**Carbon emissions in the food and beverage sector: A multiple case-study approach.**

**Abstract**

The aim of this study is to identify the critical drivers and approaches of green supply chain management adoption in small and medium businesses in the food and beverage sector. More specifically, the research incorporates a multiple case study approach by investigating four organizations located in Kosovo that produce and distribute bottled water in the local and other European markets. The Supply Chain Environmental Analysis Tool (SCEnAT) has been used to assess the carbon emissions caused by the activities within the supply chains of these companies. Once the “hotspots” of these supply chains were identified, the authors propose and assess potential interventions that would lower the overall emissions. It also was necessary that insights from companies should be gathered in the form of case studies with interviews and surveys conducted with managers.

**Track 15 Operations and Supply Chain Management**

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# 1. Introduction

Organizations have started to recognize that the issue of the sustainability in operations must be addressed. There is a definition for sustainability that states, organizations must meet the needs of the present state however without compromising the ability of future generations to meet their own needs (WCED, 1987). This definition is surrounded by vagueness and ambiguity, which is why when attempted to apply the sustainability principle in practice complications frequently arise. The interpretation of the sustainability term ranges from the term of multi-dimensional to inter-generational philosophical position for business management. In the early initiatives the focus of sustainability was around the environmental issues however as time passes by another approach to sustainability is increasingly being adopted, which is the triple bottom line or environment, social and economic issues. The degree of complexity expected is much higher since this approach involves the interaction of more. When it comes to the business context the application of sustainability and its importance have stumbled ongoing debates.

The definition of the sustainability in the business context varies in a number of ways with one being “the creation of resilient organizations through integrated economic, social and environmental systems” (Bansal, 2010). In other words, the resilience of organizations in a time period, connected tightly to the healthy social, environmental and economic systems, and has the ability to better respond to external and internal shocks. Due to this, the life cycle implications of the decisions organizations make are significantly being considered. Thus there is an increased prominence in the supply chain management.

The aim of the study is toidentify the critical drivers and approaches of green supply chain management adoption in small and medium businesses of food and beverages sector in Kosovo, for achieving improved overall performance. However until now there has not been any observation or analysis regarding the implementation of GSCM in Kosovo SME’s which shows that there is an academic and practical gap in the market when it comes to adoption of green practices in organizations, what drives them to adopt such practices, what are the implications or even successful cases of green organizations in Kosovo.

**2. Literature Review**

**2.1 Green Supply Chain Management**

Corporations are being pressured to increase their awareness about the environmental protection due to the overwhelming green trend of preserving the resources of the earth and the environment worldwide (Chien and Shih, 2007). Changes in the environment and climate have made people even more concerned today as never before (Intergovernmental Panel on Climate Change, 2007). The responsibility of organizations role in society has increased, especially in the context of business and management (McWilliams and Siegel, 2000; Strandberg, 2002) due to their ability to minimize the impact on the environment (Walker et al., 2008). Manufacturers need to incorporate the concerns about environment into their strategic agenda and their regular practices. These concerns come from increasing community pressure, customers, along with the government imposing stricter regulations as pointed out by Zhu et al. (2008a).

Industries seeking to improve their environmental performance have gained the attention on one particular innovative philosophy; that of green supply chain management (GSCM) (Rao, 2007; Srivastava, 2007). GSCM is considered an important philosophy in organizations, because it plays a critical role in minimizing waste, achieving profit and market share objectives through saving costs, facilitating the environmental performance by promoting synergies and efficiency between alliances, reducing the impact and risk of environment while improving the partner and organization ecological efficiency (Carvalho et al., 2010; Rao and Holt, 2005; Van Hoek and Erasmus, 2000).

GSCM implementation in an organization, if effective, it has a crucial role in the development and management of competitive advantage (Zhu and Sarkis, 2004). The concept of supply chain management evolves with a customer centric vision of organizations that initiates changes through the organization’s external and internal linkages, which later on captures the inter-functional and inter- organizational synergy of collaboration and integration as defined by Min and Zhou (2002).

Seeing the increasing interest in environmental issues the past decade it is implied that the environmental pollution issue along with the industrial development must be addressed as a whole with supply chain management, thus contributing to the philosophy of green supply chain management (Sheu et al., 2005). When considering small and medium enterprises it is important to emphasize that they play a crucial role in the growth of the economy of a country by contributing to the industrial output, exports to international markets and creation of new jobs or sustaining of existing jobs. Seeing this significant impact on the economy, it is worth mentioning that SME’s do impact the environment at an extent. When considered as a unit, individually, SME’s impact on the environment may be limited, however when looking collectively the environmental impact is significantly higher (Chiu et al., 1999). In addition, Chiu et al. (1999) mentions that SME’s tend to ignore the environmental regulations.

When considering innovation, Sarkis et al. (2011) emphasize that green supply chain management is in line with environmental innovation where manufacturers implement GSCM through hard and soft technological innovations such as increased collaboration of suppliers in eco-design and cleaner equipment for production.

**2.2 Drivers and Benefits of GSCM Adoption**

When considering the green supply chain nature it is important to consider what drives organizations to implement such a philosophy; what is worth looking at are the management practices and the relationships between them, as emphasized by Holt and Ghobadian (2009) in the examination of green supply chains in the manufacturing sector in UK.

Hu and Hsu (2010) identified twenty critical factors for implementing green supply chain management along four dimensions when exploring the GSCM practices in electronic industry relative to the EU directives about environment. Such dimensions are supplier management, the life cycle management, organization involvement and recycling of products. When looking at a chip manufacturer, Townbridge (2001) categorized internal and external factors that drive the implementation of GSCM. Willingness to improve the risk management for potential interruptions in supply chain, willingness to collaborate with suppliers in the quest for finding equipment and materials that have a minimal impact on the environment was the main internal driver for implementing GSCM. While as for the external factors the author identified several stakeholders such as non-governmental organizations, customers and investors.

As for the stakeholders, Reinhardt (1998) emphasized that since the environment is a public good then the quality of environment can be preserved only through regulations that governments impose. People and organizations in particular have as a common goal the maximization of profits; spending on environmental issues is thought not as an investment that would benefit themselves as individuals. Thus green practices shall be required by law and not left as a matter of choice.

When considering the strategies for environment, Lee and Rhee (2007) developed four types which are proactive, reactive, focused and opportunistic. Proactive strategies take into consideration the latest environmental practices, whereas reactive strategies focus on low-level environmental responsiveness. Focused strategies take into consideration only the highest levels of environmental management while opportunistic tackle the medium level.

Measuring the environmental performance of organizations is critical for the implementation of GSCM and a variety of factors have been incorporated for that matter. Hervani et al. (2005) presented 40 key performance indicators ranging from recycling to energy renewal to air emissions, while Walker et al. (2008) went into depth to analyze and review existing literature investigating several factors that assist organizations in implementing initiatives of green supply chain management; factors obstructing such initiatives were also examined. The main internal driver was the organizational factor while the external drivers were customers, regulations, suppliers, competitors and the society. In addition, respondents in seven different public and private sector organizations identified cost and lack of legality as the main internal barriers; regulations and lack of commitment from suppliers as well as several industry-specific issues were identified as external barriers for implementing GSCM (Walker et al., 2008).

The collaborative paradigm presented by Chen and Paulraj (2004) and Lee et al. (2000) was expanded by Vachon and Klassen (2006). By looking beyond the core operations in a supply chain two dimensions came from this expansion, which are the collaboration and monitoring of the green practices. Pun et al (2002) found that several critical factors and processes affect the Environmental Management System (EMS) planning. A five stage framework for EMS planning was proposed starting from formulation of strategy to the implementation and evaluation of the system.

When considering the initiatives of green supply chain Holt et al. (2001) presented seven categories for improving the environmental performance of organizations. Such categories were governments, partnerships, companies, organizations that support businesses, not for profit NGO’s that support green organizations, trade associations and green business clubs. The green supply practices when analyzed in relationship with capabilities of supply management several drivers are identified according to Bowen et al. (2001b). Such internal drivers as corporate environmental pro-activity, supply management capabilities, strategic purchasing and supply are critical for implementing green supply policies. Bowen et al. (2001a) emphasized that two types of green supply strategies are found in the implementation patterns of green supply chain, these of product based and advanced green supply.

Interpretive Structural Modeling (ISM) is a framework, which was used by Ravi and Shankar (2005) to identify and analyze the barriers in activities of reverse logistics. By using ISM along with Analytic Hierarchy Process (AHP) model Kannan et al. (2008) was able to select and analyze suppliers based on their environmental performance. When considering the practices of environmentally friendly businesses Lin et al. (2001) distinguished three dimensions, the strategic and decision making procedures which fit in the analytical dimension, motivation and culture issues that fit in the behavioral dimension, and the organizational dimension which tackles the issues of supply chain environment and regulations.

In a research conducted by Zhu et al. (2008b) it was found that the practices of green supply chain management do not adopt uniformly across the industrial contexts based on four Chinese industries. A multi objective programming model proposed by Sheu et al (2005) has the ability to optimize the used product reverse logistics and the forward logistics in a green supply chain. This proposed model according to a case study presented by the author, resulted in aggregate net profits improvement by 21%, while Sarkis (2003) presented a framework for strategic decision making of evaluating alternatives in the green supply chain, using an analytical network process.

Integrated green supply chains, which create competitive advantage and superior economic and operational performance, are created by greening of different phases of the supply chain, according to Rao and Holt (2005). Lee (2008) identified what pushes organizations to adopt GSCM practices, these being the influence of buyers, involvement of government, and readiness of the green supply chain; while Wee and Quazi (2005) in their research of environmental management identified seven critical factors for implementing GSCM practices, such as management of suppliers, green design process of products, the whole commitment and involvement of employees, measurement, training and information management.

The benefits that organizations receive from green supply chain management are numerous, ranging from reduction in costs, as mentioned before, to participative decision-making integration of suppliers that foster environmental innovation (Rao, 2002; Bowen et al., 2002). Despite its difficulties, implementing GSCM can lead to cost reductions in materials purchases and energy consumption as stated by Zhu and Sarkis, (2004). Additionally, the greening of products or services has a significant positive impact on financial performance of organizations such as growth in market share, increases in profit margins and reductions in cost structure. When considering SME’s Duber-Smith (2005) added that adopting green supply chain practices derives benefits of competitive advantage and differentiation of products, increasing efficiency and reduction of costs, sustainability of resources, better target marketing, return on investment, ethical imperatives and boost in employee morale, while leaving pressure in competitive supply chain, conformance to regulations and reduction of risks as negative drivers for adopting GSCM.

Hussey and Eagan (2007) emphasize that large organizations as opposed to smaller ones are more likely to adopt GSCM or any environmental pollution prevention opportunities. Small organizations according to Epstein and Roy (2000) do not recognize benefits of cost reduction, efficiency and profit growth that come from environmental enhancements. These organizations cannot get their suppliers involved in such green initiatives mainly due to the costs incurred in additional resources to adjust to the environmental performance for suppliers (Arimura et al., 2011). However as the importance of environmental performance increases, these small businesses must adopt GSCM to sustain themselves in the market (Mathiyazhagana, 2013).

**3. Methodology**

The methodology in this study utilizes the Ecoinvent database in conjunction with SCEnAT (**S**upply **C**hain **En**vironmental **A**nalysis **T**ool), concerning total emissions of greenhouse gas to undertake a hybrid LCA assessment for producing 1t (tonne) of tap water at four local tap water companies.

**3.1 Research objectives**

The objectives of this research are to:

* identify the critical drivers and approaches of green supply chain management adoption in small and medium businesses of food and beverages sector in Kosovo.
* perform a carbon assessment of the life cycle of tap water production and identify the “hotspots” in each case study.
* identify and suggest interventions that would allow the companies to reduce production carbon emissions and other costs overall.
* investigate whether interventions to lower the carbon emissions are common across the sector.

**3.2 Data requirements and collection of data**

Sources of data:

* Information from company documents such as process maps and reports of environmental issues as additional data.
* Observations done in the four companies regarding the activities, processes and existing environmental policies implementation through site visits to the factories.
* Interviews with executive members of the companies discussing environmental practices and processes to ensure a deeper understanding is gained.

The plant manager and the production manager of each company were interviewed, providing a total of eight interviews. The carbon analysis of the tap water supply chain was conducted based on the data obtained from the sources mentioned above, along with secondary data from Ecoinvent, an inventory database of lifecycle emissions. Interventions made possible to reduce emissions of carbon were identified from this analysis, while incorporating observations and interviews provided additional information.

The following primary information was required from companies to perform a hybrid LCA analysis:

* Raw materials used to make 1 tonne of tap water (quantities and unit prices).
* Consumables used in the process of producing 1 tonne of tap water (chemical quantities and unit prices).
* Utilities used to make 1 tonne of tap water (electricity forms, gas, diesel, water quantities and unit prices).
* Packaging used to make 1 tone of tap water (quantities and unit prices).
* Waste generated from production of 1 tonne of tap water (quantities).
* Suppliers, which provide with raw materials and consumables spent in the production of 1 tonne of tap water (locations).

All calculations were performed by SCEnAT software, producing the final emissions report for each company participating in the study.

**4. Findings and Discussion**

**Input name Ca**

**4.1 Case studies**

**Case 1. Company BO**

The headquarters and the factory of BO locate at Lipjan, Kosovo. Established in 2000 this site employs more than 50 employees who work in three shifts, has a capacity of 8000 bottles per hour with the new investments being made on new technologies that have allowed increases in capacity and elimination of waste.

**Environmental management of BO**

BO’s stakeholders have been exercising pressure on the company in recent years to introduce energy and environmental management strategies. The head office has been drafting preliminary documents about the firm policies in regard to goals, objectives, and strategies; however these policies currently are not so widely enforced. A team of 5 employees has been sent to training to be certified as health, environment and safety managers, which allow the company to tackle the environmental issues more professionally. The company wants to adopt an integrated environmental management system mainly because of two reasons: a) the mandatory obligations enforced upon the company by the Carbon Reduction Commitment (CRC) when exporting to EU states, and b) to strengthen the reports and activities of corporate social responsibility for improving the brand name.

**Case 2. Company SI**

The headquarters of the company in Kosovo are in Vrella, Kosovo where its factory also resides. Established in 2011 the company employs more than 100 people and works in two shifts. The production capacity of the company is around 8,000 bottles per hour however it varies according to the type of the product. The technological expertise and innovative production equipment has made the production line of SI worldwide renowned for its low cost and high quality production.

**Environmental management of SI**

Unique taste and high quality are the main focus for SI products. As a global brand SI adapts to the particular circumstances and characteristics of each country - all products are naturally produced in accordance with local laws and food hygiene regulations. The ingredients contained in the beverages are produced exclusively in Germany and distributed to licensees around the world, so that the SI products stand for German quality worldwide. Other components, especially the water contained in SI beverages are sourced regionally with specific ingredients that meet strict quality criteria. This ensures maximum freshness and the consistently high quality of the products. Due to the internationalization of the brand, along with the quality standards the company has to follow environmental regulations set by the center company in Germany. The environmental management has not been the focus of the company since its start in Kosovo, mainly due to the negligence of the government to impose strict rules on the carbon emissions however compared to other companies in Kosovo, SI stands much better in waste elimination and environment protection since it outsources all its waste to recycling companies.

**Case 3. Company UR**

The water plant of the company is located in Rugove, Kosovo. Established in 2006, the company employs more than 30 employees working on three shifts with a production capacity of 8000 bottles per hour. The company is licensed with ISO certificate 22000 and 22005 for food standardization.

**Environmental management of UR**

The company has not undertaken any environmental management activities since its creation. This is mainly due to the low environmental impact that the company has for its business processes. Its supply chain in its initial years when the company was a business unit of another company, was formed and shaped in that way that the environmental impact is minimal, while requiring from its suppliers environmentally friendly supplies and strong cooperation with its distributors to minimize the transportation, thus minimizing the carbon emissions. However much is needed to achieve international standards, especially since the company has introduced new products and is trying to expand into other markets. The main environmental activity that the company considers as environmental management is the sourcing of wastes to local recyclers. UR is the main partner of a project that aims to help people in need of wheelchairs but who can’t afford to buy them.

The “Kosova CAP” project recycles plastic caps as a source to buy and donate wheelchairs to people with disabilities in Kosovo. Support for this initiative began in February 2012, initially by manufacturing and installing the bins used to collect plastic caps inside bars, restaurants and other public institutions in Kosovo. Through the help of the company, the project achieved a higher echo thus increasing exposure, cover and participation of citizens in collecting plastic caps.

**Case 4. Company WA**

Brewery began construction in 1968 and started production since 1971. Compound plant includes surface of 24 ha, with its entire infrastructure. The initial capacity was 300 thousand hectoliters of beer per year, while the current capacity is 900 thousand hectoliters. Within the brewery complex, there is also a malt factory, refined alcohol factory, dealer network and last the water-bottling factory. The company currently employs 25 employees in its water department, with capacities of 8000 bottles per hour, and works in three shifts depending on the demand. The company has modern laboratory for monitoring the microbiological and chemical analyses of raw materials, analysis of manufacturing phases, final production and control of sanitation in production and packaging machines. Leadership of the technological process at every stage of production filtration, purifying and in the end filling. The whole process is done in automatic computerized systems.

**Environmental management of WA**

The environmental management strategies have got the attention of the stakeholders of the company in the recent years. Goals, objectives and strategies have started to emerge from the discussions and meetings of the main shareholders in the company. However it is worth mentioning that these policies have not yet been implemented, nor they have been considered important by the company employees. To strengthen the environmental importance to the company, an environmental manager has been hired to consult upon the actions needed for the company if it were to enter new markets where the environment issues are of crucial issue.

**4.2 Data**

Table 1 below, produced by SCEnAT, shows the full supply chain data for Company BO. The first three input names, where the emission percentages are above 10%, are considered as the “hotspots” of the supply chain.

**Table 1. Full supply chain data of Company BO.**



In order to receive these results, the calculations were based on the following data taken from the Ecoinvent database. The values extracted from that database are presented in Table 2 below:

**Table 2. Unit cost and GHG intensity**

|  |  |  |
| --- | --- | --- |
| Material | Unit cost | GHG intensity |
| Water | 0.01 | 0.00 |
| Plastic Bottle | 1.07 | 2.89 |
| Plastic Cap | 1.07 | 2.89 |
| Bottle Etiquette | 1.07 | 2.89 |
| Plastic Packaging Film | 1.07 | 2.89 |
| Plastic Pallets | 1.07 | 2.89 |
| Electricity | 0.06 | 0.97 |
| Diesel | 0.98 | 1.96 |

Table 3 below, displays summarised data of the “hotspots” for each case-company under investigation.

**Table 3. Hotspots emission of all companies**

|  |  |
| --- | --- |
|  | **Hotspots Emission Table** |
| Company BO | Input name | Carbon emission | Emission % |
| Plastic pallets | 48,602.4000 | 54.0% |
| Electricity | 17,536.6800 | 19.5% |
| Plastic caps | 17,358.0000 | 19.3% |
|  |
| Company SI | Input name | Carbon emission | Emission % |
| Plastic pallets | 40,502.0000 | 53.9% |
| Electricity | 14,613.9000 | 19.5% |
| Plastic caps | 14,465.0000 | 19.3% |
|  |
| Company UR | Input name | Carbon emission | Emission % |
| Plastic pallets | 60,753.0000 | 61.9% |
| Electricity\* |  7,306.9500 |  7.4% |
| Plastic caps | 21,697.5000 | 22.1% |
|  |
| Company WA | Input name | Carbon emission | Emission % |
| Plastic pallets | 44,552.2000 | 58.1% |
| Electricity | 15,911.5000 | 20.8% |
| Plastic caps | 10,229.7300 | 13.4% |

**4.3 Possible Interventions for lowering carbon emissions**

**4.3.1 Renewable Energy**

Since energy is one of the main hotspots for carbon emissions of the companies it tells that the company relies heavily on machinery to perform its processes, which are crucial for the product quality and use electricity at high quantities. This shows that there is a need for finding alternative sources of energy, while utilizing the local resources that the companies have at their disposal; thus, creating synergies that could benefit the whole community. Three of the companies are of the same region, having their water source in rural areas and villages, thus it helps them utilizing the natural resources to be a benefit for them. The companies can cooperate with local farmers and farm companies into investing to build renewable energy alternatives such as bio energy farms, where it benefits the companies and the farmers with electricity and fertilization. Moreover, they can divide their investment costs and maintenance, thus resulting in less money spent to eliminate their carbon emission from electricity, while significantly reducing cost of electricity. This does not mean that only bio farms can be utilized; if the location of the plant is in a rural area, the company can pursue a different form of energy such as small hydro power plant where a small investment in turbines combined with dense river flows can produce just enough electricity for the company to eliminate its electric expenditures, while reducing carbon emissions significantly. In addition, this can help sustain the community it surrounds, where it offers energy available to everyone at all times.

Since some of the companies cannot find new sources of water where the processes of filtration and purification occur as a process of nature, then this has to be replaced with machinery to perform such processes. Therefore, companies have to invest in order to reduce the carbon footprint of such machinery as well as costs. Figure 1 shows that with a 50-100kwh hydro power plant or bio gas plant the emissions of the companies can significantly decrease by eliminating all the electricity emissions. Taking into account how much electricity the companies spend on average per year, with this scenario it will help on calculating what capacity of alternative energy power plant is needed to cover their needs.

It can be said, for example taking into consideration the BO company, that a hydro power plant would reduce the energy costs by 99%, while reducing the electricity emissions by 49% from 17,536.68 to 9,000.00. It also reduces the overall company supply chain emissions by 9%, from 90,076.96 to 81,540.28.

**Figure 1. Gains from hydro-electricity**



**4.3.2 Consolidated Transportation**

Consolidated shipments together with local companies nearby that can be suitable, would reduce the emission of both companies and also costs. Around the region there are many companies having their own transport means, however with cooperation, both companies can minimize their emissions from transportation fuel though consolidated shipments. Such an example can be when the company has to transport to the capital city of Prishtina, there are already established local transportation companies that can do that for the company. This way the company loses some control over its transportation however it reduces its emissions and costs. In addition, the distributors can help the company cover every part of every city. How this will impact on the current amount of emissions can be seen from the graph below where it shows the difference of the current situation and the scenario.

**Figure 2. Gains from consolidated transportation**



The emissions from the own transportation are reduced 50% when sharing transportation. Also it is worth mentioning that the total emissions of the company are reduced by 12% from 90,076.96 to 79,705.53 (BO company). The scenario is calculated by assuming if companies cooperate to consolidate their shipments, then their transportation emissions are divided by two or more companies, which is the same for the cost which goes down in half for fuel, wages, insurance and maintenance since they have to be paid in half, however more fuel is used since more trips are made to satisfy all customers of all companies and this can be minimized if companies have similar routes. In addition this can help maximize satisfaction of retailers and minimize out of stock situations.

**4.4 Drivers for organizations to adopt GSCM**

As supported by the literature, the information retrieved from the companies emphasized that cost reduction, compliance to the governmental regulations and brand identity or being an environmentally friendly brand were among the main drivers for adopting GSCM, thus reducing their total lifecycle emissions.

Undertaking of carbon assessment schemes such as hybrid LCA are crucial for the companies in the future as they try to enter new international markets, thus having a responsibility to publish their carbon emissions report to their stakeholders. Measuring the greenhouse gases of the companies ensures that they are following EU regulations and legislations. Such data were retrieved by the literature review conducted on the requirements that governments have for organizations in regard to the environmental protection. These requirements derive from the commitments that states have made to reduce their carbon emissions by 20% until 2020. Even though these requirements in developing countries are not seen as crucial, as in the case of Kosovo, it is important to consider that in other countries where they are seen as potential markets for Kosovo companies, the emission intensities or carbon emissions of a brand are of high importance by the consumers. This was proven to be true with the companies in this study where their environmental management was of low importance, as seen in their efforts to calculate emissions or even recycle their wastes. However when considering their aims and objectives which are international expansion and new market penetration, then green supply chain management is considered as a tool to make the companies’ brands environmentally friendly and complying to the EU regulations.

In addition to the brand image and compliance to regulations, reduction of costs was seen as a driver for adoption of GSCM. As the literature supported the claim that organizations can drive their costs down by investing in GSCM via the replacement of old with new technologies or elimination of waste processes, it was seen also in the case of the companies in this study. Their main purpose when approaching environmentally friendly activities was to consider the cost aspect of them, if it will drive costs down in the long run or it will contribute to driving sales up. When interviewed, managers supported the claim that if the activities of green supply chain can lower the cost of production, packaging or transportation they are more inclined and driven to adopt such approaches.

**4.5 What barriers do organizations hassle with when adopting GSCM?**

The study shows that businesses which support and implement low carbon practices among their supply chains, they face issues of multi-discipline nature involving a range of activities such as supplier selection, distribution optimization, collaboration and end of life management. Firms must consider their product impacts from a lifecycle approach if they want to meet the objectives established by EU regarding reduction of greenhouse gas emissions. This is able by considering all stages from raw materials environmental pressures to disposal stage, while incorporating direct and indirect emissions.

According to the literature review of the green supply chain methodologies such as life cycle assessment, input output assessment and hybrid LCA, there were issues such as truncation error, lack of knowledge and complex supply chain emissions. When considering the nature of the products or services an organization offers and their emission aspect it is important to find the related database or inventory of emissions. This is necessary since there may be truncation errors, meaning that not all emission from products or processes are in the public inventories such as Ecoinvent. There may be processes or materials that are not added to such a database, which makes it harder for organizations to assess their supply chain emissions. This was supported in the study with the companies, where difficulties were encountered to identify all emissions in the process. This was mainly due to the lack of assessments of this nature in the past. Such an example can be the processes the company undertakes to treat the water into becoming drinkable and ready to be bottled. There was no evidence in the literature of the emissions intensity these processes such as purifying or filtering produce, which is why it was more logical to group these processes as a whole production process. This made it simple and easier for companies to assess and present their emissions intensity for their processes.

**5. Conclusions and Recommendations**

The interventions mentioned above in the study are summarized to depict a more clear understanding of the impact the green supply chain activities have on the companies participating in this study. The utilization of local natural resources such as renewable energy from hydro power plants or biomass farm to reduce their emission intensity with clean energy for the processes of the companies run by the machinery in the plant, and the consolidation of the shipments of products to distributors with other companies to reduce costs and transportation fuel used to bring the product to the end consumers, show that by their implementation supply chain total lifecycle greenhouse gas emissions could be reduced by double digit figures.

Not only these interventions could reduce the emission of the companies but also can help in reducing the costs of the processes that the companies undertake to serve customers with their products and helps them on improving their process efficiency while reducing wastes that these processes leave behind. Such improvement in process efficiency could be alternative sources of water where natural processes replace actual processes of companies while eliminating wasteful, emission and cost intensive processes.

Utilizing the GSCM field accepted knowledge, the SCEnAT application for carbon assessment modules and the data obtained from the companies, the following recommendations concerning green procurement, green production and green transportation through collaboration are made to be considered in future environmental decision-making.

**5.1 Green procurement**

When undertaking the selection of suppliers, it is favorable to identify a standardized set of guidelines which incorporate the method of environmental auditing. It is also helpful to consider the local supply as it is more beneficial than overseas supply when sourcing suppliers to cut down on emissions of transportation. Further, it is possible to compare new products offered by existing suppliers with current products used in production while assessing them to ensure that the product used is the most efficient in terms of environmental impact, quality and costs.

Companies can also negotiate contracts with more benefits through collaboration with major suppliers in the region to gain benefits from transfer of knowledge, in particular environmental strategies, systems and policies. Such examples can be capital recovery from waste treatments and recycling. This would help companies share more complete data with suppliers in order to manage carbon emissions more efficiently and easily by extending the carbon management throughout the whole company’s supply chain.

**5.2 Green production**

Companies should continue with the elimination of production wastes as well as with recycling of waste products. They can reduce electricity consumption through the elimination of the artificial processes, which clean and nourish the water with those of natural ones. Finding new sources of water, springs that perform these natural processes, can help in reducing electricity for some companies. Reducing the water usage and amount of water needed for treatment in the plant can help in reducing the amount of chemicals needed and their associated transportation and disposal. In addition, companies can undertake more assessments of the current equipment used to find ways for interventions where consumption of electricity could be reduced.

**5.3 Optimised transportation**

To optimize the distribution of goods to the end consumers, it is necessary to collaborate with suppliers in order to avoid situations such as backhauling, and to recover waste goods though reverse logistics flows. Also, it is important to emphasize that companies have limited strategy to the activities of re-ordering which needs to be considered. Through collaboration, companies can establish together with suppliers a demand tracking system where it helps in minimizing the number of deliveries, thus reducing unloading and loading costs along with transportation and inventory holding.

Implementation of the suggestions mentioned above, which derive from the scenarios, can help companies in reducing their total lifecycle chain greenhouse gas emissions for bottled water which is the focus product of the study, and for the companies in general.

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