Sustainability of technological dimension in dairy agribusiness

R Mastuti*, F Alham, C Gustiana, H Hanisah, M Jamil, M Muslimah and R Rozalina
Department of Agribusiness, Faculty of Agriculture, Samudra University, Aceh, Indonesia

*rinimastuti@unsam.ac.id

Abstract. This study aims to analyze sustainability index and status of technological dimension in dairy agribusiness in Batu City. Research methods applied were analysis Multidimensional Scaling (MDS) analysis, termed Rapuse, and Descriptive analysis. Study result was expressed in sustainability index and status. Moreover, to examine attributes sensitively affected sustainability index and status also the effect of error, analysis of Leverage and Monte Carlo was performed, followed with descriptive analysis. Data were obtained from key respondent and field observation. Four villages from three sub-districts in Batu City were purposively selected as research site, namely Village of Pesanggrahan, Tlekung, Oro-o-ro Ombo and Gunungsari. Sustainability analysis resulted in technological dimension of 60.40 or moderately sustainable condition and three leverage factors of AI breeding, adlibitum water application, and chopper use. Other factors in technological dimension should be taken care immediately since they sensitively have an effect on the increasing sustainability index and status with small error at confidence level of 95%. Factors included biogas installation, provision of dry concentrate, fresh milk handling, and cage cleanliness should be improved to increase sustainability index of technological dimension through role and support improvement of stakeholder consisted of milk cooperation, IPS, government institution related, and cattle farmers.

1. Introduction
Currently, about 91 percent of domestic fresh milk production (SSDN) is produced from local dairy cattle, yet its production only supplies not more than 25 percent of national milk demand, while the rest of 75 percent is from imported milk. Milk import causes losses, both in local dairy business and government since it results in the depletion of foreign exchange reserve, loss of potential revenue should be obtained by the government from taxes, and opportunity loss due to underutilization of available resource potential for the development of dairy agribusiness [1].

The dependency on imported milk urges government to conduct various efforts to develop dairy cattle in national milk producing regions in the hope to meet the domestic milk demand. In order to achieve those efforts, one of government programs applied is the establishment of National Livestock Region or Kawasan Ternak Nasional for the development of dairy cattle business through Law No: 43/Kpts/PD.410/1/2015 [2]. Batu City is one of six dairy cattle development regions for the next five years. The program of dairy cattle region development is expected to be sustainable to increase the production and supply of SSDN. Considering this issue, it is necessary to examine the sustainability status of dairy business in Batu City as region for dairy business development.
This study aims to analyze sustainability index and status of dairy business in Batu City concerning technological dimension. Analysis method applied was Multi Dimensional Scaling (MDS) called Rapuse. Analysis result was expressed as sustainability index and status of dairy business on technological dimension. Result of analysis will facilitate the government or stakeholder to arrange and conduct program also to perform improvements on attributes sensitively affect sustainability status of dairy business on technological dimension, in order to achieve the success of sustainable dairy business development program.

2. Research method

2.1. Framework
Government set the development of livestock region in Batu City to develop sustainable dairy business in order to support increase in production and supply of SSDN. In developing dairy business, it is essential to apply the concept of sustainable development comprehensively viewed as a unity in an agribusiness system concept from upstream to downstream [3] as a responsibility of today’s generation to the future generation, in addition to ensure milk self-sufficiency program continues to perform. According to Dirjen PKH [4] the development of livestock farming is considered sustainable if it applies the concept of sustainable development. According to Pitcher [5] and Mersyah [6] reference criterion for sustainable development, in principle, is related to dimension of ecology, economy, socio-culture, law-institution, and technology.

Analysis in ecological dimension was performed by Mastuti et al., [7] that resulted in sustainability index of 59.02 percent in category of moderately sustainable and 2 leverage factors consisted of availability of green fodder and manure handling.

Dairy business is considered meeting the criteria of technological dimension in the concept of sustainable development is the technology used in business is able to effectively and efficiently support the increase in production and productivity of sustainable dairy business. This dimension in sustainable dairy business is defined into ten attributes entirely describe the condition of dairy business analyzed from the perspective of technological dimension. Result of analysis is in the form of leverage factor and sustainability index that are important as a basis to arrange and perform improvements on attributes sensitively affect sustainability status of sustainable dairy business.

2.2. Place and time of research
Study was conducted in Batu City, Province of East Java. Determination of research location was done purposively. The study was particularly carried out in Pesanggrahan Village and Oro-Oro Ombo Village of Batu Sub-district, Tekung Village of Jumrejo Sub-district and Gunungsari Village of Bumiaji Sub-district that have been set as regions for dairy cattle development.

2.3. Type and source of data
Data used in this study included primary data and secondary data. Primary data were sourced from respondents and selected experts, also from direct observation in research site, while secondary data were obtained from literature study, internet browsing, and documents from several institutions related to research data.

2.4. Data collection method
Data collection in analysis of dairy business technology sustainability in Batu City for livestock region development was done through the method of field survey, questionnaire, interview, and discussion with respondents considering research topic.

2.5. Analysis method
Method of sustainability analysis of dairy business on technological dimension in Batu City for the development of livestock regions was performed through the approach of Multi Dimensional Scalling
(MDS) called Rapuse (Rapid Appraisal Usaha Sapi Perah or Rapid Appraisal for Dairy Business). Rapuse adopts the technic of Rapfish (Rapid Appraisal for Fisheries) analysis developed by Fisheries Center, University of British Columbia [8]. MDS method is a statistic analysis technic that transforms each dimension factor towards the dimension of dairy business sustainability. In this study, there were 10 attributes used to determine sustainability status of dairy business on technological dimension. Multi-Dimensional Scalling (MDS) approach through Rapfish program had been applied to analyze the sustainability of technological adoption in livestock waste treatment to produce organic fertilizer [9].

Determination of sustainability index and status in accordance with technic that adopts Rapfish analysis Pitcher [5]; Kavanagh [8]; and Nababan et al., [10] included stages as follows: 1) Scoring of attributes in each sustainability dimension and measure the attribute based on actual data through field observation, depth-interview with key respondent, and literature study, 2) The score of attributes of each sustainability dimension was further analyzed using Rapfish program in Microsoft Excel to obtain a value of sustainability index, 3) Categorizing the value of sustainability index based on sustainability interval to obtain sustainability status. Interval for sustainability score of each dimension: bad (0-25), poor (26-50), moderate (51-75), and good (76-100).

Position of sustainability dot is depicted in vertical or horizontal axis line. Value of sustainability index ranges from value of 0 percent (bad) to 100 percent (good). If the dimension measured has an index below 50 percent, it considered poor or unsustainable, and if the index of dimension is above 50 percent, dimension of system is sustainable. This scoring is illustrated in Figure 1.

![Illustration of sustainability index value.](image)

In Rapuse analysis, Monte Carlo simulation, Leverage analysis, the determination of Coefficient of Determination (R²) and determination of Stress value were also performed. Simulation of Monte Carlo was used to estimate the effect of error at confidence level of 95%. Leverage analysis was performed to find attributes sensitively affected the sustainability status by considering the priority order resulted from leverage analysis, that was by observing changes in RMS (Root Mean Square) value on the x-axis. Higher RMS value means that the attribute is more sensitive or has bigger role in increasing the sustainability status of dairy business.

Values of sustainability index generated from analysis of Monte Carlo and MDS were further compared, if the difference of both value is less than 25%, it indicates that: 1). Analysis process repeatedly performed is stable; 2). Error in data input and data loss is able to be avoided; 3) Error in scoring of each attribute is relatively low; 4) Variation in scoring due to opinion difference is relatively small which means that Rapuse method is quite appropriate to be applied as one of tools to evaluate sustainability of dairy business in Batu City and the result approaches the real condition.

Moreover, mapping of the data analyzed were well performed. Stress value is a lack of fit measure, in which higher stress value indicates inappropriateness. Stress value is applied to examine whether the result of output approaches the real condition or not. The closer the value to zero, the output produced is more similar to the real condition. Moreover, coefficient of determination (R²) is used to observe the proximity between data and perceptual map. Through R² we can conclude whether the data is well mapped or not. Value of R² closer to 1 indicates that the data are perfectly mapped. Perfect model in MDS is shown by the value of $R^2 = 1$.

Ordination technic (determination of distance) in MDS is following Euclidean Distance in an n-dimensional space through the following equation:

$$
d = \sqrt{(|X_1 - X_2|^2 + |Y_1 - Y_2|^2 + |Z_1 - Z_2|^2 + ...)}
$$

(1)
Configuration or ordination from an object or dot in MDS is further approximated by regressing Euclidean distance \(d_{ij}\) from dot \(i\) to dot \(j\) with the initial dot \(\delta_{ij}\) as in the equation below:

\[
d_{ij} = \alpha + \beta \delta_{ij} + \epsilon
\]  

(2)

In general, there are three techniques applied to perform regression for the equation above, namely least square method (KRYST), alternating least square based on the root of Euclidean Distance (squared distance) or termed as ALSCAL method. Algorithm of ALSCAL is the most appropriate method for Rapfish and it is available in most of statistic software (SPSS and SAS) [11]. ALSCAL method optimizes squared distance (squared distance = \(d_{ijk}\)) towards quadrat data (initial dot = \(o_{ijk}\)), which is in three-dimensional form \((i, j, k)\) is expressed in a formula known as S-Stress below:

\[
S = \sqrt{\frac{1}{m} \sum_{k=1}^{m} \left[ \sum_{i} \sum_{j} \left( d_{ijk}^2 - o_{ijk}^2 \right) \right]^2 \sum_{i} \sum_{j} o_{ijk}^2}
\]  

(3)

Where the quadrat distance is the weighted Euclidean distance, or written as:

\[
d_{ijk}^2 = \sum_{a=1}^{r} w_{ka} (X_{ia} - X_{ja})^2
\]  

(4)

Figure 2. Stage of multi dimensional scaling analysis.

3. Results and discussion

Value of sustainability index resulted from Rapuse analysis of technological dimension in dairy business in Batu City for the development of livestock region was 60.40% and according to the classification of sustainability status, this condition of technological dimension is categorized as moderately sustainable. Whereas, sustainability index and status of technological dimension in each village were as follows: Tlekung Village of 63.87% (moderately sustainable), Oro-oro Ombo Village of 55.81% (moderately sustainable), Pesanggrahan Village of 68% (moderately sustainable), and Gunungsari Village of 53.95% (moderately sustainable) as depicted in Figure 3.

Attributes expected to affect sustainability of dairy business considering the technological dimension included: cage drainage, cage, cage sanitation, dry concentrate, biogas installation,
adlibitum water application, AI breeding, use of chopper, milk handling, and administration of vaccine. Based on the result of leverage analysis, there were three attributes sensitively affected the sustainability of technological dimension of dairy cattle, namely AI breeding, adlibitum water application, and chopper use.

Other analysis performed in dairy business was Participatory Prospective Analysis that obtained six key factors greatly affecting sustainability, namely: milk price, milk processing industry, labor, feed technology, green fodder, and profit [12].

![Leverage of Attributes Technological Dimension](image)

![RAPUSE of Technological Dimension](image)

**Figure 3.** Value of sustainability index and attributes sensitively affect the sustainability of technological dimension.
Table 1. Value of sustainability index of technological dimension in diary business.

| Dimension              | Value of Sustainability Index (%) | Difference |
|------------------------|----------------------------------|------------|
|                        | MDS                              | Monte Carlo|
| Technology             | 60.40                            | 59.47      |
| 1. Village of Tlekung  | 63.88                            | 62.82      |
| 2. Village of Oro-oro Ombo | 55.80                        | 55.57      |
| 3. Village of Pesanggrahan | 67.99                         | 66.30      |
| 4. Village of Gunungsari | 53.95                          | 53.22      |

Table 2. Value of stress and rsq of rapuse analysis result.

| Description               | Technology |
|---------------------------|------------|
| Stress                    | 0.1303     |
| Squared Correlation (RSQ) | 0.9425     |
| Number of Iterations      | 2          |

In Table 2, Rapuse analysis resulted in stress value of less than 25% for all dimensions, while RSQ value was closer to 1. It means that Rapuse method is quite appropriate to be applied as one of tools to evaluate the sustainability of dairy business in Batu City. In addition, the result approached the real condition and the data analyzed were perfectly mapped.

In Table 1, sustainability status of dairy business in Batu City and each research village, considering the result of Rapuse analysis, were included in category of moderately sustainable in all villages. It means that application of technology in dairy business was able to support the existence and sustainability of dairy business in Batu City. Pesanggrahan Village obtained the highest value of sustainability index among the three other villages since the village has implemented better attributes of technological dimension compared to other villages. The attribute included the application of AI in cattle breeding, application of adlibitum water, and the use of chopper and biogas installation.

3.1. Leverage factor

3.1.1. AI breeding. Breeding through Artificial Insemination (AI) has been applied by 100% of cattle farmers to breed their cattle. The use of AI method eases cattle farmers to manage the reproduction aspect, such as selection of dairy calf, breeding control, etc. AI service is provided by BATU milk cooperation, Local Department of Forestry and Agriculture of Batu City, and private veterinarian. Cattle farmers who need AI service may use the available service. The AI service provided by Milk Cooperation is free of charge since it is subsidized by the cooperation. However, if farmers ask for the service from the Local Department of Agriculture or veterinarian, there will be charge at various amounts.

Cattle farmers mostly use AI service provided by milk cooperation since it is free, even though sometimes farmers need 2 or more AI services for one cattle which leads to delayed pregnancy schedule as well as time loss and cost spent to raise cattle before pregnancy occurs. Interview result revealed that AI service performed more than one time or S/C > 1 is caused by (1) far distance between locations so that AI cannot be performed at the right time, (2) cattle farmers are less careful in observing the estrous process in cattle, (3) inseminator is less skilled in providing AI service. Several cattle farmers prefer to use AI service other institutions except milk cooperation because of better calf produced and only one AI required to cause pregnancy (S/C = 1), thus saving time and money for heifer maintenance.

3.1.2. Application of adlibitum water. Adlibitum water is system of unlimited drinking water supply to cattle. The drinking tank is specially made in which drinking water is always available in the tank. This method has been applied by almost 50 percent of cattle farmer in Batu City. Based on the result
of interview and observation, this method has been able to increase average milk production by 1.5 – 2 litter/cattle/day. This production increase significantly provides benefit to cattle farmers and cooperation besides supporting the government program to increase the production of SSDN.

Construction of adlibitum water installation is funded by cattle farmers with subsidy from milk cooperation. The subsidy provided occurs in turn so that financial performance of cooperation will not be too burdened. Cooperation expects this technology will be implemented by 100% of cattle farmers to further increase their income and welfare.

Limitation factor of implementation of this technology included cost and farmers who do not fully understand this technology that they still applied the old technic of cattle farming.

3.1.3. The use of chopper. The use of chopper machine or machine to cut Green Fodder or Hijauan Makanan Ternak (HMT) is to reduce the length of HMT, thus cattle will be easy to eat and finish HMT. Result of observation showed that HMT cut through chopper machine was able to completely given to cattle since only a small part of HMT left uneaten. This condition resulted in profit for cattle farmers since they were able to utilize the available HMT maximally, thus saving the cost for feed. It was mentioned in several studies that feed cost might reach 70% of total cost spent for dairy cattle maintenance. Moreover, since most of HMT parts can be utilized and green fodder is not consumed fast by cattle, farmers will gain profit because they will have more time in preparing HMT.

Limitation factor of implementation of this technology is the price of chopper machine that is relatively expensive, hence cattle farmers need more capital or additional cost for machine investment. Mutual Cooperation of Industri Pengolahan Susu (IPS) or Milk Processing Industry provides solution in the form of subsidy for cattle farmers who want to buy the machine. Currently, almost 40% of cattle farmer already use personal chopper machine in their own cattle cage. Big-size machine was previously provided by the government and IPS to cattle farmer groups to be utilized mutually and in turn.

4. Conclusion and recommendation

4.1. Conclusion
Based on the results of study, it is concluding that

- The value of sustainability index of technological dimension in dairy business system in Batu City was 60.40% with status of moderately sustainable. Analysis results for Tlekung Village, Oro-or Ombo Village, Pesanggrahan Village, and Gunungsari Village were 63.88, 55.80, 67.99, and 53.95, respectively.
- Result of leverage analysis indicated three attributes that sensitively affected the sustainability of technological dimension, namely AI breeding, adlibitum water application, and the use of chopper machine.
- Result of statistic test showed that Rapuse method was excellent as one of tools to rapidly evaluate (rapid appraisal) the sustainability of dairy business in Batu City.

4.2. Recommendation
It is necessary to increase the value of sustainability index of technological dimension in dairy business in Batu City through improvement in sensitive attributes to the sustainability of technological dimension in dairy business.

References
[1] Agustina T 2016 Outlook Komoditas Pertanian Subsektor Peternakan Susu (Jakarta: Pertanian, Pusat Data dan Sistem Informasi Jenderal, Sekretariat Pertanian, Kementerian)
[2] Kementan 2015KEPUTUSAN MENTERI PERTANIANREPUBLIK INDONESIA NOMOR 43/Kpts/PD.010/1/2015 1–7
[3] Saragih B 2004 Pembangunan pertanian dengan paradigma sistem dan usaha agribisnis
[4] Dirjen PKH 2016 Renstra Ditjen PKH (2015-2019) Rev II.pdf 77
[5] Pitcher T J 1999 Rapfish, a rapid appraisal technique for fisheries, and its application to the code of conduct for responsible fisheries *FAO Fish. Circular* 52
[6] Mersyah R 2005 Desain Sistem Budidaya Sapi Potong Berkelanjutan Untuk Mendukung Pelaksanaan Otonomi Daerah Di Kabupaten Bengkulu Selatan
[7] Mastuti R, Fanani Z, Nugroho B, Utami H and Siregar A 2016 Determining the Key Factors of Dairy Cattle Business Sustainability in Batu City Using Participatory Prospective Analysis. *Int. J. Adv. Res.* 4 2059–69
[8] P Kavanagh and T J Pitcher 2004 Implementing Microsoft Excel Software For Rapfish: A Technique For The Rapid Appraisal of Fisheries Status *Fish. Cent. Res. Reports* 12 2 p. 75
[9] Abdullah A, Ali H M and Syamsu J A 2015 Status Keberlanjutan Adopsi Teknologi Pengolahan Limbah Ternak sebagai Pupuk Organik *Mimbar* 31 11–20
[10] Nababan B, Dewita Y D and Hermawan M 2008 Tinjauan aspek ekonomi keberlanjutan perikanan tangkap skala kecil di Kabupaten Tegal Jawa Tengah *Bul. Ekon. Perikan.* 8 50–68
[11] J Alder, D Zeller and T Pitcher 2002 A Method for Evaluating Marine Protected Area Management pp. 121–131
[12] R Mastuti, Z Fanani, B Nugroho, H Utami and A Siregar 2016 Determining the Key Factors of Dairy Cattle Business Sustainability in Batu City Using Participatory Prospective Analysis *Int. J. Adv. Res.* 4 8 pp. 2059–2069