Synergy of Lean and Green for Improving Small-Scale Agroindustry Performance

Muslikah Desti Kurniasari[1], Nafis Khuriyati[*,1], and Wagiman[1]
[1] Department of Agroindustrial Technology, Universitas Gadjah Mada,
Jl. Flora No.1 Bulaksumur 55281, Indonesia.
Email: nafis.khuriyati@ugm.ac.id [*]

Abstract

Small Medium Enterprises (SMEs) play an important role in the economy of Indonesia. It contributed to the 21.20% of national total economy. Global competition is a challenge and an opportunity for SMEs including agroindustry sector. Therefore, it is needed for strengthening their competitiveness. In the midst of this effort, the raising concern about environment issue has increased. This research aims to determine the alternatives or options in production aspect based on lean and green for small-scale crackers industry. Sustainable Value Stream Mapping (SVSM) was applied to describe the production condition and identify wastes from lean and green point of view. Furthermore, Value Stream Analysis Tools (VALSAT) and Life Cycle Impact Assessment (LCIA) were used to analyze waste throughout the production activity. The results show that the small-scale cracker industry has already implemented synergy of lean and green, however some alternatives for reducing lead time and waste are needed such as demand forecasting and improvement of working methods

Keywords: *Cracker industry; green; lean; value stream mapping.*

1. INTRODUCTION

The Implementation of AEC (ASEAN Economic Comunity) in 2015 is a challenge and an opportunity for Small Medium Enterprise (SME). SMEs are encouraged to increase their competitiveness in order to survive among SMEs in national and ASEAN. In ASEAN, SMEs occupied in strategic position, more than 96% of total enterpreneurs is SMEs actor who contribute to GDP by 30-50 % [1].

In Indonesia, SMEs contributed 21,20% of Indonesia's total economy. The amount of this contribution is certainly worthy of attention and when entering the AEC 2015, SMEs challenged to maintain or increase its contribution by improving the competitiveness. In the midst of an effort to improve the competitiveness, the raising concern about environment issue has increased. In addition to the increased competitiveness and raising concern about environment leading to synergy between the lean and green supply chain. Synergy lean and green supply chain focus on reducing waste and lead time.

Sahara industry is one of small scale agroindustries who produces crackers. It has low competitiveness with market share of 0,6% in regency level and 0,11% in a province level[2]. Production capacity of Sahara industry is 250 kg of tapioca flour as a raw material. Sahara industry already implementing lean strategies especially in materials requirement that done with Just in Time (JIT) principles and implementing green strategies by implementing rework on their defective products. However, their implementation of the lean and green strategy is not optimal yet. It is due to large quantities of semi-finished materials inventory and return crackers from sales. This research aims to determine the improvement alternatives based lean and green to reduce waste and lead time in it supply chain.

2. MATERIALS AND METHODS

2.1 Materials

This research was held on the small crackers industry 'Sahara' located in Bantul Regency of Yogyakarta Special Province Indonesia. This research used many data. Lean supply chain need data such as raw material ordering data, sales data, activities distance, quantity of input, output, scrap, defect, and rework, cycle time, and quantity of workers. Green supply chain need data such as quantity of input, output, scrap, rework, and waste, fuel and energy requirement data, type of vehicle used, activity distance, cycle time, and quantity of workers. There is similarity from both lean and green data, the similar data is data of synergy lean and green, there are quantity of input, output, scrap, rework, activity distance, cycle time, and quantity of workers.

These data collected by using some methods like interview, observation, and study literature. These data collected per batch production. For some data like time of cycle time production need some repetition collecting in order to get accurate data.

2.2 Methods

Analysis methods were used Sustainable Value Stream Mapping (SVSM) to described supply chain condition and identify of wastes from concept lean and green supply chain [3], Value Stream Analysis Tools (VALSAT) and Life Cycle Impact Assessment (LCIA) to analyze waste throughout the supply chain activity. Phases of this research as follows:

1. Identification activity and actor on supply chain of Sahara industry
2. Processing data for Current State Sustainable Value Stream Mapping
3. Making Current State Sustainable Value Stream Mapping
4. Waste identifying from aspect lean and green
5. Waste analysis used Value Stream Analysis Tools (VALSAT) and Life Cycle Impact Assessment (LCIA)
6. Composing alterative improvement

In processing data for Current State Sustainable Value Stream Mapping, there were many calculation data, i.e:

- Cycle Time
  Cycle time (CT) has been defined as the length of time between starting and finishing the production of an order[4].

- Takt Time
  It can be defined as the ratio of available time and customer demand. Available time is total time for production process exclude break time. Cycle time should be less than takt time[5]. Equation (1) shown how to measure takt time.

  $$T = Ta/D \quad (1)$$

  T = Takt time
  Ta = Available time
  D = Demand (customer demand)

- Total process lead time (PLT)
  Total PLT is total time required for production process from raw material to finished products. Total process lead time calculate based on value added time (VAT), non-value added time (NVAT), and lead time (LT). Value added time is time from activities that add value to product or customer. Non-value added time is time from activities that doesn't add value to product or customer. Lead time is the time spent between the original customer order and final delivery of the product[6] or waiting time at production process for the next process (work in process). Equation (2) below indicates how to measure total process lead time.

  $$\text{Total PLT} = VAT + NVAT + LT \quad (2)$$

- Process Cycle Efficiency (PCE)
  PCE is a measure indicator from process value added. Equation (3) below indicates how to measure process cycle efficiency [7].

  $$PCE = VAT/(VAT+NVAT+LT) \times 100\% \quad (3)$$

- Production efficiency defined as comparison of output and input, related an achievement maximum output with an input [8]. Equation (4) below indicates how to measure production efficiency.

  $$\text{Prod Eff} = \text{output/input} \times 100\% \quad (4)$$

- Raw material usage is quantity of raw material start with original, then there are added material and removed material, to finish. Raw material usage will be monitored[9] on a mass basis and calculate through mass balancing. Mass balancing is a tool to get the details of the calculation of the amount of raw materials required to obtain number of products.

- Total water consumption is consumption the amount of water used during the manufacturing process and represents an important aspect that must be evaluated for improvement from an environmental sustainability perspective. However, water added to the product (say for liquid chemical) is not include here [10].

- Total energy consumption is amount of energy consumed per unit during and between each process [11].
- Pollutant load of wastewater can be calculate by formula on Equation (5) below [12].

$$BPA = (CA)j \times (DE) \times f \quad (5)$$

BPA = Pollutant load of wastewater (kg parameter per day)
(CA)j= Real concentration of parameter j (mg/l)
DE = Wastewater flow (l/second)
f = Conversion factor

- Pollutant load of wastewater can be calculate by formula on Equation (6) below [13].

$$BE = (CE)j \times (QE) \times f \quad (6)$$

BE = Pollutant load of emission (kg parameter per day)
(CE)j= Real concentration of parameter j (g/kg)
QE = Emission flow (kg/second)
f = Conversion factor

3. RESULTS

3.1 The Supply Chain of Sahara Industry

In general, the actors in supply chain of Sahara industry are suppliers, manufacturers, distributors, retailers and end consumers. The supplier are Putra Subur store, Interutama Sakti unit trade, Bringharjo traditional market, fire wood seller, and LPG gas seller. The manufacture is Sahara industry and the distributor is crackers seller. The retailers are grocery shop, restaurant, and traditional market. And the final consumer is public.

Production capacity per day of Sahara industry is 250 kg of tapioca flour as a raw material. Sahara industry produce 3 kind of crackers which are small-round crackers, big-round crackers, and square crackers. The number of worker in Sahara industry is 8 worker and there are 25 seller who delivered the crackers. Production run 6 day per week and per day start from 06.00 to 16.00 with a break time of 30 minute for meals. Production process in Sahara industry started with making spices, pulping, mixing, flatting, forming, steaming, first drying, shelling, second drying, frying, packaging, and loading.

3.2 Identification and Analysis of Waste

In supply chain of Sahara industry, there are actors who doing activities to support the flow of Sahara's supply chain, they are supplier, manufacture, distributor, retail, and final consumer. Each activity released waste, both time waste and material waste (solid, liquid, gas). Detail activities and waste shown on Appendix A as Figure A.1. Table 1 display waste identified that extracted from the SVSM. It shows the current situation of supply chain in Sahara industry.

Table 1. Current Situation of Supply Chain in Sahara Industry

Indicator	Value
Total Process lead time	23987 minutes
Process cycle efficiency	10.097 %
Production efficiency	37.34 %
Raw material usage	Original = 250 kg Final = 435.96 kg
Total water consumption	953 L/unit (159 L/unit lost)
Total energy consumption	1161.73 kWh

From Table 1, using Equation (1), the takt time was known (2.84 min/kg). The SVSM shows the waste identified on each aspect, lean and green supply chain.

3.3 Lean Supply Chain

The current condition of waste in Sahara industry were identified based on 7 waste categorized by Ohno. They were weighted by scoring as shown in Table 2.

From the result of scoring, it is known that unnecessary inventory has the highest score. The scoring used as input in calculating on selecting value stream analysis tools for waste analyzed. The result of selecting tools can be seen on Table 3.

Table 2. Scoring of Waste Weight

No	Waste	Score	Explanation	Real Condition
1	Overproduction	3	There is overproduction which began to cause inventory and takes place that disrupt the process flow and cause inventory cost.	Overproduction of 92.23 kg of dry crackers
2	Defect	3	There is a defect that occurs in the later-step process leading to rework or potentially reschedule	Total rework of 121.9 kg Total scrap 3.81 kg
3	Excessive Transportation	1	Occurs transport excess but not interfere with the production process	Transport time of 413.63 minutes per one batch per day
4	Inappropriate Processing	4	Inappropriate processing time increase production so can extend the lead time	Total inspection time of 187.41 minutes
5	Unnecessary Inventory	5	There is excess inventory that is not needed that require more storage and cause damage to the goods is not known because of the large inventory	• The amount of raw materials in the warehouse of raw materials is 1250 kg with days of inventory 5 days • The amount of pulp spices on warehouse is 189.8 kg with days of inventory 1 day • Number of semi-finished materials (dry crackers) in a storage is 92.23 kg with days of inventory of 0.46 days • Number of crackers mature in warehouse is 200.5 kg with days of inventory 1 day • Total time work in process is 13,925 days with total of material is 2491.61 kg
6	Unnecessary Motion	1	There is unnecessary movement but not interfere with the production process	• Activity transport of flour from the yard to the warehouse of raw materials • Workers at the steaming who have to deal with high temperatures • Workers should be lowered to move the board crackers to trolley • Flakes of dry crackers on shelling process that can injure the face and hands of workers
7	Waiting	1	The waiting are not interrupt the production process	Delay time is 25.46 minutes per one batch per day
TOTAL SCORE		17		

Table 3. Recapitulation of VALSAT calculation

Waste	PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	3	9	0	3	9	9	0
Waiting	9	9	1	0	3	3	0
Excessive Transportation	9	0	0	0	0	0	1
Inappropriate Processing	36	0	12	4	0	4	0
Unnecessary Inventory	15	45	15	0	15	15	5
Unnecessary Motion	9	1	0	0	0	0	0
Defect	3	0	0	27	0	0	0
TOTAL	84	64	28	34	27	31	6
RANGKING	1	2	5	3	6	4	7

PAM=Process Activity Mapping, SCRM=Supply Chain Response Matrix, PVF=Production Variety Funnel, QFM=Quality Filter Mapping, DAM=Demand Amplification Mapping, DPA=Decision Point Analysis, PS=Physical Structure

Based on Table 3, the selected tools is PAM or Process Activity Mapping because it has highest score by 84. PAM used to analysis of waste on 5 activities like delay, inspection, operation, storage, and transportation.

3.4 Green Supply Chain

Waste from green aspect divided into 3 kinds of waste, which are solid waste, wastewater, and emission. From SVSM it is known that the 17.94 kg solid waste were originated from raw material. The removal raw material were discharged into the environment or reworking the removal raw material to waste reduction. The removal raw material derived from various solid waste. From SVSM, known that forming process released highest rework by 11.98 kg per forming process. In a day, they have 10 times of forming process, therefore the raw material should be reworked was 119.8 kg.

The wastewater of 159 L has not been able to rework or reuse for production processes or other activities in the supply chain. The wastewater would be dumped through the waterways without prior treatment. To identified wastewater, concentration of wastewater were tested to compare the standard in Yogyakarta Special Province. The standard refer to governor rule No. 7 of 2010 regarding effluent standards for industrial activities, services, health, and tourism services. The characteristics of wastewater can be seen on Table 4.

Table 4. Wastewater Concentration Testing Results

Parameter	Threshold	Real Concentration
pH	6,0-9,0	3.73
BOD	75 mg/l	86.72 mg/l
COD	200 mg /l	1240 mg/l
TSS	100 mg/l	17.19 mg/l

Emission can be calculate by multiply the used energy with emission factor each fuel. Sahara industry used fuel for production process such as fire wood, LPG gas, and for transportation used gasoline. The emission released by activities in Sahara Industry shown on Table 5.

Table 5. Emission Released by Activities in Sahara Industry per Batch per Day

No	Fuel	Pollutant (gram)		
		CO_2	SO_2	NO_x
1	Gasoline	$0.45x10^{-7}$	$0.134x10^{-6}$	$0.85x10^{-7}$
2	LPG gas	9048.715	0.003	3.610
3	Fire wood	209.857	2.460	16.023
4	Electricity	53.650	0.074	0.633

4. DISCUSSION

4.1 Lean Supply Chain

From analysis with PAM, there were 61 activities with total activity/process time by 22339.84 minute. Percentage of each activities type is shown on Table 6.

Table 6. Percentage of Activities Type on Supply Chain of Sahara Industry

No	Activity Type	Time (minute)	Percentage (%)	Total Activity
1	Delay	25.46	0.11	4
2	Inspection	255.11	1.14	7
3	Operation	2209.69	9.89	19
4	Storage	1938.40	86.76	5
5	Transportation	467.18	2.09	26
	TOTAL	**22339.8**	**100**	**61**

From Table 6, it is known that storage has the highest percentage. It means that there were high inventory, although storage is necessary but point of 'non value added' increased lead time. The high inventory needs more energy such electrical energy and large space for storage. The high of percentage of storage caused by overproduction due to anticipating of uncertain weather and not all material done by same day. Therefore, Sahara industry must reduction the storage.

4.2 Green Supply Chain

The waste analysis on green supply chain done by approach of Life Cycle Impact Assessment (LCIA). This approach used to analyse waste and how the impact of waste to environment[14].

The high of solid waste in forming process caused by some factor, like from machine and workers. Design of forming machine is continually expand daugh and the design make much dough left behind on machine. From workers factor, there was dough defect because it not exactly forming on above layer. The workers are less meticulous in putting layer above belt conveyor. The high of solid waste in forming process has impact to increase solid waste in shellering such drying crackers.

Solid waste caused by machine factor increased water consumption because much water needed for cleaning the machine and tools. Moreover, having solid waste decreased product output. From SVSM also known that forming activity turn out 11.98 kg of dough as a rework material in the work station of mixing. Rework can increase lead time, increase energy used which mean incrased releasing of emission.

The reason of real concetration were surpassing threshold is the length of soaking production tools before wasing and length of soaking dry crackers in rework process for additive material on process pulping. Moreover, there are much scrap on production tools and production machine, that is caused by worker unclean on taking dough which stick to production tools and machine.

Pollution load wastewater is the amount of a pollutant elements contained in water or wastewater. The pollution load is what will be covered by environment. The less of pollution load is better for the environment. Pollutio load of wastewater by Sahara industry shown on Table 7.

Table 7. The Real Pollution Load

No	Parameter	Pollution Load
1	BOD	0.036 kg/day
2	COD	0.512 kg/day
3	TSS	0.007 kg/day

Based on Table 8, it is known that COD has the highest pollution load. The high of COD and BOD can leads to reduced oxygen in the environment, so it will interfere the existing ecosystem. Analysis of emissiom was done by comparing the quantity of pollutant with emission standard. The comparison is shown on Table 8.

Table 8 shown that emission NO_x from fuel surpassing threshold. NO_x have many environment impact like acidification, eutrophication, photochemical ozone creation, and human health. Moreover, the pollution load of emission was 92.787 kg/day. The environment impact and high pollution load requires Sahara industry to conduct treatment for reducing waste and delayed the environmental damage.

Table 8. Comparison of Pollutant Quantity with Emission Standard

Source	Emission	Unit	Type	Threshold	Emission by Industry
EPA	SO_2 NOx	g/kg	Fuel	4.037 3.309	2.463 19.633
Regulation of The Minister of The Environtment	NOx	g/km	Motorcycle Car Truck	0.3 0.5 1.2	0.45×10^{-7} 0.4×10^{-7} -

(Source: EPA, 2008)[15]

4.3 Alternative Improvement

Based on the above analysis of waste, the proposed alternative for improvement are shown in Table 9.

Table 9. Alternatives for Improvement

No	Alternative
1	Forecasting of production and raw materials requirement
2	Increasing the workers precision in Putting strimin on the belt conveyor belt on forming process
3	Increasing the workers accuracy in taking the remaining dough at forming process
4	Taking of dough leftover at the end of product by using ladle board layer
5	Cleaning residual material on tools and machines before washing
6	Replace or reduce the use of energy sources emitters

The first alternative is used to solve problem of overproduction and unnecessary inventory. By implementation this alternative, Sahara industry will produce according to demand. In the other word, there is no product to save. Therefore, it can reduce the inventory and reducing lead time. Alternative number 2 until 4 are used to solve problem of solid waste. Through these three alternatives, Sahara industry can reduce the defect at forming process, reduce solid waste in shelling process, and reduce time of inspection in forming process. Alternative number 5 is used to solve problem of wastewater. With this alternative, Sahara industry can reduce the pollution load of wastewater. Alternative number 6 used to solve problem of surpass emission from standard emission. With this alternative, Sahara industry can reduce the pollution load of emission. For alternative number 6, Sahara industry can replace the fuel with other fuel which has high calorific value, so that quantity of fuel can be reduce.

CONCLUSIONS

The proposed alternatives for improvement the supply chain based on lean and green aspects are forecasting of production and raw materials requirement, increasing the workers precision in putting layer on the conveyor belt on forming process, increasing the workers accuracy in taking the remaining dough at forming process, taking of dough leftover at the end of product by using ladle board layer, cleaning residual material on tools and machines before washing, and replace or reduce the use of energy sources emitters. These alternatives are focus on waste reduction and lead time reduction which are consistent with the synergy of lean and green supply chain.

REFERENCES

Agrahari, R. Priyanka A.D and KV. Chandratre. 2015. Improvement of Process Cycle Efficiency by Implementing a Lean Practice: A Case Study. *International Journal of Research in Agroindustrial and Mechanical Engineering*, Vol 3 Issue 3: 38-51.

Barath R and G. S. Prakash. 2014. Lead Time Reduction Using Lean Manufacturing Principles for Delivery Valve Production. *Global Journal of Finance and Management* , Volume 6 (1): 35-40.

Brabazon, T. 1999. Manage Your Costs by Managing Cycle Time. *Journal Management Accounting*, Vol. 77 No. 6: 48-49.

Brown, A. Joseph A. and Fazleena B. 2014. Sustainable Value Stream Mapping (Sus-VSM) in Different Manufacturing System Configuration: Application Case Studies.

Journal of Cleaner Production, Vol 85: 164-179.

Disperindagkop. 2015. Data Potensi Industri Tahun 2012-2014: Program Revitalisasi dan Pengembangan IKM Satker Dinas Perindustrian Perdagangan Koperasi dan UKM Pemda DIY Tahun Anggaran 2012-2014. Disperindagkop. D.I. Yogyakarta.

Dues, C.M, Kim H.T and Ming L. 2013. Green As The New Lean : How to Use Lean Practice As A Catalyst to Greening Your Supply Chain. *Journal of Cleaner Production,* Vol 40: 93-100.

Environmental Protection Agency. 2008. Compilation of Air Pollutant Emission Factors. EPA. Ohio.

Faukner, W. et al. 2012. Visualizing Sustainability Performance of Manufacturing Systems using Sustainable Value Stream Mapping (Sus-VSM). *Proceeding of the 2012 International Conference on Industrial Engineering and Operation Management.* Turkey.

Faulker, W. and Fazleena, B. 2014. Sustainable Value Stream Mapping (Sus-VSM): Methodology to Visualize and Assess manufacturing Sustainability Performance. *Journal of Cleaner Production*, Vol 85: 8-18.

Gaspersz, V. 2007. *Organizational Excellence*. Jakarta: PT Gramedia Pustaka Utama.

Guinee, Jeroen B. 2002. Handbook on Life Cycle Assessment; Operational Guide to ISO Standards. Kluwer Academic Publishers. Dordrecht.

Kemenprin. 2015. Encourage Economic Growth Expansion of SMEs. On http://www.kemenperin.go.id/artikel/5774/Pertumbuhan-Ekonomi-Dorong-Ekspansi-UKM. Access on 20th April 2015 at 21.34 pm.

Ministry of the Environment No. Kep-03 / MENLH / 1/1998 About: Pollution Load Calculation for Determining Maximum Quality Wastewater dated: January 15th, 1998, annex II

Risandewi, T. 2013. Analysis of Productive Efficiency on Robusta's Coffee in Temanggung Regency: Case Study in Candiroto Sub-Regency. *Journal of Research and Development of Central Java Province,* Volume 11 No. 1.

Secretariat of Ministry of the Environment. 2013. Program of Improving Corporate Performance Assessment in Environmental Management: Self Assessment Proper 2012-2013. Proper. Jakarta.