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Implementation of green supply chain management for sustainable agroindustry in coffee processing unit, a case of Indonesia

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ABSTRACT

Waste management, ecological impact, emission, and water and energy usage were common problems in coffee processing. Green cultivation, green processing or manufacturing, and green distribution as a part of green supply chain management (GSCM) which focuses on the environmental aspects, have a strong role to overcome these common problems. The purpose of this research was to study the smallholder coffee processing unit from the green concept approach in supply chain activities. The field survey, direct visit, and in-depth discussion with key persons were used in this study to reach accurate data. Farming activities, processing, and distribution aspects were also evaluated in detail as part of GSCM. The techno-ecological aspect was assessed in this study using certain criteria to determine the potential of GSCM implementation in the study area. The result of the research area found that minimizing water and optimization of processing waste have been implemented to support green processing indicators. Reducing emissions during distribution has a high potential as an effort to reach the green distribution concept. A high score of techno-ecological feasibility analysis shows that the GSCM concept has a strong potential to be implemented in this research area. Improvement activities were strongly required to support the implementation of the GSCM concept to support this small coffee processing unit.

Key words: Ecotechnology; Supply chain; Emission; Water usage.

1 INTRODUCTION

In term of geographical location, Indonesia's climate is highly suited to the growing and production of coffee. Presently Indonesia is the fourth largest coffee producing country in the world, producing mainly Robusta coffee (estimated around 83% of national coffee production) (Neilson; Wright; Aklimawati, 2018). Sumatra, Java, Nusa Tenggara, Sulawesi, and Kalimantan are the coffee growing areas in Indonesia. Java is one of the large islands in the archipelago and also the second largest producer of coffee after Sumatera based on Central Bureau of Statistics Republic of Indonesia (Central Bureau of Statistic Republic of Indonesia/BPS, 2019).

Beamon (1999) described that traditional concept of supply chain was an integrated manufacturing process wherein ram material are manufactured into final product, the delivered to customers through distribution process, retail activities or both. Zhu and Sarkis (2004) defined that Green Supply Chain Management (GSCM) ranged from green purchasing to integrated supply chain flowing from supplier to manufacturer, to customer and reverse logistics, which is a close loop management. This is clearly shown that green supply chain involved not only integrating manufacturing process and distribution to customer, but also from the beginning product is designed until the product is disposed. It shows that a strong collaboration of the players along the product life cycle is required to support GSCM concept.

In coming years in daily industrial activities, when environment become stricter, business could reach benefit significantly from adoption of sustainable supply chain such as waste minimization, green product design, and technology cooperation (Nguyen; Sarker, 2018). Implementation of environmental management in manufacturing (green manufacturing) is a part of GSCM. Green manufacturing was a concept which focusing on environment-friendly through reducing of resource usage, waste, and emissions (Ghobakhloo et al., 2013). In industrial activities, GSCM practices are also considered as environmentally friendly practices, which include water efficiency, energy efficiency, waste management, environment conservation, recycling and reuse, and hazardous and optimization of transportation (Sabat; Krishnamoorthy, 2018). The implementation of environmentally sustainable supply chain practices has become a challenging issue especially in the food processing. The food and drinks products are very dynamic with constant changes in the customer demand (Beske; Land; Seuring, 2014; Trienekens et al., 2012). In term of coffee product, usage of water in field irrigation and processing, would influence the quality of coffee. In the end the quality of coffee would determine the final commercial value of coffee (Dardengo et al., 2018).

Seth, Rehman and Shrivastava (2018) explained that green manufacturing minimizes wastes, pollution, and also leads to financial gains and better image, if this implemented correctly. The objective of green manufacturing were reducing of raw material cost (energy and water usage), safety cost, and improvement the company performance in environmental impact to community. The implementation of SCM in agroindustry that more attention to the environmental aspect, would more advantages related to improved process such as production capacity, inventory control, and procurement of raw material (Suryaningrat, 2016). Green manufacturing is a product making process that consume less materials, less energy, substituting input materials reducing unwanted outputs, wastes, emissions, and converting outputs to inputs. Green manufacturing (as a part of GSCM) also helps to produce economically viable products with a minimum environmental and social impact (Thanki; Thakkar, 2019).

In term of industrial activities including agroindustry, damage to the environment has been the major challenge faced in overcoming years' aims to limiting waste within production process, save energy usage, and prevents the debauchery of harmful material into the environment (Sharma; Chadna; Bhardwaj, 2017). GSCM initiatives comprise the optimization of manufacturing processes to reduce waste and emissions. GSCM is emerging to be an important approach for enterprises, industry (agro-industry) to improve performance. GSCM encourage enterprises suppliers to improve their environmental performance utilizing relationships between the key players of large-sized buying firms and their suppliers (Kim; Rhee, 2012). GSCM could be achieved by integrating the various determinants such as green marketing, green design and development, green procurement, green manufacturing, and environmental management system (Malviya; Kant; Gupta, 2018). Presently, research in implementing GSCM is still insufficient, only a small in number in South East Asian Region. The implementation of GSCM within SMEs is not very clear and need more investigation (Holt, 2009). This was reinforced by Afum (2020) and Siregar (2022). The research related to GSCM is massive and there is no broad range of studies to support the advancement of GSCM (Dubey, 2017). Pham (2017) and Tseng (2019) stated that very few empirical studies in term of GSCM implementation for the SMEs. The purpose of this research was to study the SMEs coffee processing unit from green concept approach in supply chain activities. The improved implementation of GSCM in agro-industry will improve their product design, procurement procedure, internal processing, distribution, re-processing operations, and etc.

2 MATERIAL AND METHODS

This study was conducted at the coffee processing unit, at Sidomulyo village at Jember district, East Java Province. This research area is a center of smallholder coffee plantation (small farmers) with coffee processing unit. This area with small farmers produced high quantity of Robusta coffee from 155 Ha coffee field. Coffee bean was produced by wet process and semi wet process with 6-ton average capacity per day process. Survey method was conducted as a first step in this study. Direct visit and in-depth discussion were used to reach complete data related to recent condition at the study area. Whole activities of supply chain of coffee production in this area were also evaluated. These activities were field activity, transportation process, machinery at the processing unit, and distribution activities. Potential of GSCM implementation were also evaluated to this coffee processing unit. This evaluation based on organic farming concept in the Regulation of the Minister of Agriculture (Number 64/Permentan/OT.140/5/2013), Ministry of Agriculture of the Republic of Indonesia (2013). Measurement indicators used to analyze farming activity such as farmer skill on organic farming, transportation activity, organic fertilizer and bio-pesticide, water supply and operational cost. Qualitative score from 1 to 3 was implemented for eco-technology feasibility analysis of GSCM concept. Score 1 if the farmers have less than 50% involvement into indicators, score 2 if the farmers have 50% to 75% involvement into indicators and score 3 if the farmers have more than 75% involvement into indicators.

In term of GSCM implementation of processing aspect, minimization of water usage, and optimization of waste process were used in this study. Indicators used in this aspect were technological skill, waste processing facilities to produce biogas and workers. Related to evaluation of supply chain on distribution aspect, comparison of emission and warming potential was implemented in this study. Level of emission would be evaluated using equation regarding on Intergovernmental Panel on Climate Change (IPCC) (Cellura; Cuzenza; Longo, 2018).

Fuel $\propto$ = volume of fuel × Energy content
Emission: = $\sum \propto$ (Fuel $\propto$ × EF $\propto$)
Energy content of gas= 34.66 MJ L^{-1}
Energy content of fuel = 36.68 MJ L^{-1}
Fuel $\propto$ = volume of fuel (MJ)
EF $\propto$ = Emission factor of gas per fuel $\propto$ (g MJ^{-1})
Emission = total emission (g)
$\propto$ = gas or fuel

Techno-ecological aspect was also evaluated on this coffee processing unit. The indicators used were green cultivation, green processing, and green distribution. Final score of this evaluation using 0% to 100% scale with certain criteria were: (i) good (76% to 100%) if the GSCM provide maximum advantages to the area with high potential to be implemented; (ii) fair (55% to 76%) if GSCM provide an enough advantage to the area; (iii) poor (33% to 55%) if GSCM concept provide minimum advantages to the environment with minimum potential to be implemented to the area.

3 RESULT

Agro-industrial unit at this research area was coffee processing supported by small holder coffee plantation as raw material supplier. This area with small farmers produced high quantity of Robusta coffee bean was produced by wet process and semi wet process with 6-tons average capacity per day process. Most of small coffee farmers were employed low investments in the application of technologies such as several types of mechanization, differentiated managements and other technologies for harvesting and processing of coffee product (Corsini et al., 2018). This coffee processing has also a coffee farmer cooperation with around 90 members to support marketing activities and to market the product for regional market and industry for export market. Generally coffee production supply chain in this area consisted of field production, processing and marketing or distribution.

Integrated green supply chain in small coffee processing is presented in Figure 1. On farm activities, processing and distribution are the main factor in green supply chain. Usage of coffee processing waste for coffee plantation is also illustrated in processing activities as part of this figure. Involvement of transport activities is expressed in every step of this green supply chain. This figure explains the flow of activity, material, information and financial from farm activity, processing and distribution of product to consumers.

4 DISCUSSIONS

4.1 Implementation of GSCM on field production (on farm activities)

In this area, organic farming of coffee plantation has been implemented for 3 years. Result of qualitative assessment with some indicators is shown in the Table 1.

Table 1 shows that the involvement of farmers into organic farming and supply of fertilizer has highest score compare to other indicators. In term of organic farming activities, coffee farmers in this area have a strong involvement in preparing and managing field for coffee plantation. Availability of coffee skin in big quantity per day (around 6,300 kg from pulping process and 3,400 kg from washing process) as waste from coffee processing was used to be processed as organic fertilizer in coffee plantation (could be seen in Figure 1). In agro-industrial process, in applying the principle of zero waste management, Malithong et al. (2017) explained that the remains of agro-industrial (oil palms) production process, the remains materials such as debris, leaves, stem, and shell fiber were converted to fertilizers.

Daily activities in this study area, motorcycle was the most vehicle used to transport this organic fertilizer from processing unit to the field. Big quantity of organic fertilizer needs a bigger capacity transport like a truck or small truck. In term of daily operational cost, government provide aids

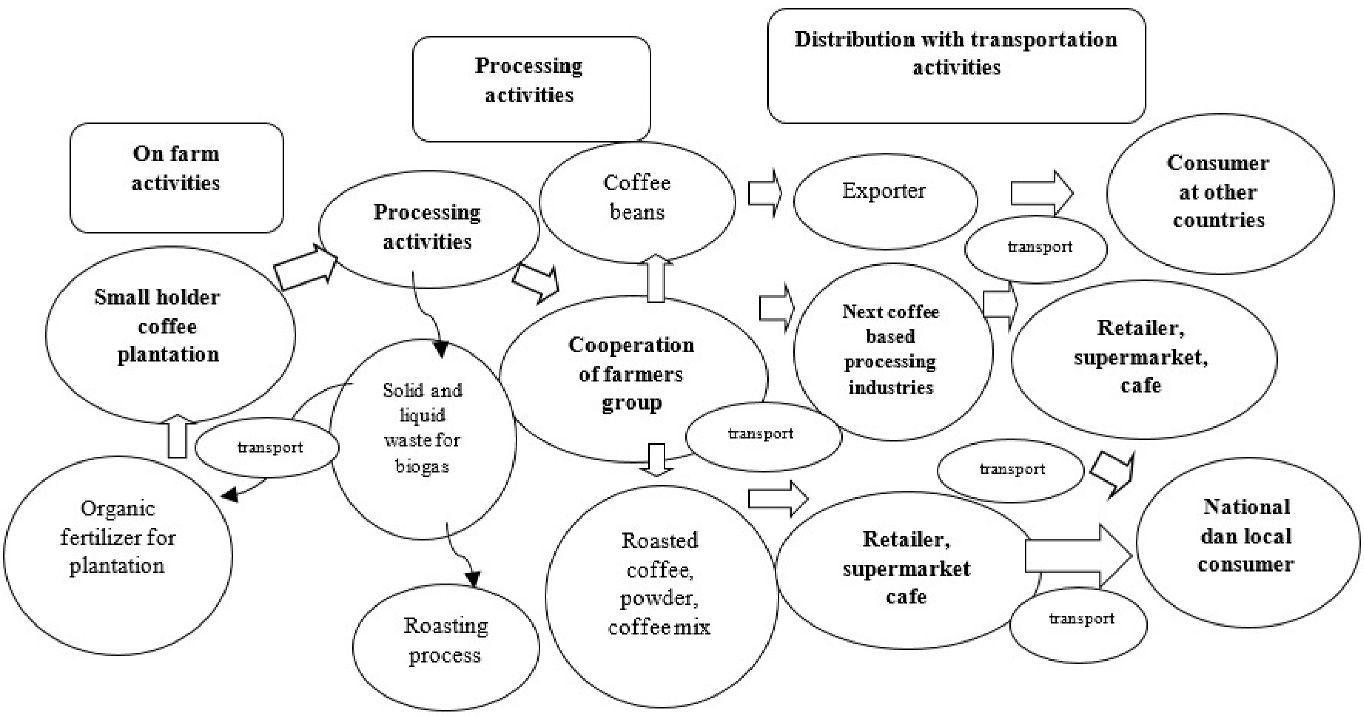

Figure 1: Integrated green supply chain of SMEs coffee processing.

through university program to support some requirement items related to organic farming. This program could solve cost problem faced by farmers. In term of financial aspect, previous study found that finance plays major role in green supply chain management implementation (Govindan et al., 2014). Availability of bank loans to encourage green products/processes also a barrier for implementing GSCM in many industries. Total percentage score of 73% means that most of farmers still have a strong potential in implementation of GSCM to provide many advantages for this research area.

Table 1: Potential to support implementation of GSCM.

No	Indicators	Score
1	Involvement of farmers into organic farming activity	3
2	Transportation for field activities (fertilizer)	2
3	Supply of fertilizer and biopesticide	3
4	Water supply	2
5	Supporting operational cost from farmers	1
	Total score	11
	Percentage score	73

4.2 Implementation of GSCM on processing activities

Processing activities are also illustrated in Figure 1. The food supply chain (FSC) raises to an interdependent system of organizations, processes, activities, stakeholders and resources involved in flow of food from producers to consumers. The processes in a typical FSC involve production, processing, distribution, consumption and disposal (Ghadge et al., 2017). In processing activities, water usage and optimization of waste were evaluated in this study. Earlier research Novita et al. (2012) resulted that minimizing water usage (water consumption during process) of coffee processing in this area could reach in 2.987 m3 to 3.345 m^3 per ton coffee process. Table 2 shows a comparison of water usage in coffee processing in research area.

Table 2 shows that with GSCM concept water usage in coffee processing could reduce 54.2% compare to without GSCM concept. Reducing of water usage come from water consumption per ton process, water consumption per day process and volume of liquid waste produced in coffee processing. In term of solid waste, this research area has a processing area which process solid waste (coffee skin) from coffee processing unit. Quantity of solid waste of coffee processing are shown in Table 3.

Table 3 shows that this coffee processing unit produced 586 t of coffee skin from hulling process. From this waste material could be produced 96 tons organic fertilizer per year. In this area, 25 farmers were involved with 155 ha coffee plantation. From the availability of organic fertilizer, 619 kg could be provided for every hectare coffee plantation. In term of processing, Sharma, Chandna and Bhardwaj (2017) stated that green manufacturing (processing) could be achieved by reducing emissions and waste (re-use) and lower consumption of energy and raw supplies. This is relevant to this study in reuse waste for an organic fertilizer used for plantation. Related result, one of main areas of food waste generation was by-product from food processing (Raak et al., 2017). In food manufacturing, by-products should be immediately processed to avoid microbial growth and deterioration reactions, provoking safety risks or decreasing yield (Struck et al., 2016). In coffee processing, this is an opportunities for increasing benefits and reduced environmental loads exist in the conversion of coffee husks and pulp into fortified organic fertilizer for increased land productivity (Kanyiri; Waswa, 2017).

4.3 Technological skill

In term of GSCM, solid waste for organic fertilizer, liquid waste for biogas and minimizing or water usage have been implemented by farmers in this area (Figure 1). Minimizing of water usage was also implemented on semi-wet process technology in coffee processing unit. This means

Table 2: Water usage on coffee processing.

Implementation of concept	Water consumption per ton of coffee process (m^3)	Water consumption per day (m^3)	Volume of liquid waste per day (m^3)
Non-GSCM	5.838	35.030	26.433
GSCM [19]	3.166	18.996	14.334
Percentage of reducing		54.2%	

Table 3: Solid waste from coffee processing unit.

Waste of coffee skin per day (tons)	Waste of coffee skin per month (tons)	Waste of coffee skin per year (tons)	Production of organic fertilizer per year (tons)
9.77	293.16	586.31	96

that coffee farmers in this area have a strong technical skill to produce organic fertilizer and biogas made from waste of coffee processing unit. Technological skills related to organic fertilizer are preparing materials (coffee skin), mixing materials with other additional materials to be processed, managing and implementing the organic fertilizer to the field, and scheduling of fertilizing into the field of coffee plantation. In term of biogas, skills of the farmers are preparing reactor and materials to be processed, controlling the gas in reactor, and usage (implementation) of gas into coffee processing unit. This study related to previous study by Sharma, Chandna and Bhardwaj (2017) where other form of energy (biogas) could be implemented in processing unit.

Related with waste management for producing of biogas, additional supporting facility were also required in this area. Presently biogas could be produced in this area was 7,223 g cm^{-2} from one reactor. In coffee processing, 8,157.6 g cm^{-2} was required for daily processing activity. It means that 934.6 g cm^{-2} was still required to support gas capacity for processing activity. Additional of waste reactor was needed to increase gas capacity for energy supply to roasting process in coffee processing unit. This additional facility could be supported from government program through department of agriculture, university or Corporate Social Responsibility (CSR) program from companies. Some barriers in implementing of GSCM in SMEs were lack of government support to adopt environmentally friendly policies, lack of technical expertise and financial constraints. Strong involvement from government and other institution are strongly required to support GSCM implementation. Similar result could be found in the study conducted by Lin et al. (2020), strong involvement of government is required to support implementation of GSCM in SMEs activities.

4.4 GSCM on distribution process

In term of distribution process, comparison of emission level was evaluated in this study (Figure 1). Emission level was resulted from usage of biofuel 20 (B20) and potential of biofuel 30 (B30). Presently still fuel with biofuel 20 provided in the market. Regarding to government regulation, fuel with biofuel 30 has been provided in the market in 2019. Sharma et al. (2017) explained that transportation sector is a crucial part of supply chain. Transport sector has also one of the highest gas emission in supply chain activities. Previous research also found that the majority of the environmental pollution was driven by production and logistics activities and there was a need for the environmentally friendly practices to reduce CO_2 emission (Dubey; Gunasekaran; Ali, 2015; Pålsson; Kovács, 2014).

In this study, distribution activity by using truck from coffee processing unit to export company (PT. Indocom) in Surabaya (200 km distance). Besides, transportation activities were also required to support local market such as restaurants, cafes, supermarket and retailers. As other research result, strong role of government through regulations and policies could also accelerate the GSCM implementation in industries. These policies include preparing logistics infrastructure as a part of supply chain process such as controls efficient and effective forward and reverse flow and storage of goods, services, and related information among partners in order to meet customers' requirements (Kim; Rhee, 2012).

According to Sungur et al. (2017) explained that in transportation and industrial activities, substitution of biofuel 30 (B30) has improved performance compared to biofuel 20 (B20), it could reduce gas emission of CO_2 and SO_2. Detail of reduction of emission level explained in Table 4.

Table 4: Comparison of level of emission between B20 and B30.

Fuel	Emission (g)	
	CO_2	SO_2
B20	108 431.06	671.97
B30	103 660.09	606.12

In term of operational cost, this study assumed that price of B30 would be 20% higher than B20. This means that transportation cost of distribution activity using B30 would also be higher than B20. Therefor to maintain transportation cost, transportation facility, and rescheduling of distribution should be provided to support continuity of GSCM. Bigger truck with higher capacity (10 t) could be an alternative for distribution activities. Higher efficiency could be reached using bigger truck with bigger capacity. This alternative would also be supported by better scheduling of distribution process. Increasing capacity of transportation facilities (bigger truck) would reduce frequency of distribution, from 30 times to 24 times per year. This reduction of distribution frequency would also reduce emission of transportation process. Reduction of emission is explained in Table 5. This study result was also relevant to Choudhary et al. (2015), explained that facility location and transportation mode selection, could significantly influence their carbon emission. It is important to consider emission reduction issues in supply chains (SC) and logistics systems.

Table 5: Reduction of emission from distribution process.

Distribution activities	Level of emission (gram)	
	CO_2	SO_2
Present distribution (1)	3,443,835.12	21,342.08
Reschedule distribution (2)	2,820,978.82	17,482.12
Total reduction of emission	622,856.30	3,859.95

4.5 Techno-ecology in implementation of GSCM

Potential advantage for the environment and involvement of farmers in implementation of GSCM were evaluated in this study. Cultivation, processing and distribution were indicators in this evaluation. Table 6 shows the result of evaluation.

Table 6: Evaluation of techno-ecology.

No	Indicators	Score of potential of GSCM implementation
1	Green cultivation	2
2	Green processing	3
3	Green distribution	3
	Total score	8
	Percentage (%)	88.8

Table 6 shows that total score of techno ecology is 88.8% (8/9). Based on the score level, it means that more than 75% of farmers in this research area were strongly involved in implementation of GSCM activities. In term of cultivation activities, compare to other, lower score because of operational cost and transport facilities problems faced by the farmers. This is also relevant to other research, some barriers had been identified in implementing GSCM in some Small and Medium Enterprises (SMEs) in other countries. According to Mathiyazhagana et al. (2013) that in their GSCM implementation in SMEs, especially for maintaining the environmental awareness, the supplier barrier was the dominant one compare to others. Involvement of cooperative to provide low-interest rate credit and farmer group transport was strongly needed for these problems. More attention should be paid to this cultivation activities to reach better result. Related to green processing, this maximum score could be reached because of implemented activities, minimizing of water usage, optimizing of processing waste, and processing of liquid waste for biogas. These activities could be implemented by farmers supported by technological skill, facilities and supporting cost as investment. In green distribution, substitution of on to B30 could reduce emission in transportation activities. Bigger truck facilities and rescheduling of distribution would also reduce emission in transportation activities. All of these activities provide strong support to reach maximum score of green distribution. Generally, with high score of final result (88.8%) of techno ecological aspect shows that in this research area has a strong potential of GSCM implementation to support a sustainable agroindustry of coffee processing unit.

5 CONCLUSION

High score of techno ecological evaluation shown that GSCM concept has a strong potential to be implemented in this research area. Organic farming and supply of fertilizer and bio pesticide were the highest indicators of implementation of GSCM. Minimizing of water usage and optimization of processing waste has been implemented in processing activities. Improvement activities such as involvement of cooperation, solid and liquid waste processing, reducing emission during distribution, were strongly required to support implementation of GSCM concept to support this small coffee processing unit. Substitution better level of biofuel, higher capacity of transport facilities and rescheduling on distribution activities would support the implementation of GSCM in this coffee processing unit. Green processing and green distribution were indicators with high contribution to techno ecology in research area.

6 AUTHOR' CONTRIBUTIONS

IBS performed field activities and experiment, conducted analyses and wrote the manuscript, reviewed and approved the final version of the work.

EN conducted the experiment and analysis, co-worked the manuscript, reviewed the final version of the work.

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