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Selection of alternative solution for implementing green productivity of milk agroindustry in Malang Raya

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KEYWORDS

Analytical hierarchy process

Cost

GPI

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ABSTRACT

The dairy agroindustry in Malang Raya has high development potential due to the increasing market demand for dairy products. Previous studies have analyzed the application of green productivity at SMEs Milk X in Malang City and proposed alternative solutions to make liquid organic fertilizers, install wastewater treatment equipment, and utilize wastewater as hydroponic growing media. This study aimed to follow up the results of previous studies, focusing on selecting alternative solutions to be applied to SMEs Milk X and analyze the green productivity index (GPI) value from the selected alternative solutions. In selecting alternatives, the analytical hierarchy process (AHP) method was used with data obtained from questionnaires. The results obtained indicate that the selected alternative solution that potentially to be applied in the SMEs Milk X was the manufacture of liquid organic fertilizer. In this alternative, the GPI value increased from 0.24 to 1.078.

Introduction

Today's global competition will continuously increase the development of various industries aiming to meet human demands and needs. Nowadays, only industries that able to provide excellent goods and services may have advantages to compete in the market (Oraman et al., 2011). One of the industries that continue to grow to meet human needs today is agroindustry. In developing various agroindustries, careful attention to the environment and nature are critical (Lermen et al., 2018). Agroindustries that pay attention to environmental issues can support their productivity (Cerri et al., 2020). One strategy that can increase productivity toward environmental issues is green productivity (Hou et al., 2021) (Yan et al., 2020). Green productivity is a strategy carried out to increase the productivity of the production process by balancing environmental and economic factors (Zhang et al., 2021).

One of the agroindustry that requires the application of green productivity concept is the dairy agroindustry. Milk is one of the leading commodities to be developed in Malang Raya. Data from Livestock Service Office of East Java Province (2019) states that fresh cow's milk production in Malang Raya in 2018 was 147,368 tons. In Indonesia, the cattle business that produce fresh milk are categorized into three, consisting of 3% of large-scale enterprises, 17% of medium-scale enterprises, and 80% of small-scale enterprises (Mandaka and Hutagaol, 2015). Cattle-raising businesses, especially those producing fresh milk, are experiencing problems, in particular the facilities that support the quality of cow's milk and business productivity (De Vries et al., 2020). As a source of high nutrition for humans, milk if not managed hygienically is easily contaminated by microbes which can endanger human health. Meanwhile, the implementation of green activity in the dairy agroindustry in Malang Raya is still focused on improving the product's image sold to the market. On the other hand, in the factory area, the implementation of green activities is still not visible (Ramadhan et al., 2015).

Applying green productivity strategies in the cow's milk industry has not been widely studied, especially at the small- and medium-enterprises (SME) level (Tricarico et al., 2020). The research

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involved the SMEs that produce dairy products in Malang Raya. The SMEs were chosen as the research's object was due to the constant obstacles on the production process and workforce, which can affect their productivity (Lähdesmäki and Suutari, 2020; Onkelinx et al., 2016). Therefore, the efforts made in SMEs are expected to enable them to overcome the obstacles, especially in productivity and environmental performance (Sahu et al., 2021). SMEs used as research objects are SMEs Dairy X, one of the dairy agroindustry located in Malang Raya. SMEs Dairy X is a dairy agroindustry that produces various types of products, mainly milk soap.

In previous studies, an analysis of the application of green productivity in SMEs Milk X was carried out with a GPI value of 0.24. There were three alternative solutions proposed, including organic waste treatment, installation of waste treatment equipment, and wastewater as a hydroponic growing medium. Based on these results, it is necessary to select alternative solutions that can be applied and recalculate the GPI value from the chosen alternative. This study aimed to select alternative solutions that can be applied by SMEs Milk X following the proposed alternative solutions and analyze the new GPI value from the selected alternative solutions.

Research Methods

The research was conducted using the analytical hierarchy process (AHP) method. The data was collected by distributing questionnaires to the selected respondents. The determination of respondents was done by the purposive sampling method. Respondents in this study were selected by considering the data required and the expertise of the respondents. There were two types of respondents, including owners and dairy agroindustry experts. They assessed the weighting of alternative criteria and determine alternative priorities for increasing company productivity. Specific to the dairy agroindustry experts, they should know the overall condition of the production process. Also, experts from the Malang City and Regency Environmental Service were selected for weighting strategies related to AMDAL. The questionnaire given to the respondents contained the weighting of alternative solutions arranged in the implementation of the research.

A rating scale was used in the pairwise comparison method, as shown in Table 1. The data from the questionnaire was then processed by forming a comparison matrix as in Table 2. In this method, the consistency index (CI) was calculated, and used for determining the level of consistency of a matrix using Equation 1 below:

$$CI = \frac{\lambda \max - n}{n-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where λ max is the maximum value contained in the Eigen matrix and N is the number of criteria being compared (Wu and Tu, 2021).

In addition, the consistency ratio (CR) comparison was carried out using Equation 2, as follows:

$$CR = \frac{CI}{RI} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where RI is a random consistency index (Liu et al., 2020), as shown in Table 3.

Table 1. Scale of Importance of Elements/Criteria (Chen et al., 2013)

Numeric Scale	Verbal Scale	Description
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one over another
5	Strong Importance	Experience and judgment strongly favor one over another
7	Very Strong Importance	Activity is strongly favored, and its dominance is demonstrated in practice
9	Absolute Importance	Importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate Values	Used to represent a compromise between the priorities listed above

Table 2. Pairwise Comparison Matrix (Zhao et al., 2020)

Factor	F1	F2	....	Fn
F1	1	....	....	....
F2	....	1	....	....
....	....	....	1	....
Fn	....	....	....	1

Table 3. List of Random Consistency Index (Wei et al., 2020)

Matrix Order	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Then, the next step was to calculate the operational costs consist of fixed costs and variable costs of the selected alternative (i.e. making liquid organic fertilizer). First, calculating the total costs (TC) dan operational costs (OC) which include depreciation costs, production costs, and determination of cost of production and selling price, total income, profit analysis, and R/C ratio. Finally, the new economic indicators in SME Milk X were re-calculated.

Results and Discussion

In the process of determining alternative solutions, questionnaires were distributed to respondents. Respondents from the study were the owners and the head of production division of the SME Milk X. The results of the questionnaires were processed using the pairwise comparison method with Microsoft Excel (Perzina and Ramík, 2014). The results obtained were the weight value of the alternative criteria and the alternative priority value (Mastrocinque et al., 2020), as shown in Table 4.

Table 4 shows that the alternative for processing wastewater of SME Milk X can be done was by utilizing wastewater from the production of milk soap as the main ingredient in the manufacture of liquid organic fertilizer. The production capacity of the SME Milk X was 1000 bars of milk soap. From this process, about 14 L of wastewater was generated, mainly from the washing process with the production of 3 times in one week. The results of the alternative weighting for the alternative value of making liquid organic fertilizer was 0.71. This shows that the alternative of making liquid organic fertilizer is considered more suitable to be applied than the other two alternatives, e.g. the installation of wastewater treatment equipment (Sar et al., 2021); and wastewater as a hydroponic growing medium (Lei and Engeseth, 2021).

The selected alternative solution based on data processing is pro was to use the wastewater as raw material for making liquid organic fertilizer. With this alternative solution, the amount of wastewater that directly discharge into the environment could be reduced. The alternative of making liquid fertilizer using the anaerobic method is expected to increase the economic value of SMEs Milk X. An increase in the economic aspect was comes from the sale of liquid fertilizer. The assumption used in this study was to manufacture the liquid organic fertilizer two times in one month. The operational costs consisted of fixed and variable costs, with detail calculations are as follows.

Total Cost

The estimated total investment and operating costs per day for alternative of manufacturing the liquid organic fertilizer (i.e.with production capacity of 84 L) are below, with the summary values are shown in Tabel 5 and 6. The economic value in calculating fixed costs was assumed to experience depreciation per month during the production process (Livdan and Nezlobin, 2021). The depreciation costs vary between materials required. The operational costs used were the costs of each production per month, where the production was carried out twice per month. The economic calculations are as follows.

a. Depreciation Cost

Depreciation per month

$$= \frac{\text{Amount (IDR))}}{\text{Economic Age } (Month)} \quad \text{..... (3)}$$

1. Plastic barrel = $\frac{IDR\ 160{,}000}{3\ x\ 12}$ = IDR 4,444
2. Wooden stirrer= $\frac{IDR\ 160{,}000}{1\ x\ 12}$ = IDR 13,333
3. Hose = $\frac{IDR\ 80.000}{2\ x\ 12}$ = IDR 3,333
4. Plastic Bottle = $\frac{IDR\ 24{,}000}{1\ x\ 12}$ = IDR 2,000
5. Filter Cloth = $\frac{IDR\ 80{,}000}{1\ x\ 12}$ = IDR 6,667

b. Production cost

TC = TFC + TVC
= IDR 29,777 + IDR 515,000
TC = IDR 544,777/ month
TC = IDR 6,537,324 / year

Table 4. Alternative Weighting Results

Alternative	Weight	Priority Ranking
Manufacturing of liquid organic fertilizer	0.71	1
Instalation of wastewater treatment equipment	0.08	3
Utilization of wastewater as hydroponic planting media	0.21	2

Tabel 5. Investment and Installation Cost (Fixed Cost)

No	Cost breakdown	Amount (unit)	Cost per unit (IDR)	Amount (IDR)	Economic Age	Depreciation Value
			Investment and Installation Cost (Fixed Cost)			
1.	50 Liter capacity plastic barrel	Two units	80.000	160.000	Three years	4.444
2.	Wooden stirrer (100 cm)	Two units	80.000	160.000	One year	13.333
3.	Hose (250cm)	Four units	20.000	80.000	Two years	3.333
4.	Plastic Bottle (30 cm)	Eight units	3.000	24.000	One year	2.000
5.	Thin cloth filter (2 meters)	Two units	40.000	80.000	One year	6.667
	Total investment cost			**604.000**	**Total depreciation value per month**	**29.777**

Tabel 6. Variable Cost

No	Cost breakdown	Amount (unit)	Cost per unit (IDR)	Amount (IDR)	Economic Age	Depreciation Value
		Variable Cost			**Description**	**Amount**
1	Raw material (milk soap wastewater) (42 L/barrel)	84 L	0	0	Two times production/month	0
2	Activator (EM4) (1 L / 84 L)	1 L	25.000	25.000	Two times production/month	50.000
3	Brown sugar (1 kg/84 L)	1 kg	14.000	28.000	Two times production/month	56.000
4	Clean water	3 L	1.500	4.500	Two times production/ month	9.000
5	Liquid fertilizer manufacturing workers	2 workers	20.000	40.000	Two times production/ month	80.000
6	Supervisory workforce	1 worker	15.000	15.000	20 working days/ month	300.000
7	Tool maintenance			20.000	One time/ 2 months	20.000
	Total operating costs per month					**515.000**

c. Determination of Cost of Production and Selling Price

1. Cost of goods manufactured.

= Total cost per years/ Amount per years
= IDR 6,537,324 / 2,016 L
= IDR 3,242.72

2. Selling Price

Calculation Mark up:

$$Mark\ up = \frac{\left(\left(30\%\ x\ Total\frac{Cost}{Year}\right) + Fixed\frac{Cost}{Year}\right)}{Variable\ Cost/Year}$$

$$Mark\ up = \frac{((30\%\ x\ 6{,}537{,}324) + 357{,}324)}{6{,}180{,}000}$$

Mark up = 0.38

Selling Price = (Mark Up x Cost of goods manufactured) + Cost of goods manufactured
= ((0.38 x 3,242.72) + 3,242.72)
= IDR 4,474.95

Selling Price = IDR 4,500 /L

d. Total Income

TR = P x Q
= IDR 4,500 / L x 2,016 L

TR = IDR 9,072,000

Description:
TR = Total Receipt (IDR /year)
P = Selling Price (IDR)
Q = Amount of liquid fertilizer (L/ year)

e. Profit Analysis

π = TR – TC
= IDR 9,072,000– IDR 6,537,324
= IDR 2,534,676

f. R/C ratio

R/C ratio $= \frac{TR}{TC}$
$= \frac{\text{IDR 9,072,000}}{\text{IDR 6,537,324}}$
= 1.39

Calculation of Economic Indicators

The new economic indicators in SME Milk X were as follows:
Estimated After Application of Alternative Liquid Fertilizer Production Profit Milk Soap per year:

π = TR – TC
= IDR 936,000,000 – IDR 546,000,000
= IDR 390,000,000

Profit of Liquid Fertilizer Sales per year:

π = TR – TC
= IDR 9,072,000– IDR 6,537,324
= IDR 2,534,676

Total Profit :
= sale of milk soap + sale of liquid fertilizer
= IDR 390,000,000 + IDR 2,534,676
= IDR 392,534,676

a. Economic Indicators

Total selling price :
= IDR 936,000,000 + IDR 9,072,000
= IDR 945,072,000

Total production cost :
= IDR 546,000,000 + IDR 6,537,324
= IDR 552,537,324

Economic Indicator :
= selling price/production cost
= IDR 945,072,000/IDR 552,537,324
= 1.7104

b. GPI Value After Alternative

EI = (0.2 x 5.5 kg) + (0.4 x 1.2 kg)
= 1.1 kg + 0.48 kg
= 1.58

$$GPI = \frac{economy\ indicator}{environmental\ performance\ indicators} \quad (4)$$

$= \frac{1.7104}{1.58}$

GPI = 1.078

The estimation for the calculation of economic indicators on alternative solutions was carried out over one year. The profit from the sale of milk soap was IDR 390,000.000, and the sale of liquid fertilizer was IDR 2.534.676. The total profit each year was IDR 392,534,676. The economic indicator before the calculation of liquid fertilizer sales was 1.714, slightly reduced to 1.7104. Before valorizing the wastewater, the environmental performance indicator was 7.18 kg, and reduced to 1.58 kg following the selected alternative. The GPI value obtained was 1.078, indicating a significantly increase from before the implementation (i.e. GPI value of 0.24). The wastewater valorization could reduce the magnitude of the environmental impact, but there is a slight decline in the economy. This may be caused by the estimated calculation of economic indicators, which need further in-depth study (Marimin et al., 2014). The GPI values before and after the implementation of the selected alternative solutions can be seen in Table 7.

Table 7. Results of GPI Values Before and After the Selected Alternatives

No.	GP Indicator	Before Alternative	After Alternative
1.	Environmental performance indicators	7.18	1.58
2.	Economic indicators	1.714	1.7104
3.	GPI value	0.24	1.078

Each alternative solution proposed has advantages and disadvantages in its application. The main advantage from transforming the wastewater into liquid organic fertilizer was to reduce the impact on the environment. The advantage of applying this alternative also include an increase in the PI value of the milk soap production process of SMEs Milk X. The weakness was that the liquid fertilizer production cannot be carried out every day due to limited facilities and a slight decrease in economic indicators. Inaccurate calculation estimates can cause a decline in economic indicators. Therefore, it is necessary to evaluate and improve the estimated cost of making liquid organic fertilizer from milk soap waste (Marimin et al., 2014; Luo et al., 2022).

Conclusion

The selected alternative solution to increase the productivity of the milk soap production process in SMEs Milk X was the manufacture of liquid organic fertilizer. This alternative may potentially reduce the environmental performance indicators value from 7.18 kg to 1.58 kg, as well as significantly increase the GPI value from 0.24 to 1.078. This alternative has a drawback, namely a slight decrease in economic indicators due to the estimated cost of making liquid organic fertilizer. However, this can be handled by evaluating and improving the estimated cost of making liquid organic fertilizers. The GPI value calculation is expected to be used as the basis for solving problems related to green productivity. The selected alternative solution should be trialed and improved in terms of manufacturing costs.

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Declarations

Conflict of interests The authors declare no competing interests.

References

Cerri, B. C., Borreli, L. M., Stelutti, I. M., Soares, M. R., da Silva, M. A. (2020) 'Evaluation of new environmental friendly particulate soil fertilizers based on agroindustry wastes biopolymers and sugarcane vinasse', *Waste Management*, 108, pp. 144–153

Chen, Y., Yu, J., and Khan, S. (2013) 'The spatial framework for weight sensitivity analysis in AHP-based multi-criteria decision making', *Environmental Modelling and Software*, 48, pp. 129–140

De Vries, A., Kaylegian, K. E., and Dahl, G. E. (2020) 'MILK symposium review: Improving the productivity, quality, and safety of milk in Rwanda and Nepal', *Journal of Dairy Science*, 103(11), pp. 9758–9773

Dinas Peternakan Provinsi Jawa Timur (2019) *Produksi Susu Sapi Segar* (*Production of Fresh Cow's Milk*) [Online] Available at: https://disnak.jatimprov.go.id/web/data/statistikproduksi (Accessed: 17 November 2021).

Hou, C., Chen, H., Long, R., Zhang, L., Yang, M., and Wang, Y. (2021) 'Construction and empirical research on evaluation system of green productivity indicators: Analysis based on the correlation-fuzzy rough set method', *Journal of Cleaner Production*, 279, pp. 1-11

Lähdesmäki, M., and Suutari, T. (2020) 'Good workers, good firms? Rural SMEs legitimising immigrant workforce', *Journal of Rural Studies*, 77, pp. 1–10

Lei, C., and Engeseth, N. J. (2021) 'Comparison of growth characteristics, functional qualities, and texture of hydroponically grown and soil-grown lettuce', *LWT*, 150, pp. 1-10

Lermen, F. H., Echeveste, M. E., Peralta, C. B., Sonego, M., and Marcon, A. (2018) 'A framework for selecting lean practices in sustainable product development: The case study of a Brazilian agroindustry', *Journal of Cleaner Production*, 191, pp. 261–272

Liu, F., Zou, S. C., and Li, Q. (2020) 'Deriving priorities from pairwise comparison matrices with a novel consistency index', *Applied Mathematics and Computation*, 374, pp. 1-16

Livdan, D. and Nezlobin, A. (2021) 'Investment, capital stock, and replacement cost of assets when economic depreciation is non-geometric', *Journal of Financial Economics*, 142(3), pp. 1444–1469

Luo, Y., Lu, Z., Salman, M., and Song, S. (2022) 'Impacts of heterogenous technological innovations on green productivity: An empirical study from 261 cities in China', *Journal of Cleaner Production*, 334, pp. 1-13

Mandaka, S., and Hutagaol, M. P. (2015) 'Analisis fungsi keuntungan, efisiensi ekonomi dan kemungkinan skema kredit bagi pengembangan skala usaha peternakan sapi perah rakyat di Kelurahan Kebon Pedes, Kota Bogor (Profit function analysis, economic efficiency and possible credit schemes for the development of smallholder dairy farming businesses in Kebon Pedes Village, Bogo City)', *Jurnal Agro Ekonomi*, 23(2), pp. 191–209 [In Indonesian]

Marimin, Darmawan, M. A., Machfud, Putra, M. P. I. F., Wiguna, B. (2014) 'Value chain analysis for green productivity improvement in the natural rubber supply chain: A case study', *Journal of Cleaner Production*, 85, pp. 201–211

Mastrocinque, E., Ramirez, F. J., Honrubia-Escribano, A., and Pham, D. T. (2020) 'An AHP-based multi-criteria model for sustainable supply chain development in the renewable energy sector', *Expert Systems with Applications*, 150, pp. 1-17

Onkelinx, J., Manolova, T. S., and Edelman, L. F. (2016) 'The human factor: Investments in employee human capital, productivity, and SME internationalization', *Journal of International Management*, 22(4), pp. 351–364

Oraman, Y., Azabagaoglu, M. O., and Inan, I. H. (2011) 'The firms' survival and competition through global expansion: A case study from food industry in FMCG sector', *Procedia - Social and Behavioral Sciences*, 24, pp. 188–197

Perzina, R., and Ramík, J. (2014) 'Microsoft Excel as a tool for solving multicriteria decision problems', *Procedia Computer Science*, 35, pp. 1455–1463

Ramadhan, D. R., Mulatsih, S., and Amin, A. A. (2015) 'Keberlanjutan sistem budi daya ternak sapi perah pada peternakan rakyat di Kabupaten Bogor (Sustainable dairy cattle farming systems: A case study of smallholders in Bogor District)', *Jurnal Agro Ekonomi*, 33(1), pp. 51–72 [In Indonesian]

Sahu, A. K., Padhy, R. K., Das, D., and Gautam, A. (2021) 'Improving financial and environmental performance through MFCA: A SME case study', *Journal of Cleaner Production*, 279, pp. 1-19

Sar, T., Harirchi, S., Ramezani, M., Bulkan, G., Akbas, Pandey, A., Taherzadeh, M. J. (2021) 'Potential utilization of dairy industries by-products and wastes through microbial processes: A critical review', *Science of The Total Environment*, 810, pp. 1-18

Tricarico, J. M., Kebreab, E., and Wattiaux, M. A. (2020) 'MILK Symposium review: Sustainability of dairy production and consumption in low-income countries with emphasis on productivity and environmental impact', *Journal of Dairy Science*, 103(11), pp. 9791–9802

Wei, C., Wei, J., Kong, Q., Fan, D., Qiu, G., Feng, C., Li, F., Preis, S., and Wei, C. (2020) 'Selection of optimum biological treatment for coking wastewater using analytic hierarchy process', *Science of the Total Environment*, 742, pp. 1-12

Wu, Z., and Tu, J. (2021) 'Managing transitivity and consistency of preferences in AHP group decision making based on minimum modifications', *Information Fusion*, 67, pp. 125–135

Yan, Z., Zou, B., Du, K., and Li, K. (2020) 'Do renewable energy technology innovations promote China's green productivity growth? Fresh evidence from partially linear functional-coefficient models', *Energy Economics*, 90, pp. 11-11

Zhao, Y., Song, X., Wang, F., and Cui, D. (2020) 'Multiobjective optimal dispatch of microgrid based on analytic hierarchy process and quantum particle swarm optimization', *Global Energy Interconnection*, 3(6), pp. 562–570

Zhang, S., Liu, Y., and Huang, D. H. (2021) 'Understanding the mystery of continued rapid economic growth', *Journal of Business Research*, 124, 529-537