 | 0.2333 | 0.0485 | 96.78 | 1 | 0.3967 | 0.2307 | 0.0357 |
| 4.  | Scrap [7] | \( \frac{\text{Total of scrap}}{\text{Total of raw material}} \times \frac{\text{Total of overall products}}{100} \) | 23.4 | 3 | 0.5428 | 0.1 | 0.0542 | 30 | 3 | 0.4081 | 0.0769 | 0.0313 |
| 5.  | Defect-free product [8] | \( \frac{\text{Total of defect-free products}}{\text{Total of overall products}} \) | 98 | 4 | 0.8 | 0.2 | 0.16 | 96.78 | 4 | 0.9445 | 0.2025 | 0.1912 |
| 6.  | Energy use [6] | \( \frac{\text{Energy use for production}}{\text{Total of overall products}} \times \frac{\text{Production hours}}{100} \) | 50 | 3 | 0.6666 | 0.2381 | 0.1587 | 33.33 | 4 | 0.9445 | 0.2025 | 0.1912 |
| 7.  | Water use [6] | \( \frac{\text{Water use for production}}{\text{Total of overall products}} \times \frac{\text{Production hours}}{100} \) | 26.37 | 5 | 0.091 | 0.2143 | 0.0195 | 20 | 5 | 1 | 0.2025 | 0.2025 |
| 8.  | Electricity use [6] | \( \frac{\text{Electricity use for production}}{\text{Total of overall products}} \times \frac{\text{Production hours}}{100} \) | 32 | 4 | 0.8285 | 0.2143 | 0.1775 | 26 | 5 | 0.9142 | 0.2025 | 0.1851 |
| 9.  | Waste minimization [6] | \( \frac{\text{Total of waste disposed}}{\text{Total of overall products}} \times \frac{\text{Production hours}}{100} \) | 45.4 | 3 | 0.4955 | 0.1071 | 0.0530 | 46.25 | 3 | 0.4861 | 0.1012 | 0.0491 |
| 10. | Hygiene and sanitation [9] | Estimates based on hygiene and sanitation checklist [22] | 66.67 | 5 | 0.6667 | 0.0952 | 0.0634 | 86.67 | 5 | 0.8667 | 0.1392 | 0.1206 |
| 11. | Halal production practices [10] | Estimates based on halal production practices in chicken slaughtering [22] | 66.67 | 1 | 0.1667 | 0.131 | 0.021 | 88.89 | 3 | 0.7222 | 0.1519 | 0.1097 |
| 12. | Customer complaints [6] | \( \frac{\text{Total of complaints}}{\text{Total product value}} \times \frac{\text{Production hours}}{100} \) | 6.67 | 4 | 0.37 | 0.196 | 0.0725 | 5.88 | 4 | 0.4577 | 0.2236 | 0.1023 |
| 13. | Injuries and illness [6] | Based on injuries and illness rate by [23] | 3.8 | 4 | 0.8733 | 0.1764 | 0.1540 | 3.8 | 4 | 0.8733 | 0.1428 | 0.1247 |
| 14. | Employment rate [6] | \( \frac{\text{Local workers}}{\text{Total workers}} \times \frac{\text{Production hours}}{100} \) | 80 | 5 | 0.753 | 0.2352 | 0.1771 | 100 | 5 | 0.2608 | 0.2608 |
| 15. | Internal halal management employees | \( \frac{\text{Total of halal internal staff}}{\text{Total workers}} \times \frac{\text{Production hours}}{100} \) | 0 | 1 | -0.1111 | 0.196 | -0.021 | 0 | 1 | -0.1111 | 0.1863 | -0.020 |
| 16. | Halal training | \( \frac{\text{Total of halal trained workers}}{\text{Total workers}} \times \frac{\text{Production hours}}{100} \) | 0 | 1 | -0.25 | 0.196 | -0.049 | 0 | 1 | -0.25 | 0.1863 | -0.046 |
2.2.4. Aggregation method

Sustainable Production Performance Index (SPPI) was calculated using the linear aggregation method formulated as follows:

\[
\text{Sustainable Production Performance Index (SPPI)} = W_i \times X_i
\]  

(2)

\(W_i\) : Weighting value; \(X_i\) : Normalized value

This study was used standard rating for the company score developed by Amrina and Vils [4] as the basis for determining the rating criteria of Overall SPPI. Overall SPPI was formed in percentage. The rating criteria were designed as follows.

- If \(10\% \leq \text{index} \leq 40\%\) then the performance level = "poor"
- If \(40\% < \text{index} \leq 70\%\) then the performance level = "fair"
- If \(70\% < \text{index} \leq 90\%\) then performance level = "good"
- If \(\text{index} > 90\%\), then performance level = "excellent"

3. Results and Discussion

The SPPI measurement has been applied to a case of two small scale chicken slaughtering. Following the Composite Index's four steps, the numerical data based on small scale chicken slaughtering are shown in Table 2. Table 2 present the measured value, rating scales, normalized value, and results (SPPI). The lowest value of SPPI both in chicken slaughtering A and B is internal halal management employees and halal training. The highest values in chicken slaughtering A was obtained at electricity use and in chicken slaughtering B was obtained at the employment rate. Overall SPPI is done by aggregating the results of each indicator. The overall SPPI for chicken slaughtering A and B were shown in Table 3.

Based on the rating standard, both of the SPPI is categorized as 'fair' as the performance level 40\% < index ≤70 \%. Chicken slaughtering A obtained the highest ratio at the economic aspect and the lowest ratio at the social aspect. Chicken slaughtering B achieved the highest ratio at the environmental aspect and lowest ratio at the social aspect. Based on that results, indicated if chicken slaughtering A was more concerned in fulfilling the economic aspect to maintain sustainable production, yet ignoring the social aspect. Chicken slaughtering B was more interested in meeting the environmental aspect to support
sustainable production, yet ignoring the social aspect. Chicken slaughtering B has proven to be able to use resources efficiently (Table 2) and has cleaner facilities for production based on the observation. However, the SPPI in social aspects in both industries has the lowest ratio, and this matter indicates that the social aspects need to be taken into consideration. The lowest KPI in social aspect in both slaughterhouses is internal halal management employees and halal training. This matter indicated that both slaughterhouses are lack in halal concept implementation. Therefore, the improvement strategy is needed.

| Sustainable aspects | Overall Sustainable Production Performance Index | Percentage (%) | Performance level |
|---------------------|-----------------------------------------------|----------------|------------------|
| Economic            | 0.5066                                        | 0.4941         | 0.3329           | 0.4445           | 44.45 | Fair |
| Environment         |                                              |                | Social           |                  |       |      |
| Social              | 0.4445                                        | 44.45          | Fair             |                  |       |      |
| Chicken slaughtering A | 0.4383                                        | 0.8584         | 0.4205           | 0.5724           | 57.24 | Fair |
| Chicken slaughtering B | 0.4941                                        | 0.3329         | 0.4445           | 44.45            |       |      |

The improvement strategy is shown in Figure 2. This figure indicated that the purposed improvement strategy was divided into four sides, that is material, method, machine, and man. The proposed improvement strategy of “method” side was applying halal certification to the Indonesian Council of Ulama (ICU) or Majelis Ulama Indonesia (MUI) and participated in training and surveillance from the local government. According to MUI [19], halal certification aims to provide certainty of halal status, so that it can reassure the consumers. The producers guarantee halal production by implementing a Halal Assurance System (HAS). Generally, chicken slaughtering is owned by individuals. Based on Pustakavet [20], surveillance from the local government comprises of providing technical guidance, counselling, and community development.

Figure 2. Lack of halal concept implementation

The proposed improvement strategy of the “material” side was to ensure that the material (carcass) is not contaminated with haram in the entire process. However, it is little contamination; that matter will
affect the halal status. The proposed improvement strategy of “man” side was to participate in halal training and form an internal halal team. For small scale industries, usually, the owner is advised to attend halal training; the internal halal team will be created after that. According to MUI [19], there are two types of halal training, i.e., internal training and external training. External training is organized by MUI. The “machine” proposed improvement strategy was facilities or tools designed explicitly for halal slaughtering and must be separated. This condition is to avoid cross-contamination with non-halal products.

Beside maintain the halalness, the chicken slaughtering industry needs to increase its credibility by ensuring the product qualities through Veterinary Control Number (VCN) Certification. According to [21], VCN ensures that industries fulfilled hygiene-sanitation requirements and implement suitable production methods to maintain product safety. However, for small scale chicken slaughtering, VCN still not appropriate because there are many requirements to fulfil. Therefore, it is necessary to consider technical requirements easily accessible by small scale chicken slaughtering, i.e., halal certification.

4. Conclusions

The proposed SPPI measurement consists of 16 indicators based on economic, environmental, and social aspects to assess sustainable production performance. The CI was developed to represent the overall SPPI. Following the four steps of CI, the numerical data based on small scale chicken slaughtering was calculated. In this study, the results offer an overall SPPI of two small scales are chicken slaughtering A is 44.45 % and chicken slaughtering B is 57.24%, respectively. Based on the rating standard, both of the SPPI is categorized as 'fair.' This result means sustainable production performance in small scale chicken slaughtering needs to be improved. The primary improvement strategy was to increase the awareness to implement sustainable production by fulfilling the technical requirements, such as submit a halal certification to MUI.

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