Green Supply Chain Operations Reference (G-SCOR): An Application for Small Garment Manufacturers in the Philippines

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Abstract

The current design of supply chain (SC) for small garment manufacturing companies in the Philippines has not incorporated green practices to address environmental issues. In the adverse environmental effect of industries worldwide, green supply chain management (GSCM) has appealed to companies to reduce the occurrence of such issues. This study evaluated the current SC design and operations of small garment manufacturing companies with respect to their environmental practices. Using the green supply chain operations reference (G-SCOR) model, data from the subject companies were evaluated based on fifteen (15) indicators of the six (6) attributes which include reliability, responsiveness, agility, cost, asset management efficiency, and green practices. Results revealed that the small garment companies have excellent performance in terms of perfect order fulfillment (POF) and working capital turnover (WCT) while good performances were observed in total SC management cost (TSCM), cost of goods sold (COGS), awareness management, and waste management. In contrast, poor performances were evident in upside supply chain adaptability (USCA), downside supply chain adaptability (DSCA), fixed asset turnover (FAT) ratio, implementation of green procurement, recycled materials, and carbon dioxide (CO_2) gas emission. A multiple regression analysis model was also created to determine the significant factors contributing to GSCM. Results revealed that among the indicators, CO_2 emission, waste management, and COGS significantly influence the GSCM. To improve the companies' G-SCOR performance, it is recommended that appropriate environmental practices such as green procurement, recycling, waste management, and reverse logistics should be implemented. Proper information dissemination campaigns should also be done in the companies so that the employees may be educated and be involved in the GSCM practices.

Keywords
Small garment manufacturing companies, supply chain, Green Supply Chain Management (GSCM), Green Supply Chain Operations Reference (G-SCOR)

1. Introduction

Supply chain (SC) management is the active management of supply chain activities starting from the product to the logistics (Handfield, 2020). It requires integration and synchronization of inter-organizational practices and strategy alignment across all companies in the SC for the intention of satisfying the final customer (Green et al. 2012). It also focused on sustainability involving the triple bottom line (TBL) principle: environmental, economical, and social dimensions (Roy, 2015). Of the three (3) principles, green supply chain management (GSCM) focused on the environmental and economic performance of a supply chain (Garguri, 2015). Emphasizing the 'green', GSCM is a sustainable way to improve efficiency which also refers to cost-cutting method. It is a practice that would minimize or remove wastes along the supply chain. With the adverse environmental effect of industries worldwide, GSCM had appealed to companies to reduce the occurrence of such issues. In developing economies like Bangladesh, GSCM had not been widely embraced in the textile industry (Tumpa et al., 2019), which is comparable to the case of the Philippines. The link between GSCM practices and better financial performance has been evident in various studies. Al-Sheyadi et al. (2019) have also established that complementarity can happen when the value of one resource rises in the existence of other related resources and when the total value, from the combination of two or more factors in a production system, surpasses the value that would be produced with the use of these factors independently. One of the tools that may be used to evaluate SC performances is the supply chain operations reference (SCOR) model. This model has aided small and medium-sized enterprises (SMEs) to select the appropriate strategy under various market scenarios and build more efficient supply chain management decisions (Alomar and Pasek, 2014; Rabelo, 2007; Okongwu, 2016).

A significant increase in the attention is given to the fashion industry due to its contribution to global environmental and social issues (Kozlowski et al., 2012). The fashion industry emits more carbon than international flights and maritime shipping combined (McFall-Johnsen, 2019). Furthermore, this industry has produced 20% of global wastewater, where textile dyeing was the second-largest water pollution contributor (United Nations Environment Programme, 2018). Fast fashion was the reason why this industry had been one of the largest across the world (The University of Queensland, 2018). People bought 60% more garments in 2014 compared to 2000 (McFall-Johnsen 2019). This is an alarming trend because "if nothing changes, by 2050 the fashion industry will use up a quarter of the world's carbon budget" (United Nations Environment Programme 2018). Previous researchers have studied and used the green SCOR (G-SCOR) model to model the supply chain of textile and garment (Jolly-Desodt et al., 2006) and invented monitoring reverse logistic system for the leather tanning industry (Kuswandi, 2018) but they have not incorporated green solutions to their objectives.

This study is focused on small garment manufacturing companies in the Philippines. Small enterprises have an asset size of three (3) million to fifteen (15) million pesos and an employment size of ten (10) to ninety-nine (99) employees (Senate of the Philippines, 2012). The startling statistics on the impact of the fashion industry on the environment inspired the study to assess the current green SC management practices in small garment manufacturing companies using the G-SCOR model.

2. Literature Review

Integrating SCOR in addressing green issues of different industries such as information technology, wood, construction, automotive, waste disposal and recycling, electronics, and green label products has been studied by various researchers (Erek et al. 2009; Schnetzler et al. 2009; Hwang et al., 2010; Erek, 2011; Yongan and Menghan, 2011; Koul and Dasari, 2013; Tippayawong et al., 2015; Wibowo et al., 2017; Liu et al., 2018; Chao et al., 2019). Few had accomplished the use of the SCOR model in establishing the link between environmentally conscious business practices and SC performance (Ntabe, 2015). A study conducted by Liu et al. (2018) established a green SC performance evaluation based on a Balanced Scorecard and SCOR model for construction projects. With a similar target field of study supporting sustainable construction, Wibowo et al. (2017) created a SCM strategy for recycled materials by exploring the SC performance of materials. In the field of automotive, resolving existing conflicts within its GSCM was achievable (Yongan and Menghan, 2011). The same initiatives were mentioned in the article of Koul and Dasari (2013). However, they applied the strategic SCOR framework for GSCM in the Indian automobile industry. In terms of handling waste disposal and recycling, the objective of Chao et al. (2019) was to target zero pollution by proposing an innovation for waste treatment.

3. Methodology

3.1 The Green Supply Chain SCOR Model

APICS (2017) considered nine (9) factors in standardizing the measurement of an SC performance using the SCOR model. These factors were grouped into five (5) performance attributes namely reliability, responsiveness, agility, cost, and asset management efficiency. The reliability attribute is considered under the perfect order fulfillment (POF) which refers to the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage, shown in Equation 1. Responsiveness is measured under order fulfillment cycle time (OFCT). It is the average actual cycle time consistently achieved to fulfill customer orders, as shown in Equation 2. Upside supply chain adaptability (USCA) and downside supply chain adaptability (DSCA) are under the agility attribute. USCA is the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days (see Equation 3) while DSCA is the sustainable percentage decrease of a quantity within 30 days without acquiring extra inventory (see Equation 4). Total SC management cost (TSCM) consisted of all expenses associated with the SCOR level 2 processes, such as in Equation 5 while cost of goods sold (COGS) pertains to the cost associated with buying raw materials and producing the finished goods. Additionally, a company's ability to efficiently maximize assets were reviewed under the cash to cash cycle time (CCC), fixed asset turnover ratio (FAT), and working capital turnover

(WCT). CCC is the time it takes for an investment made to flow back into a company after it has been spent on raw materials, shown in Equation 6 while the FAT ratio shown in Equation 7 measures a company's return on its investment in property, plant, and equipment by comparing net sales with fixed assets. WCT is a ratio that measures how efficiently a company is using its working capital to support a given level of sale (see Equation 8).

$$POF = \frac{Total\ Perfect\ Orders}{Total\ number\ of\ Orders} * 100\% \tag{1}$$

$$OFCT = Source\ Time + Production\ Time + Delivery\ Time \tag{2}$$

$$USCA = \frac{Additional\ no.of\ products\ produced}{Total\ production\ capacity} * 100\% \tag{3}$$

$$DSCA = \frac{(Previous\ total\ production - Present\ total\ production)}{Previous\ total\ production} * 100\% \tag{4}$$

$$TSCM = Cost\ to\ plan + Cost\ to\ source + Cost\ to\ make + Cost\ to\ deliver + Cost\ to\ return \tag{5}$$

$$CCC = Inventory\ days\ of\ supply + Days\ sales\ outstanding + Days\ payable\ outstanding \tag{6}$$

$$FAT = \frac{Net\ Sales}{Fixed\ Assets - Accumulated\ Depreciation} * 100\% \tag{7}$$

$$WCT = \frac{Net\ Annual\ Sales}{Average\ working\ Capital} * 100\% \tag{8}$$

Since the focus of this study was designing a green SC system, an additional attribute of green practices consisting of six (6) indicators were incorporated. Factors such as the implementation of green procurement, environmental awareness management, recycling of materials, and waste management were proven to be drivers of GSCM in the automotive industry (Jindal et al., 2013; Yongan and Menghan, 2011). Yongan and Meghan (2011) mentioned that core executives have a significant role in environmental awareness management and purchasing of raw materials from qualified suppliers, which are both essential in increasing the development of more environment-friendly products. Recycling, which can be computed using Equation 9, was also one of the bases in developing a green building performance evaluation index system for the construction industry (Liu et al., 2018) and was a strategy adopted to support sustainable construction (Wibowo et al., 2017). Previous studies have also included reverse logistics in assessing GSCM in Thai electronic firms (Tippayawong, 2015) and a Taiwanese waste disposal and recycling company (Chao et al., 2019). This can be computed using Equation 10. Furthermore, greenhouse gas emission was considered a driver for sustainable SC (Jindal et al., 2013) and this can be computed using electricity consumption and frequency of vehicles shown in Equations 11 and 12 (United States Environmental Protection Agency, 2018).

$$RM = \frac{Total\ recycled\ input\ materials\ used}{Total\ input\ materials\ used} * 100\% \tag{9}$$

$$RL = \frac{Total\ number\ of\ product\ altered\ and\ resold}{Total\ input\ materi} * 100\% \tag{10}$$

$$CO_2\ (electricity) = total\ electricity\ consumed\ (kWh) * 0.000707\ \frac{metric\ tons\ CO_2}{kWh} \tag{11}$$

$$CO_2\ (vehicle) = Frequency\ of\ vehicle\ use * 0.01268493\ \frac{metric\ tons\ CO_2}{vehicle} \tag{12}$$

To rate the GSCM performance of the small garment companies, a rubric for assessment was also constructed using a 5-point Likert scale, with 5 being the highest. The percentage and categories of each scale were adopted from Wibowo et al. (2017). The assigned percentages and categories used were as follows: 5 - Excellent (> 90%), 4 - Good (81% - 90%), 3 - Average (71% - 80%), 2 - Poor (61% - 70%), and 1 - Execrable (≤ 60%). Moreover, the assigned percentages for the CO_2 emission were rated based on the Paris Agreement which introduced the energy and climate policy including the so-called 20/20/20 targets (United Nations Climate Change, 2020). For factors that cannot be evaluated quantitatively, qualitative descriptions were provided. These factors included OFCT, TSCM, COGS, CCC time, COGS, FAT ratio, implementation of green procurement, and environmental awareness management. Similarly, to rate how good the waste management practices of the companies are, four (4) provisions were considered which include (a) the business should measure and keep track of their business waste, (b) they should also observe proper segregation of waste inside the company, (c) the management should implement practices that reduce waste produced and they should reuse and recycle any reusable or recyclable waste they incur, and (d) the disposal of non-recyclable or reusable waste should be following the law (Queensland Government, 2019).

3.2 Statistical Analysis

A multiple regression analysis model was also created using Minitab software to determine the significant factors contributing to GSCM. The dependent variable considered was the annual sales of the companies while the independent variables were the indicators of the G-SCOR model. A confidence level of 95% was used in performing the two-way analysis of variances (ANOVA) to determine the effects of the green SCOR factors on sales. The data were examined, and it passed the six (6) assumptions required for a two-way ANOVA to yield accurate results. The assumptions are as follows: (a) dependent factor is a continuous variable, (b) independent variables should consist of more than two groups, (c) independence of observations is present, (d) absence of outliers, (e) dependent variables should be approximately normally distributed, and (6) equality of variances is needed for each combination of the groups of the independent variables (Lærd Statistics, 2018).

3.3 Data Collection

Relevant data to evaluate the G-SCOR indicators were collected and reviewed from three (3) small garment manufacturing companies in the Philippines. These data included the 2019 reports on procurement, production, demand, inventory, deliveries, electricity expenses, defective items, fabric scraps, SC costs and financial statements, and 2018 reports on electricity bills and delivery. Additionally, interviews were performed to acquire supplementary information regarding the company's operations and green supply chain practices. The interviewees include the supervisors, pattern makers, seamstresses, cutters, painters, packers, deliverers, agents, and other employees involved in the SC.

4. Results and Discussion

4.1 The Supply Chain of Garments

The supply chain of garments, shown in Figure 1, includes the major players which are the suppliers of textile and thread, fabric printing and hangtags, garment manufacturer, garment subcontractor, third party distributors, and customers. Textile and thread manufacturers often use natural fibers such as cotton, silk, and linen bought from animal and plant cultivators (A&E, n.d.) while others use synthetic fibers like polyester and nylon derived from plastic companies (Resnick, 2019). Plastics exist because of the extraction of oil or natural gas by chemical companies (McKay, 2019). Garment businesses also purchase product labels from hangtag manufacturers. These tags and labels are commonly made of paper. For the designs of the garments, the companies at times hire fabric printing establishments that use different methods like block, roller, screen, and heat transfer printing (Abrahart and Whewell, 2019). In practice, enterprises in this industry increase production during peak months by subcontracting. Trimmed and packed items are then sold to retailers who bought in bulk and handed over to third-party sales and marketing agents to advertise to different department stores and malls, or directly to customers of the product.

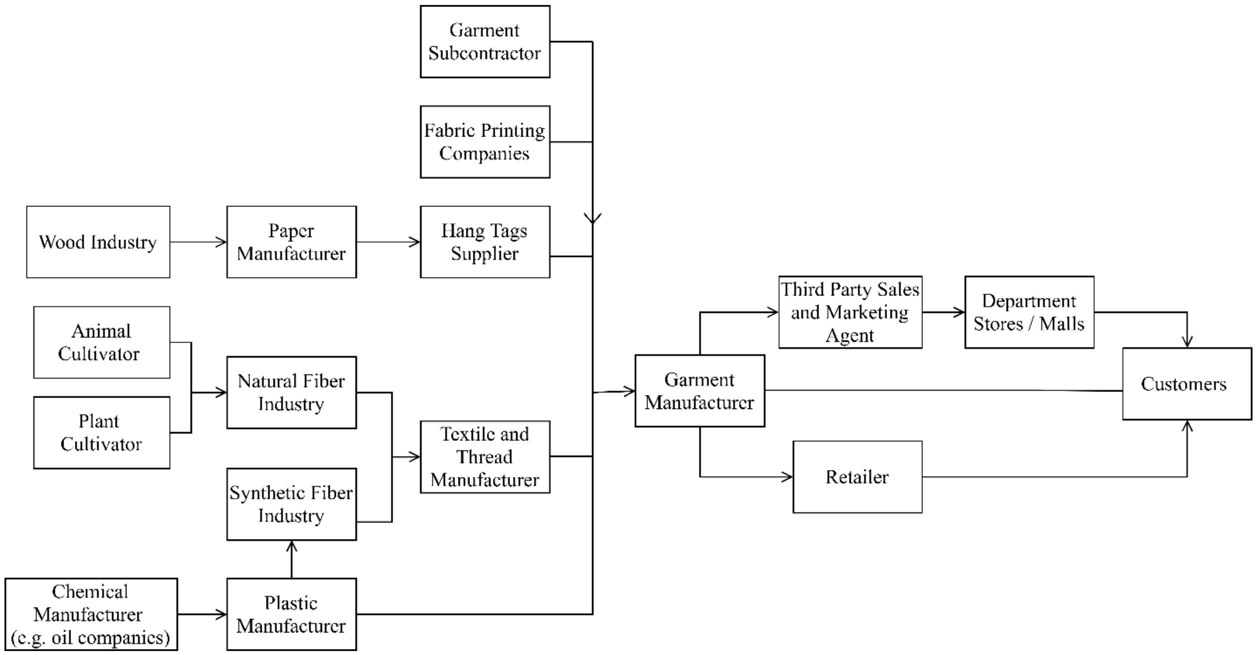

Figure 1. Supply Chain of Garments

4.2 G-SCOR Assessment Results

The summary of results of the G-SCOR assessment for the small garments companies is presented in Table 1. POF has resulted in an excellent rating with 99.43% of the orders were successfully delivered and fulfilled. Organizations having a high POF signifies a positive effect on their SCM performance (Mishra and Sharma, 2014). Having fast order fulfillment transactions, minimal damaged products, and accurately delivered items contribute to a successful POF which creates better efficiency (Dwyer, 2008) and strengthens customer satisfaction (Hasita, 2020). Results revealed an OFCT of 11.05 days, equivalent to a rating of three (3). Months with high demand caused OFCT to increase resulting in a longer waiting time for clients. Poor inventory management was the reason why it took longer to complete the orders during peak seasons since the owners have been applying estimation in buying raw materials and determining the number of products to produce without using any software in aiding their inventory system. Failure to plan and keep track of stocks causes inefficiency in inventory management (Joseph, n.d.).

Table 1. G-SCOR Assessment Results

Attribute	Factor	Average Value	Average green SCOR Rating
1. Reliability	POF	99.43%	5
2. Responsiveness	OFCT (days)	11.05	3
3. Agility	USCA	51.75%	2
	DSCA	0.80%	1
4. Cost	TSCM Cost	₱3,063,815.42	4
	COGS	₱2,907,936.88	4
5. Asset Management Efficiency	CCC time (days)	18.98	3
	FAT ratio	2.41	2
	WCT	40.60%	5
6. Green Practices	Implementation of Green Procurement	qualitative	1
	Environmental Awareness Management	qualitative	4
	Recycled Materials	qualitative	1
	Waste Management	qualitative	4

Reverse Logistics	73.78%	3
CO_2 Gas Emission (metric tons CO_2)	1.44	1

Garment factories obtained a USCA of 51.75% which is considered poor. This implied that they should revisit their SC processes to help make sustainable changes to increase product quantity for them to achieve more deliverables in 30 days. Likewise, garment factories did unsatisfactory when their DSCA was measured. Having a rating of one (1) meant that the companies were not able to sustainably decrease the number of quantities in 30 days requiring no inventory, backorders, and cost penalties (Supply Chain Atlas, 2020). The average TSCM cost and COGS of the garment companies were ₱3,063,815.42 and ₱2,907,936.88, respectively. These results demonstrated that the companies were moderately spending on their SC expenses and production of garments. Furthermore, the increase in COGS (Adkins, 2020) could be due to increasing prices for raw materials or associated with a decrease in profits.

The companies have generated an average CCC time of 18.98 days. Having a moderately fast CCC time points out a slow conversion of inventory to cash (Brown, 2017). What contributed to this was their slow transaction in collecting receivables from clients. Furthermore, the companies had a FAT ratio of 2.41. Causes of a low FAT ratio include insufficiency in generating sales and investing in too many fixed assets (Carlson, 2018). An excellent WCT was attained with an average of 40.60%. Achieving this high percentage is a good indicator of effectively using the company's short-term assets and liabilities in increasing sales (Kenton, 2020).

In the analysis of the environmental awareness factor, garment companies did well. However, executives lack strict implementation of their green protocols and training was absent for promoting environmental practices. Additionally, as with waste management, most of the companies were consistent in following the 2nd and 4th provisions yet some often forget to recycle, measure, and keep track of their trash. Tracking and monitoring waste are essential in identifying recyclables, reducing liabilities, managing costs, and most importantly minimizing environmental impact (Waste Harmonics, 2020).

Garment companies did not perform well in implementing green procurement and recycling of materials. Companies have no intention of adopting this process, neglecting the long-term effect on the environment. The companies' goals were focused more on the availability, price, and quality of the raw materials. A green SC entails a holistic approach that covers engaging and educating direct suppliers on sustainable goals to further disseminate the knowledge (Supply Chain Game Changer, 2020). Additionally, instead of recycling, garment factories have been selling or donating their recyclables. Centralizing the recycling of materials can help companies generate more money (CleanRiver, 2020). As to the reverse logistics process, 73.78% of returns were successfully repaired and resold. The average rating implied that garment factories have not been fully utilizing the value of the returned products thus affecting the sustainability of the organization and their chances of lifting customer satisfaction (Tirelli, 2019).

Lastly, garment factories emitted 1.44 metric tons of CO_2 that was based on their use of vehicles and the consumption of electricity. This increased their emission up to 8.96% in 2019. This continuous escalation in producing greenhouse gases directly affects businesses by disrupting logistics and SC, reducing agricultural productivity, and causing damage to infrastructures. By decreasing the amount of carbon footprint, companies can get rid of energy costs, improve employee morale, and rebrand themselves as leaders of sustainable products (Wood, 2019).

4.3 Factors of Green Supply Chain

Both implementation of green procurement and recycled materials were considered factors of the study but were not included in the computation of the multiple regression analysis. This is because all companies have the same data showing no significant differences and contribution to the assessment. Results of the residual plots generated from Minitab software have shown that the data were normally distributed. The data points found in the normal probability plot also showed that it closely fell under the red line. A bell-shaped and symmetrical histogram also verified this assumption. Additionally, results revealed that 99.62% of the sales were explained by the independent variables. Having a high R^2 value conveyed that the model was a good fit for the data (Enders, 2020). In detecting multicollinearity, all significant independent variables generated a variance inflation factor (VIF) lower than 4 which proved no signs of correlations (The Pennsylvania State University, n.d.). This was a good indicator to prove that the results were reliable for statistical inferences (Kenton, 2020).

Table 2. Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	3.45419E+11	86354659783	1753.89	0.000
COGS	1	1.25193E+11	1.25193E+11	2542.72	0.000
CO_2	1	225779012	225779012	4.59	0.041
Waste Mngt.	2	5613976836	2806988418	57.01	0.000
Error	27	1329370988	49235963		
Total	31	3.47E+11			

The results in Table 2 indicated that CO_2 emission, waste management, and COGS, were considered contributors to sales because their p-values were less than 0.05. Gokmenoglu et al. (2018) confirmed the unidirectional relationship between financial development and carbon emission. Sadorsky et al. (2010) added that it is an agent that causes carbon emission to increase. Another research discovered that separate waste collection appeared to be highly connected and has a slight positive correlation with financial growth. (Batolacci et al., 2018). Likewise, sales revenue influences COGS because they are directly proportional to each other, observed in Equation 13 (Hayes, 2020).

$$Gross\ profit\ =\ sales\ -\ COGS \tag{13}$$

The use of the SCOR model has been proven to benefit companies in determining SC malpractices, aligning business functions, and most importantly increasing return on investment (ROI) up to two to six times (Supply Chain Resource Cooperative, 2004). The application of the SCOR model measures the overall performance of an organization by utilizing all the factors (Lemghari et al,. 2018). With this said, looking at the entire outcome of the model best portrays its performance rather than recognizing the individual influences of each factor.

4.4 The Green Supply Chain of Garments

As illustrated in Figure 2, the primary processes included in the green SC design were procurement or management, in-house production, subcontractors, logistics, and sales and marketing. The starting point of greening a SC system is the application of green procurement (He et al., 2013). The procurement department should check first if the supplier's products have been certified eco-friendly. Alvarenga et al. (2015) suggested that companies should have a standard operating procedure (SOP) regarding the approval of suppliers considering their information, environmental practices, and the components of their product. Orders are to be placed to those suppliers that have passed all the SOPs. After receiving the purchased items, the management should also organize the inventory, provide raw materials for production, and determine whether the hiring of subcontractors will be needed. Once materials are delivered, it must be checked by the management. Defective items are be returned or re-work if necessary while unrepairable garments are to be recorded and recycled afterwards. The same procedure for inspection should be followed by the in-house production team. Waste generated from manufacturing must be collected and segregated while fabric scraps and other recyclable items can be reused and remanufactured. The logistics must deliver the ordered items to the customer while stocks are to be transported to the warehouse or store. Customers who visit the store to return defective products should be required to present their official receipt (OR). The salesperson will be in-charged of inspecting the item and determining if the garment bought has exceeded the warranty period. Only garments that are within the warranty date should be accepted and replaced. For items that do not have stocks, a delivery schedule should be set. Lastly, all returned garments should be collected for alterations or recycling. This method involving returning a product to the manufacturer or forwarding it on for servicing, refurbishment, or recycling is called reverse logistics (Rouse, 2016).

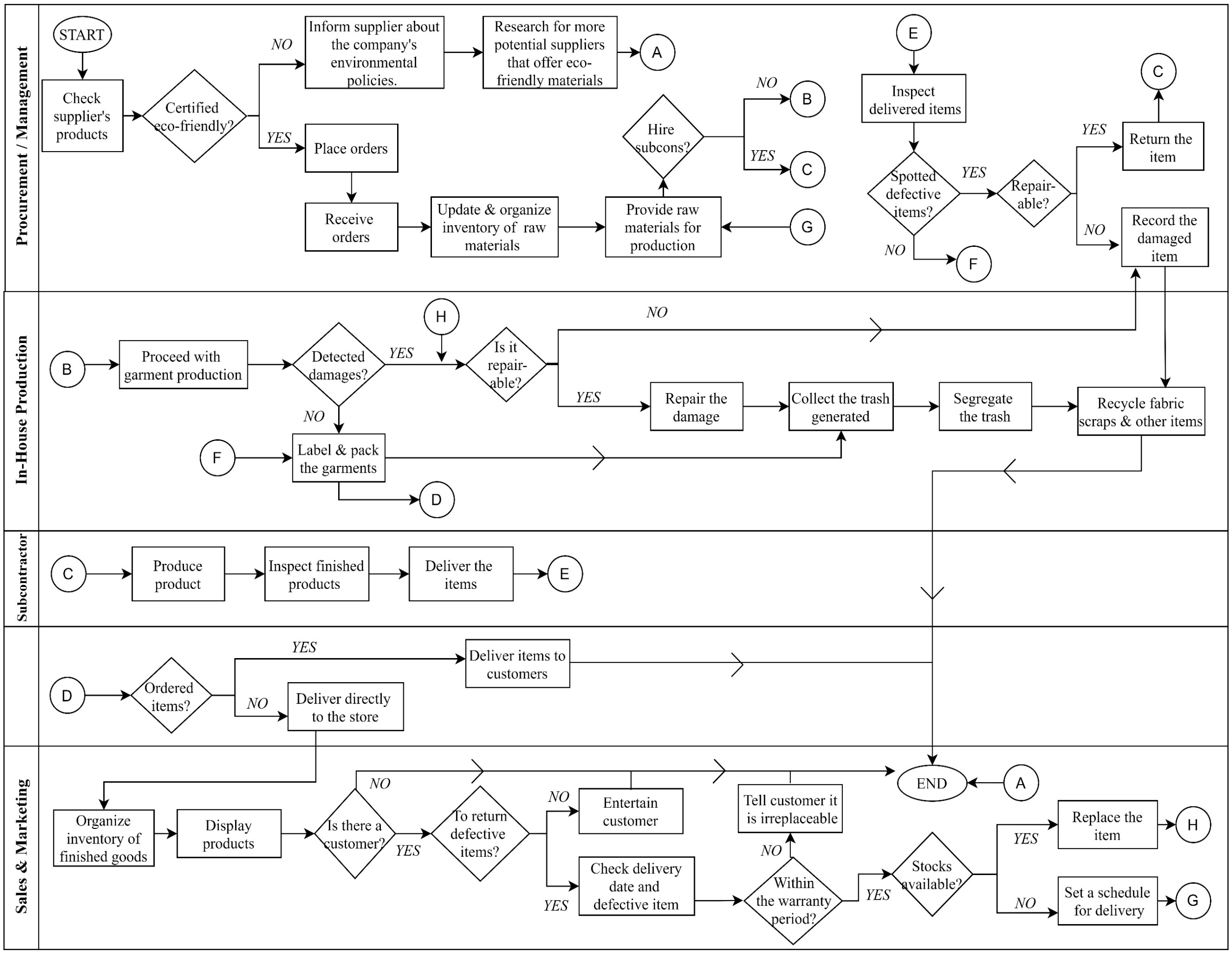

Figure 2. Green SC Design for the Manufacture of Garments

5. Conclusion

This study evaluated the green practices of small garment companies using the G-SCOR model. Data collected from these companies were analyzed using fifteen (15) G-SCOR indicators. Based on the results, the garment companies did not perform well on six (6) factors including DSCA, UPSCA, FAT ratio, implementing green procurement, recycled materials, and CO_2 emission. They attained low percentages of DSCA and USCA which meant they lacked flexibility in responding to monthly demand fluctuations due to poor inventory management. The companies also need to improve on their strategies in generating sales and utilizing fixed assets. Furthermore, the goals of the companies were not aligned with the green procurement practice rather they aimed more for good quality textiles for a cheaper price. The benefits of recycling were also overlooked. Companies prefer more on selling and donating recyclables rather than reusing and remanufacturing it. Lastly, the continuous escalation of CO_2 emission of garment manufacturers has drawn attention. Frequent use of vehicles and the increase in electricity consumption were seen to be contributors. A GSCM system was also designed to address the environmental issues identified in a garment company. The primary processes considered in the SC were procurement or management, in-house production, subcontractors, logistics, and sales and marketing. The design highlighted green practices namely recycling, waste management, reverse logistic process, and green procurement. Recycling and waste management go hand in hand to minimize waste. Recycling of fabric scraps and other materials is suggested to generate additional income. Moreover, green procurement is relevant to promote collaboration between suppliers and purchasers. Implementing a standard operating procedure (SOPs) to verify green raw materials is recommended. In this way, more will be encouraged to produce eco-friendlier products and realize the relevance of applying environmental standards. Lastly, reverse logistics was proposed to efficiently remanufacture, recycle, and resell damaged products. Altogether, this new green SC design requires the management to educate its employees and make them understand its operation. The leadership of the core management and type of communication within the enterprise have crucial roles and impact on the entire achievement of the green SC. Future researchers may explore other green factors not included in the scope of this study. Aside from G-SCOR, other models can also be used in analyzing malpractices of a company and develop appropriate green SC designs. Since the focus was more on garment factories, other industries may be considered to help promote environmental sustainability and development. Future studies on investigating how to improve the green SC of medium and large-scale enterprises may also be conducted since these enterprises have higher production volume and more advanced technology is used which contributes to higher carbon dioxide emission.

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