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Value Chain Analysis of Jackfruit Chips in Green Supply Chain Management Perspective Using the Value Chain Operations Reference Method

Analisis Rantai Nilai Keripik Nangka dalam Perspektif Green Supply Chain Management *dengan Metode* Value Chain Operations Reference

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Abstract

A green supply chain is a concept that integrates environmental aspects in the supply chain system. This study aims to identify the value chain stages affecting the environment and to determine the level of economic impact on the jackfruit chips value chain at CV XYZ. This research used Value Chain Operations Reference (VCOR) method to analyze value chain activities. Carbon emissions and total costs were calculated at the build, acquire, and fulfill stages from suppliers and enterprises. The analysis results showed that the highest environmental impact was at the build stage which produces carbon emissions of 133,314.8 kg CO_2. The frying process contributed the highest carbon emission, which was 117,600 kg CO_2. CV XYZ was in the intolerable region condition in the Global Impact matrix. The resulting carbon footprint is 16.84 kg CO_2/kg with a unit cost of 0.32 €/kg. The recommendation strategy was substituting firewood with liquefied petroleum gas (LPG) to lower carbon emissions by up to 40%.
Keywords: carbon emission, Green Supply Chain Management, Value Chain Operation Reference

Abstrak

Green supply chain *adalah sebuah konsep yang mengintegrasikan aspek lingkungan pada sistem rantai pasok. Penelitian ini bertujuan untuk mengidentifikasi tahapan rantai nilai yang berdampak pada lingkungan dan menentukan tingkat dampak ekonomi pada rantai nilai keripik nangka di CV XYZ. Penelitian ini menggunakan metode* Value Chain Operations Reference (VCOR) *untuk menganalisis aktivitas rantai nilai. Emisi karbon dan total biaya dihitung pada tahap* build, acquire, *dan* fulfill *dari supplier dan perusahaan. Hasil analisis menunjukkan bahwa dampak lingkungan tertinggi terdapat pada tahap* build *yang menghasilkan emisi karbon sebesar 133.314,8 kg CO_2. Proses penggorengan memberikan kontribusi emisi karbon paling tinggi, yaitu 117.600 kg CO_2. CV XYZ terletak pada kondisi intolerable region dalam* Global Impact matrix. *Jejak karbon yang dihasilkan adalah 16,84 kg CO_2/kg dengan biaya unit sebesar 0,32 €/kg. Strategi yang direkomendasikan adalah penggantian kayu bakar dengan liquefied petroleum gas (LPG) yang dapat menekan tingkat emisi karbon hingga 40%.*
***Kata kunci**: emisi karbon*, Green Supply Chain Management, Value Chain Operation Reference

INTRODUCTION

The industry has started to consider the green supply chain management (GSCM) concept to be a part of their process. GSCM integrates environmental factors into a comprehensive supply chain system (Sarkis, Zhu, & Lai, 2011; Tseng et al., 2019). The supply chain plays a significant role in reducing the impact on the environment related to carbon emissions, pollution, and waste. The implementation of GSCM is expected to minimize the environmental impact on the product's entire life cycle, save resources used, and reduce the use of hazardous materials (Susanty, Santosa, & Tania, 2017). The food industry is one of the industries that should pay more attention to its environmental impact as it produces a lot of waste in the supply chain process, from the production process to product delivery (Sgarbossa & Russo, 2017).

In the food industry, value chain analysis is highly needed to determine the energy, material

consumption, and waste values of each stage of the supply chain. The value chain concept is defined as a series of activities that need to be performed for a product at different phases, from raw materials to the final consumer and to waste treatment (Warsanga, 2014). Value chain analysis should be measured to determine the transfer of value from each stage of the process. Thus, the costs and levels of carbon emissions from each process can be estimated. GSCM-based value chain implementation controls environmental aspects at all process stages to minimize waste and carbon emissions (Kung, Huang, & Cheng, 2012).

CV XYZ is one of the medium-sized enterprises that processes jackfruit into chips products. This industry takes advantage of the opportunity to transform jackfruit into processed chips as jackfruit has not been widely processed into a value-added product. Besides, jackfruit also contains 330 g of vitamin A, 20 g of calcium, and low-calorie fiber as much as 95 calories per 100 g (Amalia & Susanto, 2017).

CV XYZ has not figured out the level of carbon emissions produced in processing its products, especially in the frying process by using firewood. The process produces relatively high carbon emissions from combustion. CV XYZ needs to find the level of carbon emissions resulting from its production process to control it effectively. By doing this step, they can manage their production to have an environmentally friendly process. Rising consumer awareness to consume environmentally friendly products can also elevate the company's competitive advantage (Bhardwaj, 2016). Value chain analysis with a GSCM perspective should be performed so that CV XYZ can find out the level of carbon emissions and the costs required to produce jackfruit chips. The result of carbon emissions calculation can be utilized to determine the highest amount of carbon emissions resulting from production process activities so that the production process can be improved and GSCM can be applied.

Value Chain Operations Reference (VCOR) is a method used to analyze the value chain. VCOR uses a broader and more integrative approach than SCOR. This method focuses on three centers of excellence to create and to add value for customers: product excellence, operating excellence, and customer excellence (Rabe & Weinaug, 2007; Badr & Stephan, 2017). The use of VCOR in this study aims to determine each value chain activity so that the amount of waste or carbon emissions produced by CV XYZ can be figured out. Any improvement that should be conducted during certain value chain stages can also be identified to implement GSCM properly. This study aims to identify the value chain stages affecting the environment and determine the level of economic impact of the jackfruit chips production value chain.

METHODS

This research was conducted at CV XYZ, located in Polowijen, Malang City, East Java. This research was performed from February 2020 to June 2020. This study focuses only on environmental and economic factors. Therefore, this study does not cover any social factors related to this matter. Value chain identification is carried out starting from the stage of sending raw materials to CV XYZ to the delivery process to distributors.

Determining the VCOR Model

Supplier, firm, and customer variables are used in the VCOR model in this study. The supplier variable is configured with the full module only, while the firm variable can only be configured with the acquire module since the supply chain does not specifically examine customer delivery activities. It is specific to any firm that receives products from the suppliers, processes the product, and delivers them to customers so that firms are configured with the acquire, build, and fulfill modules. The indicators used as environmental indicators for the VCOR model can be seen in Table 1.

Data Analysis

The data needed in this research is in the form of primary data and secondary data. Primary data are in the form of input and output data taken from the annual production of jackfruit chips year and suppliers' data. The primary data were obtained through direct interviews with the owner of CV

Table 1. Environmental indicator of VCOR model

Stages	Environmental Indicator
Acquire	Carbon emission (supplier)
Build	Solid waste
	Water consumption
	Energy consumption
	Carbon Emission
	Total plastic used
	Total paper used
Fulfill	Transportation carbon emission (distributor)

and field observations. Secondary data taken in the form of theoretical fundamentals information that supports research were obtained from the literature study.

Evaluation of Carbon Emission Values for Supplier and Company Activities

Evaluation of carbon emission values for supplier and company activities are including production and transportation activities. Carbon emissions and unit costs were then analyzed from each supplier and company activity. Carbon emissions were calculated by using the following equation (Zhao et al., 2012):

$$C_f = \sum_i Ap_i Gp_i + \sum_j Bt_j Gt_j + \sum_k Cd_k Gd_k \quad (1)$$

where,

Ap_i = production quantity of i^{th} product per year (kg)

Gp_i = carbon emission for production of i^{th} product (kg CO_2/kg)

Bt_j = fuel consumption for transportation of j^{th} vehicle per year (litre)

Gt_j = carbon emission for transportation of j^{th} vehicle (kg CO_2/litre)

Cd_k = volume of waste k^{th} per year (kg)

Gd_k = carbon emission of waste k^{th} (kg CO_2/kg)

Determining of Economic Impact of Environmental Corrective Measure

The economic impact of environmental problems in the supply chain is seen through the specific cost function derived from the cost function on Savino, Manzini, & Mazza (2015). Modification of the economic impact function (E_i') is:

$$E_i' = E_i + C_m - (C_f x\ C_t) \quad (2)$$

where,

E_i' = sustainable supply chain economic impact (IDR)

E_i = conventional supply chain economic impact (IDR)

C_m = environmental measurement cost (IDR)

C_f = carbon emission (kg CO_2)

C_t = carbon tax (IDR).

A country sets the carbon tax. However, Indonesia has not implemented a carbon tax so the carbon tax value used in the calculation is 0 (Climate Transparency, 2016).

Determining the Logistics Chain Carbon Footprint

Carbon footprint (C_{fp}) is obtained from equation (1) which divides the value of C_f for total annual production. The formula of C_{fp} is:

$$C_{fp} = \frac{C_f}{P_i} \quad (3)$$

where,

C_{fp} = carbon footprint (kg CO_2/kg)

C_f = carbon emission (kg CO_2)

P_i = production quantity per year (kg)

Determining the Level of Global Economic and Environmental Impact with a Matrix Approach

The Global Impact matrix can be seen in Figure 2. The Global Impact matrix consists of five Global Impact (GI) areas. The supply chain position is determined by the carbon footprint (C_{fp}) value and unit cost (E_i) value as follows:

1. The intolerable region is marked with high C_{fp} and E_i values.
2. The tolerable region is marked with medium C_{fp} and high E_i values.
3. The acceptable region is marked with medium C_{fp} and medium or very low E_i value and very low C_{fp} and medium or high E_i values.
4. The optimal region is marked with very low C_{fp} and low E_i values.

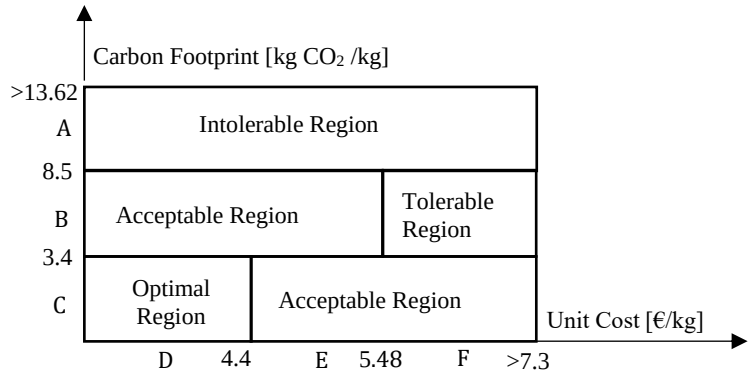

Figure 2. Global Impact Matrix

The carbon footprint is calculated by using formula (3). The unit cost value is calculated by using the following formula:

$$E_i = \frac{E_i'}{Pi} \quad (4)$$

where,

E_i = unit cost (€)

E_i' = sustainable supply chain economic impact (€/kg)

P_i = production quantity per year (kg)

The unit of measurement used in the economic impact is €/kg because it is converted from Rupiah (IDR) to Euro (€) to comply with the matrix provisions that use Euro (€) as its unit.

RESULTS AND DISCUSSION

CV XYZ Supply Chain Analysis

CV XYZ is a medium-sized enterprise in the food industry located in Malang City, East Java. CV XYZ produces fruit chips. At CV XYZ, some fruits are used as the chips' raw material, including jackfruit, apple, *salak*, banana, melon, *rambutan*, mango, and star fruit. The company also produces vegetable chips, such as carrots, potatoes, purple sweet potatoes, and broccoli chips. Jackfruit chips are the best-selling product and have the highest demand in CV XYZ. The production capacity of jackfruit chips in this company is 130 kg/day. The jackfruit chips are marketed in Malang, Surabaya, Jakarta, and Bali.

The supply chain of CV XYZ begins with the delivery of jackfruit by truck. Fresh jackfruit is shipped from 3 suppliers who collaborated with CV XYZ. Then, CV XYZ selects jackfruit by CV XYZ based on the dimensions, weight, and level of fruit maturity. The jackfruit is selected carefully to maintain the quality of raw materials. By doing this, it is expected that the production of jackfruit chips can also be maintained. The production of jackfruit chips is then sent by truck to the distributor. CV XYZ has three distributors that will market its jackfruit chips products. The Supply chain configuration of CV XYZ can be seen in Figure 3.

The supply chain activities of CV XYZ generate carbon emissions. Carbon emissions are generated during raw materials delivery to the company until the trucks go back to the suppliers and product delivery to distributors and the trucks go back to the company. Some activities that generate carbon emissions can be seen from the supply chain configuration of an industry so that the carbon footprint of each chain activity can be effectively measured (Dewani, Boer, & Jannah, 2014).

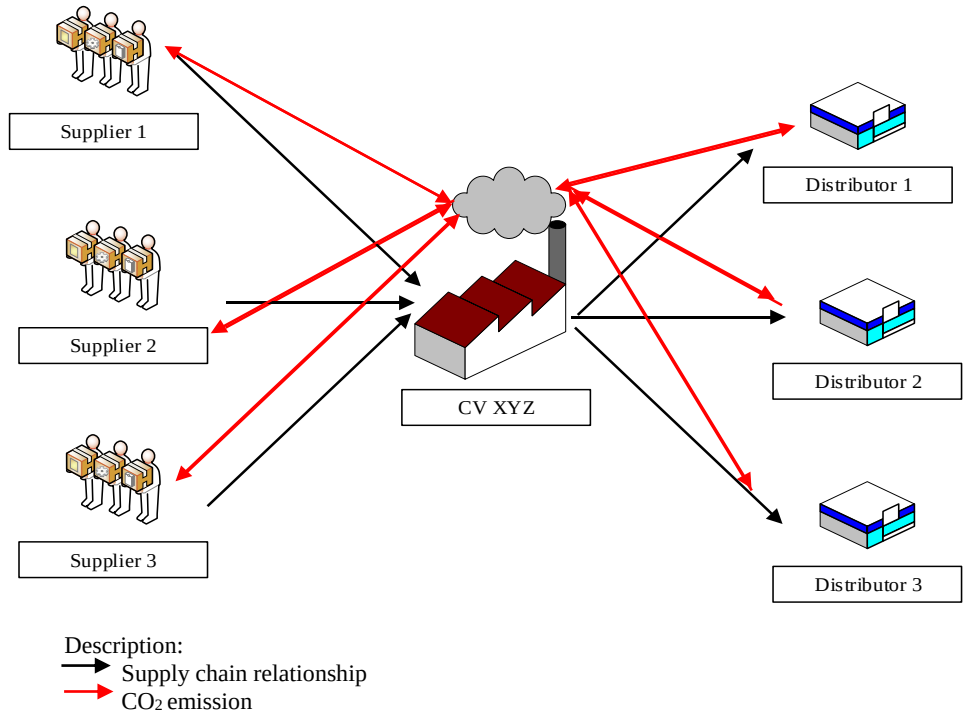

Figure 3. Supply Chain Configuration of CV XYZ

Table 2. Material quantities per year

Material	Total
Fruit delivered (ton)	15
Scrap from all suppliers (%)	1
Fruit processed (%)	99
Chips delivered to the distributor (ton)	7.995

Fruit sent by suppliers is 99% processed into jackfruit chips to meet the distributor's demand. CV XYZ produces jackfruit chips with the quantity of material that can be seen in Table 2. Table 2 shows the number of materials ranging from raw materials to jackfruit chips. Suppliers send 15 tons of fruit. The total net weight of jackfruit flesh processed into chips is 14.85 tons. This is the total amount of jackfruits without the skin and other parts that cannot be processed into chips (as much as 1% from each supplier). Jackfruit is then processed into chips through a frying process so that the output left is only 8.065 tons due to the water loss during frying process. The chips were then sorted based on specific criteria, and around 7.995 tons of jackfruit chips are sent to the distributor.

Figure 4 shows the energy balance to find out the input and output of supply chain activities generating emissions in one harvest season. According to Minx et al. (2009) the input-output analysis is a proper methodology for carbon footprint analysis because it can explain all the emissions generated in the production process.

Figure 4 shows that the cooling process at CV XYZ produces CO_2. Every 1 kWh of energy produces 0.725 kg of CO_2 (Zacky et al., 2014). The frying process that uses firewood also produces CO_2. Every 1 kg of firewood produces 1.75 kg of CO_2 (Zacky et al., 2014). The packaging material for jackfruit chips at CV XYZ uses aluminium foil as the primary packaging. Every 1 kg of aluminium foil packaging produces 24.45 kg of CO_2 (Barrett et al., 2002). The jackfruit chips were then sent to the distributor using a diesel-fueled truck, generating carbon emissions during the shipping process. Every 1 litre of fuel produces 2.2 kg of CO_2 (Zacky et al., 2014).

Value Chain Configuration

The VCOR model supports critical issues and integrates the processes within and between individual chain units for planning and governing processes. Plan level strategy is a comprehensive process that aligns strategic objectives with tactics and performing capabilities in the value chain. Govern level strategy is an exhaustive process that supports strategic objectives and enables the value chain to operate through rules, policies, and procedures in close relationship to the plan level strategy. Table 3 shows the VCOR model configuration.

The VCOR model in this study configures suppliers with fulfill stage. Fulfill is the stage where the supply chain actor carries out activities to fulfil demands from other supply chain actors. The customer is configured with the acquire stage because it does not consider delivery activities to the customer. Acquire is the stage where the supply chain actor is obtaining goods and services from other parties. The firm is configured with acquire, build, and fulfill stages. The Build stage is

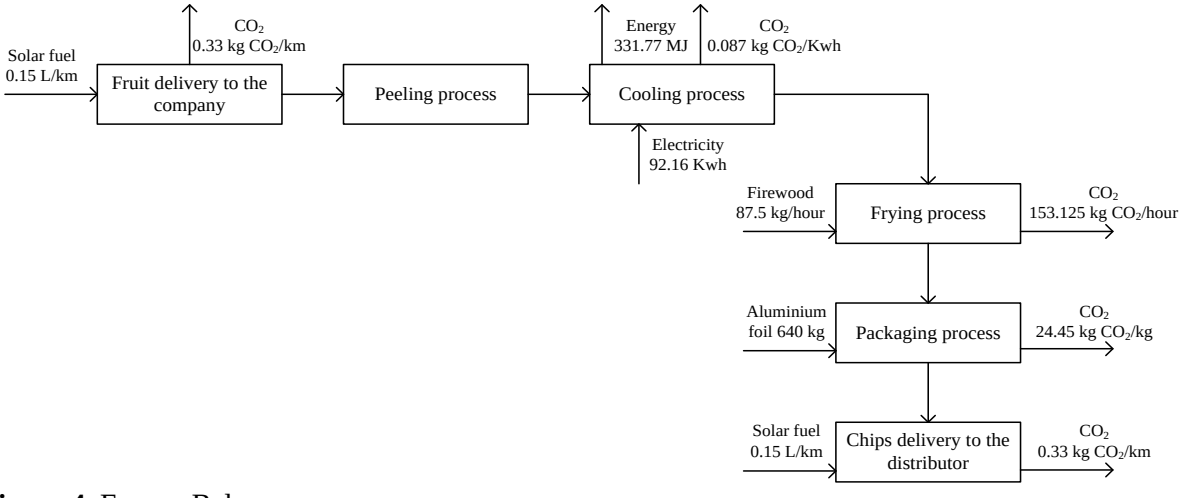

Figure 4. Energy Balance

Table 3. VCOR model configuration

Govern									
Plan									
Supplier		Firm						Customer	
Fulfill		Acquire		Build		Fulfill		Acquire	
F1	Order inquiry	A1	Qualify supplier	B1	Request resource	F1	Order inquiry	A1	Qualify supplier
F2	Confirm order	A2	Issue request	B2	Issue material	F2	Confirm order	A2	Issue request
F3	Plan load	A6	Receive order	B4	Verify product	F3	Plan load	A5	Place order
F4	Receive warehouse	A7	Verify order	B5	Package product	F5	Fill order	A6	Receive order
F5	Fill order	A8	Transfer inventory	B6	Storage product	F7	Deliver order	A7	Verify order
F7	Deliver order	A9	Process invoice	B7	Release product	F8	Verify receipt	A8	Transfer inventory
F8	Verify receipt					F10	Invoice	A9	Process invoice
F10	Invoice								

Source: Modified from Savino & Neubertn (2007)

Table 4. Details of quantities in VCOR Model

Plan						
Supplier		Firm				
Fulfill		Acquire		Build		Fulfill
				Process		
Supplier Code	Fruits (ton)	Scrap (%)	Fruits Acquired (ton)	Input (ton)	Output (ton)	Chips Delivered to Customers (ton)
1	7	1	6.93			
2	4	1	3.96	14.85	8.065	7.995
3	4	1	3.96			

the stage of manufacturing a product where the products are received from suppliers, the production process is carried out, and products are sent to the customers.

The VCOR model configuration codes in Table 3 are adapted from the research modification of Savino & Neubert (2007) by considering the codes associated with each supply chain actor's activities. Making a document for the ship's cargo (F6) is excluded from the suppliers' fulfill stage because the fruit is not sent using the ship's cargo. This stage does not include the installation and test process (F9) since suppliers send fruits that don't require installation and testing. Some activities excluded in the acquire stage from CV XYZ are proposal evaluation (A3), contract negotiation (A4), and place of order (A5) as the company does not evaluate proposals to suppliers and does not negotiate contracts with suppliers. An activity excluded from the company's build stage includes building a project (B3) since the production process has been running for a long time. Therefore, the project development is not carried out. An activity excluded from the company's fulfill stage is to compose a ship's cargo document (F6) because the product was not delivered using the ship's cargo. The installation and test activity (F9) are also excluded at this stage because the production machine has been installed and tested to carry out the production process so the product can be directly verified and packaged. An activity excluded from the customer's acquire stage is proposal evaluation (A3) and contract negotiation (A4) because the customer does not evaluate the proposal to suppliers directly and does not negotiate contracts with suppliers directly.

A quantity table from the VCOR model was then created. The table contains some processes that produce the quantity from each stage of the value chain. The configuration of VCOR with the amount processed at each stage can be seen in Table 4.

Table 4 shows that three suppliers collaborated with CV XYZ are suppliers 1 from

Semarang, suppliers 2 from Pasuruan, and suppliers 3 from Lumajang. Once received, the jackfruit skin and other unused parts are removed. A total scrap of jackfruit on each supplier is 1%. Therefore, input processed by CV XYZ is 14.85 tons of jackfruit and produces a jackfruit chips output of about 8.065 tons. This weight loss occurs due to reduced water content in the frying process. After cooling, sorting was performed to select jackfruit chips that match the criteria and quality standards set by CV XYZ. The total amount of jackfruit chips that will be sent to distributors is around 7.995 tons.

Evaluation of Carbon Emission Values for Supplier and Company Activities

Every supply chain activity produces carbon emissions that are harmful to the environment. Carbon emissions (C_f) and the total cost (E_i) at the build, acquire, and fulfill stage from suppliers and companies can be seen in Table 5. According to Savino et al. (2015) determination, C_f and E_i can provide operative implementation from value chain concept to food chain under sustainability perspective with sustainability value quantification for all VCOR modules. These values also become a guide for dealing with GSCM issues in the context of the value chain.

Value of carbon emissions in stages fulfill from suppliers to the company is affected by the amount of fuel oil used and the emission factor of that fuel. The emission factor of diesel fuel is 2.2 kg of CO_2/litre (Zacky et al., 2014). Fulfill stage from suppliers to the company generates total carbon emissions (C_f) as much as 584.03kg and a total cost (E_i) of 1,460,250 IDR**.** E_i value is affected by distance, the use of fuel oil, and the cost of fuel oil. Vehicles that produce the highest C_f and E_i of suppliers are vehicles 1 originating from Semarang because suppliers are far from the company. The more fuel needed, the farther the distance of the suppliers. This results in higher carbon emissions and requires higher costs. Research Robertson, Garnham, & Symes (2014) also shows that farther distributor sites result in higher carbon emissions.

The fulfill stage CO_2 value from the company to the distributor is also affected by the amount of fuel used and emission factors. High total carbon emission values are generated by vehicle 2, which is delivering to distributors in Jakarta. The distributor's location in Jakarta has the farthest distance so that the fuel used is higher and produces a high total value of carbon emissions. The total value of carbon emissions is also affected by the load on the truck. Nurcahyono & Yuwono (2019) explained that the capacity of the transport vehicle influences the number of transport vehicle emissions. The total value of carbon emissions generated in stages fulfill from company to distributor is 744.15 kg, and the total cost is 1,860,375 IDR.

The build stage consists of frying, packaging, and cooling processes. The build stage in the frying process is using firewood as fuel. The amount of firewood needed by the company to produce jackfruit chips in 1 year is 67.2 tons. CV XYZ's working hours to produce jackfruit chips are 8 hours per day with six working days per week for four months (during jackfruit season), so that the total working hours per year is 768 hours. The firewood needed per hour is 87.5 kg. The value of carbon emissions is affected by the required firewood per hour and the emission factor for firewood. The emission factor from firewood is 1.75 kg CO_2/kg (Zacky et al., 2014), so that the total carbon emission produced in 1 year is 117,600 kg. The total cost value of the frying process is influenced by the annual cost of firewood and the weight of firewood. Therefore the total E_i is 11,424,000 IDR.

The build stage in the packaging process is using aluminum foil. Aluminum foil needed is 80 rolls, weighing 8 kg/roll. The carbon emissions value is influenced by the packaging weight and the emission factor of the packaging type. The emission factor of aluminium foil packaging is 24.45 kg CO_2/kg (Barrett et al., 2010), so the total value of packaging carbon emissions is 15,648 kg. The E_i total value is influenced by the weight of the packaging and the cost of the packaging so that the resulting total cost is 28,800,000 IDR. It is assumed that the packaging process will produce carbon when the packaging has been disposed of and become waste (Savino et al., 2015).

The Build stage in the cooling process using the refrigerator requires 0.12 kWh/hour. CO2 value is affected by working hours, energy used, and electricity emission factors. The emission factor of electricity in East Java is 0.725 kg CO_2/kWh (Zacky et al., 2014), so that the total value of carbon emissions in the cooling process is 66.8 kg. E_i value is influenced by the annual energy use, working hours, and electricity costs for refrigerators. Thus, the total cost of the cooling process is 122,112 IDR.

The build stage generates the highest total value of carbon emissions. The frying process produces the highest carbon dioxide because it uses a lot of firewood, so that the carbon emissions pro-

Table 5. C_f and E_i determination for the value chain

Fulfill (from Supplier to Company)						
Vehicle	**Yearly Distance (km)**	**Fuel Consumption (litre/km)**	**CO_2 (kg/km)**	**Total CO_2 (kg)**	**Fuel Cost (IDR/litre)**	**E_i (IDR)**
	(a)	**(b)**	**(c)=(b)x2,2 kg CO_2/litre**	**(d)=(a)x(c)**	**(e)**	**(f) = (a)*(b)*(e)**
Vehicle 1 Semarang-Malang(filled)	840	0.15	0.33	277.2	5,500	693,000
Vehicle 1 Malang-Semarang (empty)	840	0.10	0.22	184.8	5,500	462,000
Vehicle 2 Pasuruan-Malang(filled)	69	0.15	0.33	22.7	5,500	56,925
Vehicle 2 Malang-Pasuruan (empty)	69	0.10	0.22	15.18	5,500	37,950
Vehicle 3 Lumajang-Malang (Filled)	153	0.15	0.33	50.49	5,500	126,225
Vehicle 3 Malang-Lumajang (Empty)	153	0.10	0.22	33.66	5,500	84,150
Total of Fulfil (from supplier)				**584.03**		**1,460,250**
Fulfill (from Company to Distributor)						
Vehicle	**Yearly Distance (km)**	**Fuel Consumption (litre/km)**	**CO_2 (kg/km)**	**Total CO_2 (kg)**	**Fuel Cost (IDR/litre)**	**E_i (IDR)**
	(a)	**(b)**	**(c)=(b)x2,2 kg CO_2/litre**	**(d)=(a)x(c)**	**(e)**	**(f) = (a)*(b)*(e)**
Vehicle 1 Malang-Bali (filled)	404	0.15	0.33	133.32	5,500	333,300
Vehicle 1 Bali-Malang (empty)	404	0.1	0.22	88.88	5,500	222,200
Vehicle 2 Malang-Jakarta(filled)	848	0.15	0.33	279.84	5,500	699,600
Vehicle 2 Jakarta-Malang (empty)	848	0.1	0.22	186.56	5,500	466,400
Vehicle 3 Malang-Surabaya (filled)	101	0.15	0.33	33.33	5,500	83,325
Vehicle 3 Surabaya-Malang (empty)	101	0.1	0.22	22.22	5,500	55,550
Total of Fulfill (to Distributor)				**744.15**		**1,860,375**
Build						
Frying						
Firewood Quantity (tons)	**Working Hour (hour)**	**Firewood Consumption per Hour (kg/hour)**	**CO_2 (kg/hour)**	**Total CO_2 (kg)**	**Firewood Cost (IDR/ton)**	**E_i (IDR)**
(a)	**(b)**	**(c)=(a)/(b)**	**(d)=(c)*1,75 kg CO_2/kg**	**(e)=(b)x(d)**	**(f)**	**(g)=(a)x(f)**
67.2	768	87.5	153.125	117,600	170,000	11,424,000
Packaging						
Type of Packaging	**Quantity (roll)**	**Weight (kg/roll)**	**CO_2 (kg/roll)**	**Total CO_2 (kg)**	**Aluminium Foil Cost (IDR/kg)**	**E_i (IDR)**
	(a)	**(b)**	**(c)=(b)x24,45 kg CO_2/kg**	**(d)=(a)x(c)**	**(e)**	**(f)=(a)x(b)x(e)**
Aluminium Foil	80	8	195.6	15,648	45,000	28,800,000
Cooling Process						
Type of Cooling System	**Energy (kWh/hour)**	**Working Hour (Hour)**	**CO_2 (kg/hour)**	**Total CO_2 (kg)**	**Cost (IDR/kWh)**	**E_i (IDR)**
	(a)	**(b)**	**(c)=(a)x 0,725 kg CO_2/kWh**	**(d)=(b)x(c)**	**(e)**	**(f)=(a)x(b)x(e)**
Refrigerator	0.12	768	0.087	66.8	1,325	122,112
Total of Build				**133,314.8**		**40,346,112**

duced are also higher. Total carbon emissions (C_f) obtained from supplier fulfill stage to the company, fulfill stage from company to distributor, and build stage (frying and packaging process) is 134,642.98 kg CO_2. The carbon emission value is then used to calculate carbon footprint (C_{fp}) using formula (3). The total production of jackfruit chips in CV XYZ per year is 7.995 tons, so that the C_{fp} value obtained is 16.84 CO_2/kg.

Carbon Emissions and Economic Impact

The economic impact analysis was carried out to determine the position of emissions and unit costs, as shown in Figure 2. The unit cost value obtained is 0.32 €/unit, resulting from converting the value of Rupiah (IDR) to Euro (€), 1 Euro worth 17,000 IDR. The results of the carbon emission values and unit costs show that the level of the economic impact of CV XYZ is in an intolerable region position. This is because CV XYZ produces high carbon emissions even though the unit cost value is low. If supply chain activities produce high emission values and costs, these activities cannot be accepted in the global impact matrix (Zhao et al., 2012).

C_f value that has the most impact on the environment lies in the frying process at the build stage. The frying process that utilizes firewood results in higher total carbon emissions compared to the fulfill stage. Firewood has the highest emission factor compared to LPG and kerosene (Nugrahayu, Nurjannah, & Hakim, 2017). Because of this, its impact on the environment is also relatively high, with a build stage carbon emissions total value of 133,314.8 kg. The best way to reduce carbon emissions during the build phase is to switch from firewood to LPG as the frying fuel. The use of LPG can reduce the amount of CO2 by up to 40%.

The highest total cost is also found at the build stage. Packaging contributes the highest cost at the build stage. Any reduction in unit costs will not change the position of CV XYZ in the global impact matrix as long as CV XYZ has not been able to reduce the level of carbon emissions in its supply chain activities. Therefore, CV XYZ is expected to focus more on reducing carbon emission levels by implementing the recommended solution, namely replacing fuel for frying from firewood to LPG.

CONCLUSIONS

The build stage was the value chain stage that impacts the environment the most with a total carbon emission value of 133,314.8 kg. In the build stage, firewood's frying process created the most carbon emissions value of 117,600 kg of CO_2. The economic impact level value reveals that the carbon footprint was 16.84 kg CO_2/kg with a unit cost of 0.32 €/kg. This implies that CV XYZ's value chain operations were still not environmentally friendly. The recommendation strategy for decreasing the economic impact level of CV XYZ's value chain to an acceptable level were switching the use of firewood to LPG which cut carbon emissions from CV XYZ by up to 40%. It is suggested that future research should consider all activities that generate carbon emissions. Limiting the study on carbon footprint and unit costs should also be considered to quantify the level of economic impact more accurately.

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