Carbon emissions of bottled water sector supply chains: A multiple case-study approach.*

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Abstract

The aim of this study is to assess the environmental performance of medium sized bottled water producers. More specifically, the research incorporates a multiple case study approach by conducting life cycle assessment (LCA) for three organisations located in Kosovo that produce and distribute bottled water in the local and other European markets. The Supply Chain Environmental Analysis Tool (SCEnAT) was used to assess the carbon emissions caused by the activities within the supply chains of these companies. It was found that greenhouse gas (GHG) emissions are created mainly due to the use of plastic pallets, plastic cups and electricity. Upon identifying the hotspots (where emissions account for more than ten percent of the total emissions), a number of potential interventions to lower the overall emissions are proposed. As indicated, proactive green supply chain management practices can help SMEs in the sector improve their environmental impact and reduce their operations costs.

Keywords: life cycle assessment (LCA); bottled water companies; carbon emissions; green supply chains; environmental sustainability

1. Introduction

In recent years bottled water consumption worldwide has been increased about three times more than other beverages and it is expected to continue its growth (Trefis Team 2015; IBWA 2016). In 2015, Mexico had the highest per capita consumption with 64.5 gallons, while in USA and Hong Kong the per capita consumption was 36.5 and 29.6 gallons, respectively (Statista 2016). In Europe, Italy shows the highest per capita consumption of bottled water (188.5 litter/49 gallons in 2016) while the average per capita in Europe that year was 110 litter/29 gallons (Statista 2017). The increase in bottled water consumption is attributed to the public distrust of tap water and to the effective bottled water marketing campaigns, and it is linked to consumers' preferences and perceptions regarding water taste and odor as well as convenience and safety/hygiene issues (Saylor, Prokopy, and Amberg 2011; Gamze et al. 2016). The rise in bottled water consumption has an environmental impact much higher than that of tap water due to transportation and plastic bottle manufacturing (Botto 2009; Gleick and Cooley 2009), insufficient packaging waste management (Foolmaun and Ramjeeawon 2013), resources consumed, and environmental emissions associated with the polyethylene terephthalate (PET) recycling process (Chilton, Burnley, and Nesaratnam 2010). Of prime importance is, therefore, the need for bottled water companies, to manage their resources responsibly by adopting green practices to improve their environmental footprint. This raises the question of how can small and medium-sized enterprises (SMEs) in the industry identify their hotspots to act appropriately in decreasing their environmental impact. The aim of this study is to analyze the sustainability of the specific industrial sector, focusing on the issues of carbon emissions caused by the activities within the supply chains of these companies, and to propose different environmental strategies. The objectives of this research are to:

- perform a carbon assessment of the life cycle of bottled 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.

To achieve this goal, the Supply Chain Environmental Analysis Tool (SCEnAT) has been utilized. Upon identifying the hotspots of these supply chains, the authors propose and assess potential interventions that would lower the overall emissions.

Relatively few studies have explored the environmental impact of bottled water supply chain. The case studies used in this research provide the evidence–base for sustainable development is SMEs through better understanding of the processes in their supply chain that can promote their environmental performance.

2. Theoretical background

In recent years, environmental awareness has been pressuring corporations to manage their operations in a sustainable way adhering to the triple bottom line framework: social, environmental and financial. However, this goal cannot be achieved by just improving the environmental performance at a firm level alone. The adoption of green supply chain management (GSCM) and collaborative approaches is imperative for organisations seeking to minimize their impact on the environment sustaining, thus, a competitive advantage (Vachon and Klassen 2007; Walker, Di Sisto, and McBain 2008; Zhu et al. 2008b). Organisations in various sectors should assess their greenhouse gas (GHG) emissions, identify their high carbon emission paths (hotspots) and 'de-carbonize' their supply chains.

2.1. Green Supply Chain Management (GSCM)

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 organisations role in society has increased, especially in the context of business and management (McWilliams and Siegel 2000; Strandberg 2002) due to their potential 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) and analysed by Misopoulos et al. (2018) in their discussion of institutional pressures towards sustainable practices.

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 organisations, 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 organisation ecological efficiency (Carvalho et al. 2010; Rao and Holt 2005; Van Hoek 2000).

GSCM implementation in an organisation, 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 organisations that initiates changes through the organisation's external and internal linkages, which later on captures the inter-functional and inter- organisational synergy of collaboration and integration as defined by Min and Zhou (2002). According to Sezen and Cankaya (2017) there are nine dimensions in GSCM: green purchasing, green distribution, internal environmental management, green packaging, green training, green production, eco-design, reverse logistics, customer environmental collaboration and investment recovery.

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). Organizations seeking to implement GSCM should comprehend the interrelationships among the different variables behind GSCM, namely their GSCM hard and soft dimensions as well as processes, and how these in turn impact their environmental, financial and social performance (Dubey et al., 2017). 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 influence 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. According to Calogirou et al. (cited in Blundel et al. 2013), within the European Union SMEs are responsible for 64% of the overall environmental pollution. When considering innovation, Sarkis et al. (2011) emphasise 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.

2.1.1. Bottled water supply chain

A typical bottled water supply chain involves a variety of stages: Component/Raw material suppliers/Bottlers/Wholesalers/Distributors/Retailers/End customers. The main raw materials include bottles and plastic cups as well as labels, closures and seals for packaging (de Oliveira, Roquette and Silveira 2014). This supply chain is characterized by raw materials which are non-expensive. However, it faces several challenges according to the pertinent literature. From a cost perspective, the main challenges can be the increasing packaging, transportation and distribution costs which are related to oil and petroleum prices (Coban 2012). From a Supply Chain processes perspective, the main challenges are related to a) forecasting and demand management (Galbreth et al. 2013), b) inventory management to avoid surplus or stockouts, and optimization of distribution policies (Lmariouh et al. 2014) and c) traceablility, i.e. the ability to trace product and process information through the links in a supply chain (Karlsen, Olsen and Donnelly 2010).

In recent years, the industry has been considerably criticized for its environmental impact (Ragusa and Crampton 2016) due to the use of plastic bottles, the oil consumption during the production of the bottles, the emissions from the vehicles during the transportation of bottles, the use of non-recycled plastic packaging, etc. (Torretta 2013). Responding to the criticism, many leading companies in the field, have taken initiatives to green their supply chains (Beverage Industry 2008).

2.2. Life cycle assessment (LCA)

Life cycle assessment (LCA) is a holistic framework for the calculation of GHG emissions of a product produced during all stages of its life from raw materials processing to manufacturing and packaging, distribution and consumption to final disposal (Pandey, Agrawal, and Pandey 2011). According to the International Organisation for Standardisation (ISO) 14040 (2006a) and ISO 14044 (2006b), the main phases in LCA are: (i) goal and scope to ensure that the method is performed consistently (ii) inventory analysis (LCI) iii) impact assessment (LCIA) and iv) interpretation. LCA methodology is considered the main instrument in GSCM (Hagelaar and van der Vorst, 2002). Gathering and assessing data on environmental issues, this technique is a powerful tool for strategic decision-making on how supply chains can be restructured or designed in order to improve effectively their environmental performance (Chaabane, Ramudhin and Paquet, 2012; De Benedetto and Klemes, 2009).

With regard to LCA goals, academics suggest two main categories: (1) attributional LCA (aLCA) and (2) consequential LCA (cLCA). The former provides information on a product system and its environmental exchanges whereas the latter provides information on how environmental exchanges of the system might change due to actions taken in the system (Rebitzer et al. 2004; McManus and Taylor 2015). It is argued that the LCA results depend largely on the choice between the aLCA and the cLCA. In a supply chain environment, cLCA allows for important improvement options once hotspots have been identified within the system decision makers have chosen to be responsible for (Weidema et al. 2018).

LCI is the data collection of LCA and involves the compilation and quantification of environmental inputs and outputs associated with a product or service. LCI can be process based or economic Input – Output (EIO) based. There are two methods for process based LCI: (a) Process flow diagram which shows how processes of a product system are interconnected through commodity flows and (b) Matrix method which expresses the entire product system with numerous linear equations and solves them simultaneously. EIO LCI takes data from input output databases. The method assumes that each industry, when producing its own distinct output, consumes outputs of various other industries in fixed ratios. In this sense, EIO LCI does not include the use and disposal phase within its scope, therefore, is not considered compatible with ISO standards (Suh and Huppes 2005). Both methods have their own strengths and limitations. Combining the strengths of both process based and EIO based methods, Hybrid methods make LCI more reliable and robust tool for sustainability assessment (Islam, Ponnambalam and Lam 2016; Acquaye et al. 2011).

As different LCA approaches might lead to different result, the choice of the LCA method to be used is based on the availability of indicators for the assessment to be made, such as Human Health Impact or Resources Consumption (Stavropoulos et al. 2016) and on the need for qualitative or quantitative information (Hochschorner and Finnveden 2003). In another study, Boukherroub et al. (2017) classified four methods to measure the carbon footprint considering the level of extrapolation involved. According to the authors, these are: a) the direct measurement by measuring the pollutants emitted in a production site; b) the energy-based calculations, which are used mainly for fuel consumption at production sites and during transportation; c) the activity-based calculation method, which derives the GHGs from activity information by using conversion factors, and d) the economic input–output life-cycle assessment (EIO-LCA), which converts the expenses made by a company into an average amount of carbon emissions through the life cycle of a product or service.

In light of the above mentioned analysis we argue that the SCEnAT framework is a holistic tool that provides transparency across the entire supply chain ensuring that carbon emissions become visible and are captured at all stages and allowing for better possibilities to determine the environmental impact (Lake et al. 2015; Wannaz et al. 2018).

2.2.1. LCA for bottled water

The LCA technique has been applied to various studies for the calculation of carbon footprint values coming from tap water and/or bottled water packaged in polyethylene terephthalate (PET), glass, etc. For example, Nessi, Rigamonti, and Grosso (2012) used the SimaPro 7.2.4 LCA software to assess the energy demand and specific potential environmental impacts of different scenarios (use of virgin PET bottled water, 50% recycled PET, etc.) in Italy. The study included the production of packaging materials, bottling plant operations, transportation to retailers and to consumers, and end of life post-consumer packaging. The authors highlighted the importance of the closed loop systems and the necessity of reducing the distance along which one-way bottled water is transported. Franklin Associates (2009) evaluated the environmental impact of various scenarios for bottled water in Oregon, USA. Their study included all steps for bottle production, distribution (virgin PET, recycled PET, various bottle sizes) and end of life of bottles, and they concluded on the best as well as on the worst scenario. Fantin et al. (2014) reviewed recent LCA reports and studies on bottled water to compare and harmonize results from different methodologies. One interesting observation from their review is that the majority of studies took place in Italy and USA.

2.3. Challenges of LCA implementation in SMEs

Small and medium enterprises (SMEs) are an important segment of business worldwide and they play a vital role in a country's economic growth as they contribute to employment, industrial output, international trade, etc. (World trade report 2016). When considered individually, SME's environmental impact might be limited, however, it is estimated that SMEs collectively contribute up to 70% of total industrial pollution (Hillary 2004). Due to limited resources and lack of time and expertise (Hillary 2004; Graafland and Smid 2016), SMEs are slow in implementing proactively GSCM strategies

(Hussey and Eagan 2007) and, in general, they adopt reactive strategies focusing on compliance rather than on sustainability (Nulkar 2014). SMEs are reluctant to undertake performance measurement practices, as the majority of performance measurement systems do not take into consideration the fundamental differences between SMEs and larger organisations (Bititci et al. 2012). SMEs have challenges in implementing LCA to assess their environmental performance (Heidrich and Tiwary 2013) due to the complexity of the methodology, difficulties with data collection and interpretation, and lack of assistance and guidance (Chai, Norhashimah, and Norli 2014). Few simplified LCA approaches and tools have been developed for SMEs, but they need to be improved to become robust when implemented in specific sectors (Arzoumanidis et al. 2017).

From the review of the literature, it is evident that until now there has not been any observation or analysis regarding the implementation of LCA for SMEs bottled water manufacturing in developing countries. The present work utilizes a hybrid LCA tool to identify the hotspots in three companies located in Kosovo. Bottled water producers in Kosovo are facing huge competition by domestic companies as well as from other producers from EU countries especially from neighboring countries, (Ismajli, Kajtazi, and Fejza 2013) and they seek to improve their brand image.

The present study aims at identifying the environmental impact of three companies and to relate it to their operations. Two of the companies produce natural mineral water, while the third one is a spring bottled water producer. According to the European regulations, natural mineral is water originating from an underground reservoir or aquifer and it comes from one or more springs or wells. Natural mineral water may be distinguished from ordinary drinking water by their purity at source and their constant level of minerals. Spring water is intended for human consumption in its natural state and is bottled at source, fulfilling the conditions of exploitation and the microbiological and labeling requirements included in Directive EC 2009/54.

3. Methodology

In all case studies the analysis undertook a hybrid LCA assessment for GHG emissions, using the SCEnAT (Supply Chain Environmental Analysis Tool). The functional unit was set for producing 1t (tonne) of bottled water. The system boundary included supply of raw materials, water processing, bottling, packaging and distribution to wholesalers/retailers, thus cradle to market.

3.1. Supply Chain Environmental Analysis Tool (SCEnAT)

The rationale of the selection of SCEnAT for this research over other tools was based on the outcome of the work of Koh et al. (2013). In their research, the authors classified the existing carbon accounting tools into four main categories according to the methodology they have adopted. The first category includes those tools that use a simple energy consumption based formula. The second category includes tools that focus on a single sector of the economy by utilizing a database of GHG emissions of economic activities in the specific sector. The third category includes tools based on LCA, covering upstream supply chain activities beyond the activities of the focal company. The fourth category includes tools with a more comprehensive view of the supply chain, thus covering the whole range of economic sectors.

Some of the major advantages of SCEnAT compared to other existing tools are that it implements the hybrid LCA, identifies carbon emission hotspots of the supply chain, examines not only the environmental but also the social and economic impacts, provides a supply chain mapping, and covers the sectors of the entire economy. Koh et al. (2013) provide a detailed and comprehensive view of SCEnAT's characteristics and features.

3.2 The case studies

3.2.1 Case 1: Company BO

The site was established in 2000 and occupies more than 50 employees working in three shifts. The factory's capacity is 8000 bottles per hour, and recent investments on new technologies have allowed increases in capacity and elimination of waste. The company produces natural mineral water and carbonated water on PET bottles of different size.

3.2.1.1 Environmental management of BO

In recent years, BO's stakeholders have been exercising pressure on the company to implement energy and environmental management strategies. The head office has been drafting preparatory documents regarding their environmental goals, objectives, and strategies; however, these policies currently are not widely enforced. Five employees have been trained to be certified as health, environment and safety managers, thus, allowing the company to tackle their environmental issues professionally. The company aims at adopting an integrated environmental management system mainly due to the mandatory obligations enforced upon the company by the Carbon Reduction Commitment (CRC) when exporting to EU states. Besides, strengthening their reports and activities of corporate social responsibility will improve the brand name.

3.2.2 Case 2: Company SI

Established in 2011, the company occupies more than 100 people working in two shifts. The production capacity varies according to the type of the product, and it is around 8,000 bottles per hour. Its innovative production equipment and technological expertise have made SI worldwide renowned for low cost and high quality production. The company produces refreshing drinks, natural mineral water and sparkling mineral water on PET bottles.

3.2.2.1 Environmental management of SI

SI focuses on unique taste and high quality. Being a global brand, SI adapts to each country's specific circumstances and characteristics– all products are naturally produced and in compliance with local laws and food hygiene regulations. To ensure that its products stand for German quality worldwide, SI for its beverages uses ingredients that are produced exclusively in Germany and distributed to licensees around the world. The water contained in beverages or any other components are sourced regionally and with strict quality criteria. Since its start in Kosovo, the company did not focus on environmental management as the government did not impose strict rules on the carbon emissions. Due to the brand's internationalization, however, the company, along with the quality standards, has to follow environmental regulations set by the center company in Germany. Compared to other companies in Kosovo, SI stands much better in environmental performance and waste elimination since it outsources all its waste to recycling companies.

3.2.3 Case 3: Company UR

Established in 2006, the company occupies more than 30 employees working in three shifts, and the production capacity is 8000 bottles per hour. The company produces spring water and it is licensed with ISO certificate 22000 and 22005 for food standardization.

3.2.3.1 Environmental management of UR

Since its creation, the company has not undertaken any environmental management activities but it has a low environmental impact for its business processes. This is because in its initial years, when the company was a business unit of another company, its supply chain was structured in a way that the environmental impact is minimal. The company requires from its suppliers environmentally friendly supplies and maintains strong cooperative relationships with its distributors to minimize transportation and, consequently, carbon emissions. However, since the company has introduced new products and is trying to expand into other markets, much should be accomplished to achieve international standards. The main environmental activity that the company has undertaken so far is the disposal of its wastes to local recyclers. UR is the main partner of a humanitarian project that aims to help people who need but cannot afford to buy wheelchairs. The project recycles plastic caps as a source to buy and donate wheelchairs to people in need. Support for this initiative started in February 2012, by producing and installing bins for plastic caps' collection inside restaurants, bars and other public places in Kosovo. With the company's help, the project achieved a higher echo resulting in increased participation of citizens in collecting plastic caps.

3.3 Data requirements and collection of data

Primary process data for the bottled water supply chains were taken from the three companies. Sources of data:

(1) Information from companies' records and documents such as process maps and reports of environmental issues as additional data. Primary information required were:

- Raw materials used to produce one tonne of bottled water (quantities and unit prices).
- Consumables for the production of one tonne of bottled water (chemical quantities and unit prices).
- Utilities used for the production of one tonne of bottled water (diesel, gas, electricity forms, water quantities and unit prices).

- Packaging used for the production of one tonne of bottled water (quantities and unit prices).
- Waste generated from the production of one tonne of bottled water (quantities).
- Suppliers of raw materials and consumables spent in the production of one tonne of bottled water (locations).

(2) Site visit to the factories and observations on their activities, processes and existing environmental policies.

(3) Interviews with executive members of the companies regarding their environmental practices and processes to ensure a deeper insight is gained. The plant manager and the production manager of each company were interviewed, providing a total of six interviews.

In Figure 1, the process map for each company is depicted. Companies BO and SI follow similar processes for their bottled water production.

Secondary data were obtained from Ecoinvent, an inventory database of lifecycle emissions. All calculations were performed by SCEnAT software, producing the final emissions report for each company participating in the study. Possible interventions to reduce emissions of carbon were identified from this analysis, while incorporating observations and interviews provided additional information.

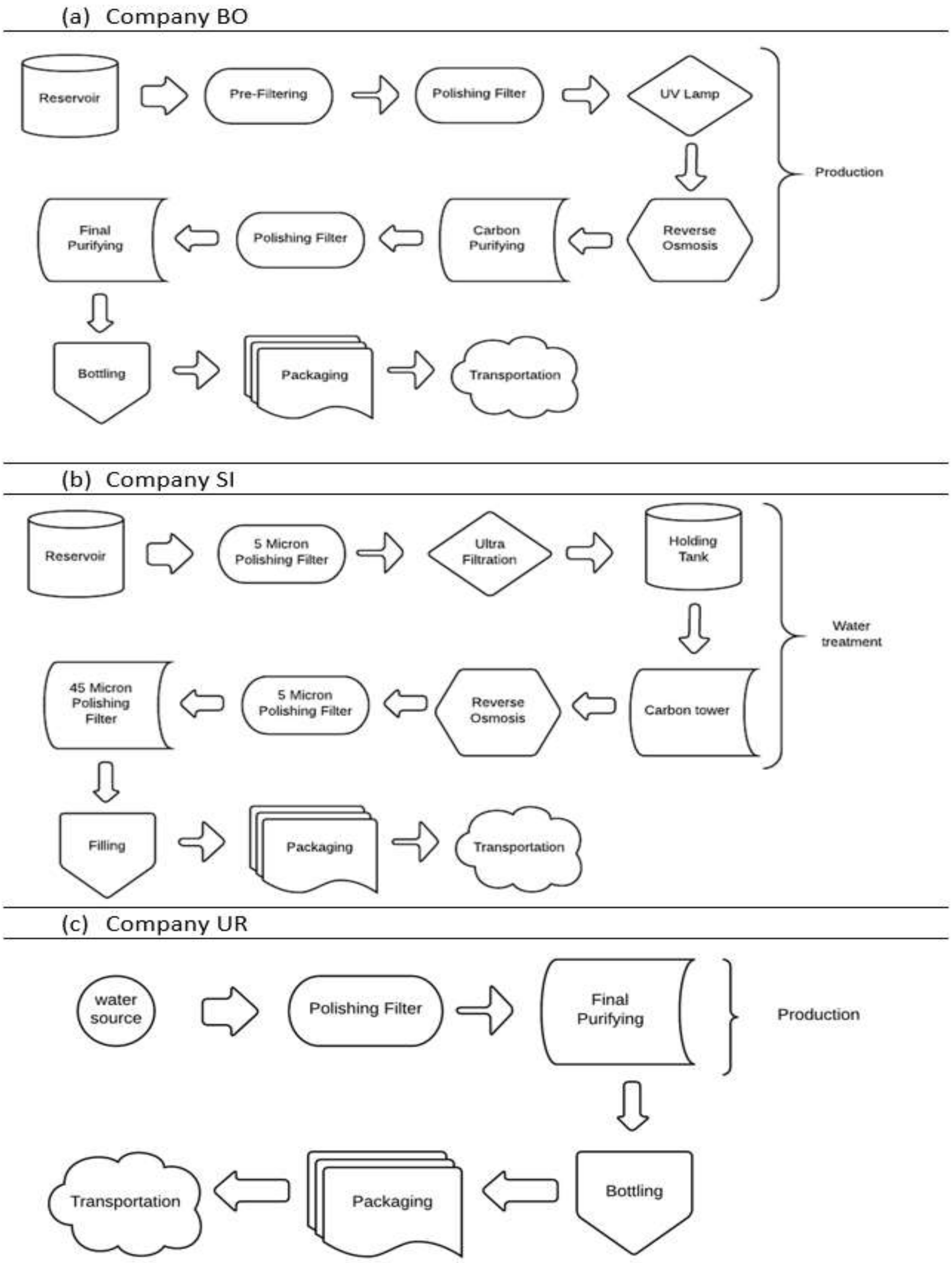

Table 1 provides the materials used by each company, while Table 2 provides inventory inputs into the process LCA system. The quantities of the inputs are referenced to one-tonne production of bottled water. Data are taken from the Ecoinvent database.

Materials	Quantity			Unit
	BO	SI	UR	
Water	4800	4000	6000	Tonne
Plastic Bottle	0.8	0.67	1.05	Tonne
Plastic Cap	6	5	7.5	Tonne
Bottle Etiquette	0.02	0.02	0.03	Tonne
Plastic Packaging Film	2.4	2	3	Tonne
Plastic Pallets	16.8	14	21	Tonne
Cleaners	2400	2000	0	Euro
Electricity	18	15	7.5	Megawatt
Diesel	1870	1560	2340	Litre

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
Cleaners	-	-
Electricity	0.06	0.97
Diesel	0.98	1.96

4. Findings and discussion

Table 3, presents the supply chain emissions for each company as they are produced by SCEnAT. Red color indicates inputs with emissions greater than 10% of the total lifecycle emission, which are considered as the "hotspots" in the supply chain. Light red color indicates high emissions (5–10%), while medium (0.3–5%) and very low (0–0.2%) emissions are indicated with yellow and green color, respectively. Companies BO and SI present similar gas emissions, with hotspots being plastic pallets, electricity and plastic caps. This does not come as a surprise as both companies produce the same type of bottled water, following similar processes in water production. On the other hand, in UR company, emissions due to electricity are 60% reduced compared to those from BO or SI, due to less complicated purifying process during water production. However, plastic pallets and caps in UR produce higher emissions than those in BO and SI. Moreover, UR presents 14% and 19% increase in GHG emissions due to transportation fuel and bottles compared to BO and SI. Other researchers have also observed the contribution of plastic caps and other packaging materials to total emissions. For example, Flanklin Associates (2009) estimated that the bottle lids and secondary packaging account, each, for 12% of total energy. Nessi, Rigamonti, and Grosso (2012) have included these materials in their scenarios with the assumption that they are totally incinerated, however, the authors did not provide any direct indication of the GHG emissions from these materials. In all case studies in the present research, GHG emissions due to transportation were estimated below 5%, which is less than those reported in other studies. As indicated above though, those figures would double when accounting for the lifespan of the pallets. However, in the present research, transportation fuel consumption was calculated for trips from suppliers to the companies and from there to retailers. Routes from retailers to end customers were not considered in the calculations.

4.1 Potential interventions for lowering carbon emissions

Assessing the results from SCEnAT, the focus shifts on the potential interventions that could be acted on those areas which cause the highest carbon emissions. These are examined in the following sections.

4.1.1 Plastic pallets and caps

As the use of plastic pallets and caps is one of the main hotspots for GHG emissions, bottled water manufacturers should aim at finding ways to reduce their carbon footprint. The production phase of LDPE caps and pallets requires considerable amount of energy (Lagioia, Calabro, and Amicarelli 2012) and depletion of natural sources. Plastic waste can be recycled or incinerated for energy recovery. However, each option has its drawbacks due to the energy involved with transportation to the recycling sites (Lagioia, Calabro, and Amicarelli 2012) and, most important, due to emissions of air pollutants

Table 3a: Supply chain emissions for company BO

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Plastic pallets*	16,800.00kg	$1.07	2.8930	48,602.4000	54.3%
Electricity	18,000.00kWh	$0.06	0.9743	17,537.4000	19.5%
Plastic cap	6,000.00kg	$1.07	2.8930	17,358.000	19.4%
Transport fuel (diesel)	1,872.00litre	$0.98	1.9601	3,669.3072	4.1%
Pet bottles	800.00kg	$1.07	2.8930	2,314.4000	2.6%
Water	4.80tonne	$0.00	0.0000	0.0001	0.0%

Table 3b: Supply chain emissions for company SI

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Plastic pallets*	14,000.00kg	$1.07	2.8930	40,502.0000	54%
Electricity	15,000.00kWh	$0.06	0.9743	14,613.9000	19.6%
Plastic cap	5,000.00kg	$1.07	2.8930	14,465.000	19.3%
Transport fuel (diesel)	1,560.00litre	$0.98	1.9601	3,057.7600	4.1%
Pet bottles	670.00kg	$1.07	2.8930	1,938.3100	2.6%
Water	4.00tonne	$0.00	0.0000	0.0976	0.0%

Table 3c: Supply chain emissions for company UR

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Plastic pallets*	21,000.00kg	$1.07	2.8930	60,753.0000	62.4%
Electricity	7,500.00kWh	$0.06	0.9743	7,307.2500	7.5%
Plastic cap	7,500.00kg	$1.07	2.8930	21,697.500	22.3%
Transport fuel (diesel)	2,340.00litre	$0.98	1.9601	4,586.6340	4.7%
Pet bottles	1,050.00kg	$1.07	2.8930	3,037.6500	3.1%
Water	6.00tonne	$0.00	0.0000	0.1464	0.0%

*A plastic pallet's life cycle is longer than a year; therefore, their emission % must be divided by their life cycle duration, in years. As a result, emission % of all other categories will increase.

during incineration (Thanh, Matsui, and Fujiwara 2011). However, a possible option is the re-use of plastic pallets. Bottled water companies can collaborate with their wholesalers and retailers, either large or small, to collect the pallets and return them for reuse. The pallets could be reused with a simple cleaning process, as they do not come in close contact with water or beverages. A study by Lee and Xu (2004) implementing a Streamlined (simplified) LCA revealed that, for example, a certain plastic pallet

(Enviropak© T760) that is all-weather, washable, re-usable and fully recyclable, causes four times less harm to the environment than the traditional wooden pallet [4.574 Environmental Load Units (ELU) compared to 18.455 ELUs for a wooden pallet]. The life span of such pallet is anywhere from five to seven years. Therefore, when pallets are reused, the emission percentage of the pallets in Table 3a-c (last column) will drop significantly. Consequently, a considerable increase of the emissions' percentage figures of all other variables (electricity, plastic caps) will occur, and will render fuel as one of the hotspots.

With regard to plastic caps, in LCA analyses conducted so far, there is no specified calculation for GHG emissions; however, as it was estimated in the present study, plastic caps contribute much to the environmental impact of the companies. Therefore, proper waste management solutions should be in place. In the literature, there is no indication of the percent of plastic caps to the total household waste. It is most possible that caps due to their small size and the absence of specific European sorting instructions on recycling material (Schlosser et al. 2015) are discharged ending up to landfill sites. Bottled water companies could stimulate public awareness by similar campaigns like the 'Kosovo CAP' or by granting a small reward to consumers returning caps to recycling centers.

4.1.2 Electricity

With the exception of the company UR, LCA results show that natural mineral water manufacturers rely heavily on machinery and use electricity at high quantities to perform their processes. As technological equipment is crucial for the product quality, it is evident that there is a need for finding alternative sources of energy. Utilizing the local resources that the companies have at their disposal and creating synergies could benefit the whole community. For example, companies of the same region can cooperate with local farmers and farm companies into investing to build renewable energy alternatives such as biomass energy, which can benefit the companies and the farmers with electricity and fertilization. Zakhidov (2008) claims that by establishing renewable energy systems will assist towards the solution of major contemporary issues such as local energy and water supply, among others. If these renewable energy systems were to be developed in rural areas, then additional benefits could accrue, such as creation of new jobs as well as advancing decentralisation of urban areas (Bergman, Colombo, and Hanley 2008). Therefore, such initiatives will promote not only environmental, but also social sustainability.

By sharing the investment and maintenance costs, bottled-water producers and farmers can reduce their electricity costs significantly, and at the same time save money by spending less to eliminate their carbon emission from electricity. In cases where the location of the plant allows it, i.e. near dense river flows, the company can pursue a different form of energy such as small hydro power plant to produce just enough electricity for its processes while reducing carbon emissions significantly. The relatively high cost of installation is offset by the low operating costs and maintenance (Okot 2013).

Hydropower is considered of the main renewable energy sources for power generation (Demirbas 2006). It was estimated that with a 50-100kwh hydropower plant or bio gas plant the electricity emissions of the companies can be significantly decreased. Taking into account their annual electricity costs, companies could calculate and decide on the capacity of an alternative energy power plant, and create a financially feasible scheme to cover their needs. Taking for example the BO company, a hydro-power plant would reduce their electricity emissions from 17,536.68 to 9,000.00, meaning a total of 49% reduction. The overall supply chain emissions would be reduced by 9% (from 90,076.96 to 81,540.28), while the energy costs would be reduced by 99%.

4.1.3 Transport fuel

Shipment consolidation policies can reduce both logistics costs and emissions (Merrick and Bookbinder 2010). Therefore, bottled water producers could cooperate with suitable neighbor companies to group their transportation and distribution. Within the region, there are a number of companies having their own transport means and cooperation through consolidated shipments can benefit both partners in terms of transportation fuel reduction and gas emissions minimization. In such a scenario, already established transportation companies in the region can provide best dispatch policies. The impact of such strategy (sharing transportation) could bring a 50% reduction of own transportation and therefore a cut in half of the amount of fuel emissions. For the BO company, it was calculated that consolidated shipments can result in 12% reduction of its total emissions (from 90,076.96 to 79,705.53). The calculations were based on the assumption that a number of companies cooperate to consolidate their shipments and the transportation emissions are divided by the number of the cooperating companies. Similar calculations can be made for sharing fuel, wages, insurance, and maintenance costs but it should be noted that more fuel is needed since more routes are made to satisfy all customers of all companies. However, similar routes can minimize fuel consumption and gas emissions. According to Rao and Holt (2005), 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. By sharing or even outsourcing distribution besides the effects in reduction of carbon footprint and transport costs, it would allow the company to focus more in their core business (Wilding and Juriado 2004).

4.1.4 PET bottles

PET bottles were the least contributing factor to GHG emissions due to recycling. However, UR company could consider redesigning its bottles, for example by reducing bottle weight to improve their carbon footprint. In the future, companies could also consider the use of bio-polymers for bottle production. However, there is still an open debate on the effectiveness of bio-based materials as an environmentally friendly alternative to plastics (Khoo et al. 2010).

5. Implications of the research

The outcomes of the current research lead to a number of implications for the bottled water industry, and therefore, organisations in that industry wishing to become sustainable should be focusing on the following three areas.

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 that are more favorable by collaborating with major suppliers in the region, and 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 data that are more complete with suppliers in order to manage carbon emissions more efficiently and easily by extending the carbon management throughout the whole company's supply chain. Small organisations, according to Epstein and Roy (2000), do not recognise benefits of cost reduction, efficiency and profit growth that come from environmental enhancements. These organisations 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 (Mathiyazhagan 2013).

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. Despite its difficulties, implementing GSCM initiatives 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 organisations 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.

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. In addition, 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. For many organisations, transportation has become a key strategic function because a high proportion of the cost of goods sold are attributed to transportation related costs, and there is evidence that transportation performance affects customer service levels (Gurav 2004).

6. Conclusions

This study has performed a Lifecycle Carbon Assessment of the operations of three SME bottled water producers. Although the research was conducted in organisations of a developing country, the authors' expect that the corresponding producers in developed countries would have similar outcomes in terms of the emissions caused by their operations. A synopsis of the results is given with the following list:

(1) Cradle to market LCA analysis for bottled water revealed that GHG emissions are produced mainly due to the use of plastic pallets and caps.

(2) Use of electricity creates a significant amount of emissions during natural mineral bottled water production, but in spring water bottling these emissions are reduced by 60% due to less complicated purifying processes.

(3) Transportation fuels and plastic bottles were the least contributing factors to the total environmental footprint.

(4) GHG emissions can be significantly reduced with the adoption of green supply chain management strategies, such as:

   a. Reverse logistics for plastic pallets and cups. Re-use of these materials can be accomplished to minimize bottled water GHG emissions, but it needs collaboration between SC members and innovative approaches to enhance end consumers' participation.

   b. Optimized consolidated transportation. Co-operative activities with logistic service providers and other companies can result in transportation fuel and emissions reduction. Such strategies help in minimizing the number of deliveries, and in addition, they reduce total costs by decreasing loading and unloading costs together with transportation and inventory carrying costs.

(5) Exploitation of renewable sources of energy for electricity can bring 10% reduction in total GHG emissions with significant cost reduction in the long run.

(6) A final conclusion from this research is that small and medium sized bottled water manufacturers should overcome their barriers, implement LCA to assess their environmental performance, and identify the ways in which they contribute to environmental pollution. This can help them take proactive measures to eliminate wasteful, emission and cost intensive processes.

6.1 Limitations

When conducting LCA and considering the nature of raw materials and products as well as the processes used in all production phases and their emission aspect, the accuracy of the results is highly related to the availability of up-to-date and reliable data. Finding a related database or inventory of emissions is crucial to eliminate any truncation errors as much as possible. However, not all emissions from processes or products are available in public inventories such as Ecoinvent, making it harder for organisations to assess their supply chain emissions. In the present study, it was difficult if not impossible to identify all emissions from specific processes. In the literature, there was no evidence of emissions intensity from processes such as purifying or filtering produce. To overcome this barrier, it was more logical to group these processes as a whole production process, which is the main limitation of the study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Arimura, T. H., N. Darnall, and H. Katayama. 2011. “Is ISO 14001 a gateway to more advanced voluntary action? The case of green supply chain management.” *Journal of Environmental Economics and Management* 61 (2): 170-182.

Arzoumanidis, I., R. Salomone, L. Petti, G. Mondello, and A. Raggi. 2017. "Is there a simplified LCA tool suitable for the agri-food industry? An assessment of selected tools." *Journal of Cleaner Production* 149: 406-425.

Bergmann A., S. Colombo, and N. Hanley. 2008. "Rural versus urban preferences for renewable energy developments." *Ecological Economics* 65:616–625.

Beverage Industry. 2008. "Bottled water companies address the environment", *Beverage Industry* 99 (5):11-11.

Bititci, U., P. Garengo, V. Dörfler, and S. Nudurupati. 2012. "Performance Measurement: Challenges for Tomorrow." *International Journal of Management Reviews* 14 (3): 305–327.

Blundel, R., A. Monaghan, and C. Thomas. 2013. "SMEs and environmental responsibility: a policy perspective." *Business Ethics: A European Review* 22 (3): 246-262.

Botto, S. 2009. "Tap water vs. bottled water in a footprint approach." [online]. Available at: http://precedings.nature.com/documents/3407/version/1/files/npre20093407-1.pdf (accessed: 2 June 2018)

Boukherroub, T., Y. Bouchery , C.J. Corbett, J.C. Fransoo, and T. Tan, (2017). Carbon Footprinting in Supply Chains. In Bouchery, Y., Corbett , C.J., Fransoo, and Tan, T. Eds., *Sustainable Supply Chains- A Research-Based Textbook on Operations and Strategy*, Springer Series in Supply Chain Management, 4: 43-64.

Carvalho, H., S. G. Azevedo, V. Cruz-Machado. 2010. "Supply chain performance management: lean and green paradigms". *International Journal of Business Performance and Supply Chain Modelling* 2 (3/4): 304-333.

Chaabane, A., A. Ramudhin and A. M. Paquet. 2012. “Design of sustainable supply chains under the emission trading scheme”. *International Journal of Production Economics* 135: 37–49.

Chai, T. A., M. Norhashimah, and I. Norli. 2014. “Challenges and Possible Drivers of LCA Implementation in Small and Medium Enterprises (SMEs) in Malaysia: A Review.” *Pertanika Journal of Social Science and Humanities* 22 (2): 335 – 347.

Chien, M. K. and L.H. Shih. 2007. An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organisational performances. *International Journal of Environmental Science and Technology* 4 (3): 383-394.

Chilton, T., S. Burnley, and S. Nesaratnam. 2010. “A life cycle assessment of the closed-loop recycling and thermal recovery of post-consumer PET.” *Resources, Conservation and Recycling* 54: 1241–1249.

Coban, A. 2012. “The impact of strategic purchasing on supply chain performance of the bottled water industry in Turkey”. *European Journal of Business and Management*, 4(8): 57-65.

De Benedetto, L. and J. Klemes. 2009. “The Environmental Performance Strategy Map: an integrated LCA approach to support the strategic decision-making process”. *Journal of Cleaner Production* 17: 900–906.

De Oliveira, L.H., R.P.L. Roquette, and S.C.L. Silveira. 2014. “Design and analysis of Brazilian mineral bottled water value chain”, 21st EurOMA Conference, 20-25 June, 2014, Palermo-Italy. [online] Available at: https://www.researchgate.net/publication/265050743_Design_and_analysis_of_Brazilian_mineral_bottled_water_value_chain (accessed 15 January 2019)

Demirbas A. 2006. "Global renewable energy resources." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 28 (8):779–792.

Duber-Smith, D. 2005. "The Green Imperative." *Soap, Perfumery and Cosmetics* 78 (8): 24-26.

Dubey, R., A. Gunasekaran and T. Papadopoulos. 2017. "Green supply chain management: theoretical framework and further research directions". *Benchmarking: An International Journal* 24(1): 184-218.

Fantin, V., S. Scalbi, G. Ottaviano, and P. Masoni. 2014. "A method for improving reliability and relevance of LCA reviews: The case of life-cycle greenhouse gas emissions of tap and bottled water." *Science of the Total Environment.* 476–477: 228–241.

Foolmaun, R. K. and T. Ramjeeawon. 2013. "Comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET) bottles in Mauritius." *The International Journal of Life Cycle Assessment* 18 (1):155–171.

Franklin Associates. 2009. "Life cycle assessment of drinking water system: bottle water, tap water, and home/office delivery water. Revised Final peer-reviewed LCA report." [online] Available at: http://www.oregon.gov/deq/FilterDocs/wprLCycleAssessDW.pdf (accessed 3 June 2018)

Galbreth, M., M. A. Waller, C. Vincent, and D. G. Hyatt. 2013. "Bottled Water Logistics and Forecasting." *Wal-Mart Sustainability Case Project 4.* University of Arkansas. [online] Available at: http://scholarworks.uark.edu/scmtwscp/4 (accessed 12 January 2019)

Gamze, G.D., L. Juneseok, M. Mirzaei, and T. Younos. 2016. "How do people make a decision on bottled or tap water? Preference elicitation with nonparametric bootstrap simulations." *Water and Environment Journal* 30 (3-4): 243–252.

Gleick, P. H., and H. S. Cooley. 2009. "Energy implications of bottled water." *Environmental Research Letters* 4 (1): 1-6 [online]. Available at: http://www.container-recycling.org/assets/pdfs/2009-BottledWaterEnergy.pdf (accessed 3 June 2018)

Graafland, J., and H. Smid. 2016. "Environmental Impacts of SMEs and the Effects of Formal Management Tools: Evidence from EU's Largest Survey." *Corporate Social Responsibility and Environmental Management* 23 (5): 297–307.

Gurav, R. (2004) Closed loop transport management. *Logistics & Transport Focus* 6: 44-47.

Hagelaar, G. J.L.F., J. G.A.J. van der Vorst. 2002. "Environmental supply chain management: using life cycle assessment to structure supply chains". *International Food and Agribusiness Management Review* 4:399-412.

Heidrich, O., and A. Tiwary. 2013. "Environmental appraisal of green production systems: Challenges faced by small companies using life cycle assessment." *International Journal of Production Research* 51 (19): 5884–5896.

Hillary, R. 2004. "Environmental management systems and the smaller enterprise." *Journal of Cleaner Production* 12 (6): 561–569. doi:j.jclepro.2003.08.006.

Hochschorner, E., and G. Finnveden. 2003. "Evaluation of Two Simplified Life Cycle Assessment Methods." *The International Journal of Life Cycle Assessment* 8 (3): 119-128.

Hussey, D. M., and P. D. Eagan. 2007. "Using structural equation modeling to test environmental performance in small and medium-sized manufacturers: can SEM help SMEs?" *Journal of Cleaner Production* 15 (4): 303-312.

IBWA. 2016. "Bottled water – the nation's healthiest beverage – sees accelerated growth and consumption." [online].Available at: http://www.bottledwater.org/bottled-water-

%E2%80%93-nation%E2%80%99s-healthiest-beverage-%E2%80%93-sees-accelerated-growth-and-consumption (accessed 1 June 2018)

Intergovernmental Panel on Climate Change. 2007. "Mitigation of Climate Change." [online] Available at: https://www.ipcc.ch/report/ar4/wg3/ (accessed 15 September 2018)

International Organization for Standardization. (2006a). ISO 14040. Environmental management - Life cycle assessment - Principles and framework, Geneva, Switzerland.

International Organisation for Standardization. (2006b). ISO 14044 International Standard. In: Environmental Management - Life Cycle Assessment - Requirements and Guidelines.

Islam, S., S.G. Ponnambalam, and H.L. Lam. 2016. "Review on life cycle inventory: methods, examples and applications." *Journal of Cleaner Production* 136: 266-278.

Ismajli, A., S. Kajtazi, and E. Fejza. 2013. "The impact of promotional activities on purchase decision making: A case study of Brands Bonita and Rugove- water bottled producers." European Scientific Journal, **9** (31): 465-474. [online] Available at: file:///C:/Users/user/Downloads/2078-6126-1-PB%20(1).pdf (accessed 2 June 2018)

Khoo, H. H., R. B. H. Tan, and K. W. L. Chng. 2010. "Environmental impacts of conventional plastic and bio-based carrier bags." *The International Journal of Life Cycle Assessment* 15 (3): 284–293.

Lagioia, G., G. Calabrò, and V. Amicarelli. 2012. "Empirical study of the environmental management of Italy's drinking water supply." *Resources, Conservation and Recycling* 60: 119–130. doi:j.resconrec.2011.12.001.

Lake, A., A. Acquaye, A. Genovese, N. Kumar, and S.C.L. Koh. 2015. "An application of hybrid life cycle assessment as a decision support framework for green supply chains." *International Journal of Production Research* 53 (21): 6495–6521.

Lee, S. G., and X. Xu. 2004. "A Simplified Life Cycle Assessment of Re-usable and Single-use Bulk Transit Packaging." *Packaging Technology and Science* 17 (2): 67-83. doi:10.1002/pts.643

Lmariouh, L., N. El Hachemi, Jamali, A., and D. Bouami. 2014. "The Multi-vehicle Mutli-product Inventory-Routing Problem: A case study", 2014 International Conference on Advanced Logistics and Transport (ICALT), 1-3 May 2014, Hammamet, Tunisia. [online] Available at: https://ieeexplore.ieee.org/document/6866332 (accessed 14 January 2019)

Karlsen, K.M., P. Olsen, and K.A.M. Donnelly, 2010. "Implementing traceability: practical challenges at a mineral water bottling plant". *British Food Journal*, 112 (2): 187-197.

Koh, S.C., A. Genovese, A.A. Acquaye, P. Barratt, N. Rana, J. Kuylenstierna, and D. Gibbs. 2013. "Decarbonising product supply chains: design and development of an integrated evidence-based decision support system – the supply chain environmental analysis tool (SCEnAT)." *International Journal of Production Research* 51 (7): 2092–2109.

Mathiyazhagan, K., Govindan, K., Noorulhaq, A. and Geng, Y. (2013) An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production* 47: 283-297.

McManus, M.C., and C.M. Taylor. 2015. "The changing nature of life cycle assessment." *Biomass and Bioenergy* 82: 13-26.

McWilliams, A., and D. Siegel. 2000. "Corporate social responsibility and financial performance: Correlation or misspecification?" *Strategic Management Journal* 21 (5): 603-609.

Merrick, R. J., and J. H. Bookbinder. 2010. "Environmental assessment of shipment release policies." *International Journal of Physical Distribution and Logistics Management* 40(10): 748-762.

Min, H., and G. Zhou. 2002. "Supply chain modeling: past, present and future." *Computers & Industrial Engineering* 43: 231-249.

Misopoulos, F., R. Michaelides, M.A. Salehuddin, V. Manthou, and Z. Michaelides. (2018). "Addressing Organisational Pressures as Drivers towards Sustainability in Manufacturing Projects and Project Management Methodologies." *Sustainability* 10 (6): 1-28. doi:10.3390/su10062098.

Nessi, S., L. Rigamonti, and M. Grosso. 2012. "LCA of waste prevention activities: A case study for drinking water in Italy." *Journal of Environmental Management* 108: 73-83. doi: j.jenvman.2012.04.025.

Nulkar, G. 2014. "SMEs and environmental performance – A framework for green business strategies." *Procedia – Social and Behavioral Science* 133: 130–140. doi:j.sbspro.2014.04.177.

Okot, D. K. 2013. "Review of small hydropower technology." *Renewable & Sustainable Energy Reviews* 26: 515-520. doi:j.rser.2013.05.006.

Pandey, D., M. Agrawal, and J. S. Pandey. 2011. "Carbon footprint: current methods of estimation." *Environmental Monitoring and Assessment* 178 (1-4): 135–160.

Ragusa, A.T. and A. Crampton, 2016. "To Buy or not to Buy? Perceptions of Bottled Drinking Water in Australia and New Zealand." *Human Ecology* 44: 565–576.

Rao, P. 2007. "Greening of the supply chain: an empirical study for SMES in the Philippine context". *Journal of Asia Business Studies* 1 (2): 55-66.

Rao, P., and D. Holt, 2005. “Do green supply chains lead to competitiveness and economic performance?” *International Journal of Operations & Production Management* 25 (9): 898-916.

Rebitzer, B., T. Ekvall, R. Frischknecht, D. Hunkeler, G. Norris, T. Rydberg, W.P. Schmidt, S. Suh, B.P. Weidema, and D.W. Pennington. 2004. “Life cycle assessment Part 1: Framework, goal and scope definition, inventory analysis, and applications.” *Environment International* 30 (5): 701-720.

Sarkis, J., Q. Zhu, and K.H. Lai. 2011. “An Organisational Theoretic Review of Green Supply Chain Management Literature”. *International Journal of Production Economics* 130 (1): 1-15.

Saylor, A., L.S. Prokopy, and S. Amberg. 2011. “What’s Wrong with the Tap? Examining Perceptions of Tap Water and Bottled Water at Purdue University.” *Journal of Environmental Management* 48 (3): 588–601.

Schlosser, O., I. Z. Déportes, B. Facon, and E. Fromont. 2015. “Extension of the sorting instructions for household plastic packaging and changes in exposure to bioaerosols at materials recovery facilities.” *Waste Management* 46: 47–55. doi:j.wasman.2015.05.022

Sheu J. B., Y. H. Chou, and C. C. Hu. 2005. An integrated logistics operational model for green-supply chain management. *Transportation Research Part E: Logistics and Transportation Review* 41 (4): 287-313.

Sezen, B. and S.Y. Cankaya. 2017. “Green Supply Chain Management Theory and Practices." In *Ethics and Sustainability in Global Supply Chain Management*. IGI Global: Hershey, PA, USA.

Srivastava, K.S. 2007. “Green supply-chain management: a state-of-the-art literature review.” *International Journal of Management Reviews* 9 (1): 53-80.

Statista. 2016. “Per capita consumption of bottled water worldwide in 2015, by leading countries (in gallons).” [online]. Available at: https://www.statista.com/statistics/183388/per-capita-consumption-of-bottled-water-worldwide-in-2009/ (accessed 1 June 2018)

Statista. 2017. “Per capita consumption of bottled water in Europe in 2016, by country (in liters per capita).” [online]. Available at: https://www.statista.com/statistics/455422/bottled-water-consumption-in-europe-per-capita/ (accessed 1 June 2018)

Stavropoulos, P., C. Giannoulis, A. Papacharalampopoulos, P. Foteinopoulos, and G. Chryssolouris. 2016. “Life cycle analysis: comparison between different methods and optimization challenges.” *Procedia CIRP* 41: 626 – 631.

Strandberg, C. 2002. The Future of Corporate Social Responsibility. *Report by Strandberg Consulting*. VanCity Credit Union, Vancouver.

Suh, S. and G. Huppes. 2005. “Methods for Life Cycle Inventory of a product.” *Journal of Cleaner Production* 13: 687-697.

Thanh, N.P., Y. Matsui, and T. Fujiwara. 2011. “Assessment of plastic waste generation and its potential recycling of household solid waste in Can Tho City, Vietnam.” *Environmental Monitoring and Assessment* 175 (1-4): 23–35. doi:s10661-010-1490-8.

Torretta, V. 2013. “Environmental and economic aspects of water kiosks: Case study of a medium-sized Italian town”. *Waste Management* 33: 1057–1063.

Trefis Team. 2015. “Bottled Water Is a Potential Growth Category That Can’t Be Ignored.” [online]. Available at: https://www.forbes.com/sites/greatspeculations/2015/06/26/bottled-water-is-a-potential-growth-category-that-cant-be-ignored/3/#58f5531c7a4d (accessed 1 June 2018)

Vachon, S. and R. Klassen. 2007. "Supply chain management and environmental technologies: the role of integration." *International Journal of Production Research* 45 (2): 401–423.

Van Hoek, R. I. 2000. "From reversed logistics to green supply chains". *Logistics Solutions*, 2: 28-33.

Walker, H., L. Di Sisto, and D. McBain. 2008. "Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors." *Journal of Purchasing and Supply Management* 14 (1): 69-85.

Wannaz, C., A. Franco, J. Kilgallon, J. Hodges, and O. Jolliet. 2018. "A global framework to model spatial ecosystems exposure to home and personal care chemicals in Asia." *Science of the Total Environment* 622–623: 410–420.

Weidema, B.P., M. Pizzol, J. Schmidt, and G. Thoma. 2018. "Attributional or consequential Life Cycle Assessment: A matter of social responsibility." *Journal of Cleaner Production* 174: 305-314.

Wilding, R., and R. Juriado. (2004) "Customer perceptions on logistics outsourcing in the European consumer goods industry." *International Journal of Physical Distribution and Logistics Management* 34 (8): 628-644.

World trade report. 2016. "Levelling the trading field for SMEs." [online] Available at: https://www.wto.org/english/res_e/booksp_e/world_trade_report16_e.pdf (accessed 2 June 2018)

Zakhidov RA. 2008. "Central Asian countries energy system and role of renewable energy sources." *Applied Solar Energy* 44 (3): 218–223.

Zhu, Q., and J. Sarkis. 2004. "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing, enterprises". *Journal of Operations Management* 22: 265-289.

Zhu, Q., J. Sarkis, J. J. Cordeiro, and K. H. Lai. 2008b. “Firm-level correlates of emergent green supply chain management practices in the Chinese context.” *Omega* 36 (4): 577–591. doi: j.omega.2006.11.009.

Zhu, Q., J. Sarkis, and K. H. Lai. 2008a. “Green supply chain management implications for closing the loop”. *Transportation Research Part E: Logistics and Transportation Review* 44 (1): 1–18.

Table 1. Materials and quantities used by the three companies

Table 2. Inputs into the process LCA system

Table 3. Supply chain emissions for the three companies

Figure 1. Bottled water process map of each company