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Analysis of opportunities for greenhouse emission reduction in the global supply chains of cashew industry in West Africa

Martin Agyemang [a], Qinghua Zhu [b, *], Yihui Tian [a]

[a] Faculty of Management and Economics, Dalian University of Technology, Dalian, Liaoning Province 116024, PR China
[b] Antai College of Economics and Management, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai 200030, PR China

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ABSTRACT

Global supply chains (GSCs) have become common for industries, and companies seek to reduce their environmental impact, particularly greenhouse gas (GHG), through their GSCs. Guided by ISO 14044, we measure and compare GHG emission of 1000 kg of cashew kernels in 12 GSCs scenarios of West Africa cashew industry, and identify opportunities for reduction. The results show that transportation, cashew processing operation and nutshells waste management produce significant proportion of the total GHG emission. Such results highlight the fact that alternatives in process units and flows in life cycle systems can reduce GHG emission of a product. Thus, limitation of transportation of raw cashew nuts for primary processing, the use of energy-efficient processing methods, and processing on large-scale gives options to supply chain managers and decision makers in the industry to reduce GHG emission. Again, making use of co-product (nutshells) reduces cashew kernels GHG emission much more than it may have been considered by most stakeholders. The challenges of measuring and comparing GHG emission in the industry's GSCs such as non-existing or inadequate quality databases are also discussed.

1. Introduction

The increasing push towards globalization has come along with an increasing common marketplace (Harvey and Richey, 2001) and organization of global industries (Gereffi and Lee, 2012). Supply chains are becoming global-based than ever (Chopra and Meindel, 2007). Competition among individual companies has been shifted to supply chains (Christopher, 2005). Any reported negative environmental impact of a product along its global supply chain (GSC) has a potential to damage its reputation (Tan et al., 2009). Concerns of greenhouse gas (GHG) as a causal factor of global climate change remain a priority for many stakeholders within the broad frame of sustainable GSCs (Avetisyan et al., 2014; Benjaafar et al., 2013; Matthews et al., 2008). Global climate change poses a threat for globalized and sustainable supply chains. Each industry requires an enhanced understanding of its unique situation on how it contributes to global climate change and how it would be affected by these climatic changes (Lee, 2011; Porter and Reinhardt, 2007). To effectively address GHG emission reduction, companies need to rethink their supply chains by acting from a broad and global perspective (Sundarakani et al., 2010). Companies need to look beyond their direct emission and adopt strategies which embrace the capacity to influence emission within the broad scope of their operation that include suppliers and customers (Hoffman and Bansal, 2012; Plambeck, 2012; Hoffman, 2007). Thus, it is important to form inter-organizational partnerships among supply chain members in the face of uncertainty and complexity in environmental information processing (Sharfman et al., 2009), to achieve GHG emission reduction in their GSCs.

GHG emission in agriculture and food industry supply chain management has become significant due to the demand for more sustainable food system and against the backdrop of increasing intensities of activities in food systems such as transportation (Jones, 2002). GHG emission of various food products such as wine (Colman and Päster, 2009; Pattara et al., 2012; Cholette and Venkat, 2009), fresh vegetables (Cembalo et al., 2013), seafood products (Ziegler et al. (2013) and bananas (Svanes and Aronsson, 2013) have been studied. Though emission in the cashew industry from individual factories is generally low, the magnitude from a cluster of

* Corresponding author.
E-mail addresses: martinon463@gmail.com (M. Agyemang), qhzhu@sjtu.edu.cn (Q. Zhu), tianyh@dlut.edu.cn (Y. Tian).

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factories is high (Mohod et al., 2011a). Distance between production and consumption of cashew raises concerns for supply chain members who are keen on sustainability. The West Africa cashew industry is a typical food and agricultural industry with supply chains globally, sometimes involving more than two continents. Although, Brito de Figueirêdoa et al. (2016) recently published an LCA peer-reviewed research on environmental impacts of cashew cultivation in Brazil, we are not aware of any other LCA that focus on cashew supply chain GHG emission. This study aims to contribute to sharing insight on the nuance of comparing complex GSCs and GHG emission based on an industry level perspective. The following are the research questions:

1. How do we measure and compare GHG emission in the GSCs of the cashew industry in West Africa?
2. How can the cashew processing sector in West Africa manage and reduce its GHG emission in GSCs?

To answer these two research questions, the rest of the paper is organized in the following manner. The next section presents an overview of the West Africa cashew industry and reviews the intersection between GSCs and GHG emission reduction. Section 3 focuses on the life cycle inventory with discussion on data sources and assumptions. Section 4 introduces the results of the study with assessment. In Section 5, opportunities to reduce GHG emission in the various GSC scenarios are examined. Further discussions of the analysis in relation to the research questions are carried out in Section 6. The study concludes in Section 7, and it takes a closer look at the wider implications of the study.

2. Background and literature review

2.1. An overview of GSCs in the West Africa cashew industry

Cashew (*Anacardium occidentale*) is one of the world's nuts with a high market price. Its global consumption, economic value, and prospective demand remain high (Azam-Ali and Judge, 2001). The nut is predominately produced in semi-arid, sub-tropical regions of Latin America, Africa and South and South-East Asia (Kanji, 2004). It is estimated that Africa produces not less than 38.8% of the global production (FAO, 2013). The main products from cashew traded on the global market are the raw cashew nuts (RCNs), cashew kernels, and cashew nut shell liquid (CNSL) (Jekayinfa and Bamgboye, 2006). Like many other global industries, cashew stakeholders are concerned with environmental issues (Mohod et al., 2011a). Regardless of their operation methods, cashew factories that process local RCNs often make claims of their ability to reduce total GHG emission in their GSCs than those who process imported RCNs for the global market. This is used as a competitive strategy in the global cashew trade (e.g. East Bali Cashews[1]). Cashew kernels buyers and retailers may use this information for purchasing decisions. It may be a rather simplistic assessment to only use distance to determine GHG emission, or for decision, to optimize processes in the supply chain (Cholette and Venkat, 2009; Saunders and Barber, 2008). The use of such data from an environmental perspective in a supply chain may be insufficient (Sanjuán et al., 2014). This can potentially create highly significant misleading metrics (Cholette and Venkat, 2009).

[1] East Bali Cashew is a cashew company in Indonesia that process local RCNs. It shows on its website that through local processing they are able to reduce GHG emission of Indonesia cashew on the global market. http://www.eastbalicashews.com/accessed on 20th February 2015.

2.2. Literature review on measurement of GHG emission and redesign of GSCs

A supply chain constitutes all stakeholders and a network of organizations involved in the direct and indirect flows of goods and information from the extraction stage to provide products or services that meet the needs of end users. At the global level, this involves integration of activities and processes among organized entities in multiple countries (Harvey and Richey, 2001). Since the 1990s, industrial activities and the nature of most contemporary supply chains tend to be geographically fragmented and expanded across countries (Gereffi and Lee, 2012). This involves the cross-border movement of goods, the emergence of global competitors and opportunities across competing supply chains (Mentzer et al., 2009). Although perspectives on GSCs have evolved from diverse fields of research and practice, the underlying meaning of a GSC is centered on the idea of increasing internationalization, integration and interdependent nature of supply chains (Sajadieh, 2009; Mentzer et al., 2009). Similarly, in this study, GSC means activities and processes carried out in and between different countries to meet a customer's need.

An extensive span of the literature brings to the research community and business environment the concerns of GHG emission in supply chains. Most of these studies (Edwards et al., 2010; Point et al., 2012) focus on relatively simple supply chains characterized by two distant locations (Avetisyan et al., 2014). Others focus on carbon efficiency of local products versus imported goods (e.g. Saunder et al., 2006; Jones, 2006). However, international supply chain networks of companies are usually not characterized by one or two locations but multiple locations (Hameri and Hintsa, 2009). Different logistics and other complex determinants such as market, production systems, technology, skills and government policies can influence GHG emission in a GSC. The rapidly growing trend of GSCs in industries makes it essential (Brenton et al., 2009) to identify, understand, quantify, analyze and manage the impact of GHG emission (Sundarakani et al., 2010).

It has been recognized in an increasing number of life cycle management literature (e.g Sánchez et al., 2004), that potential process units or stages of life cycle may generate more emission than identified hotspots. Thus, to enable companies and other decision-makers to take environmentally appropriate decisions for selection of raw materials, suppliers, and processes for the production, and delivery of goods to the end users, it is important to make comparison of options available.

Many tools and indicators for assessing environmental impacts have been developed. Examples include life cycle analysis (LCA), product carbon foot printing, energy, exergy or emergy analysis, material flow analysis, substance flow analysis and monetizing environmental impacts. Among these instruments, LCA has been recognized as a well elaborate scientific method and quantitative decision-support tool for assessing potential environmental impacts and resource used throughout a product's lifecycle (ISO, 2006a,b). It has been widely used by companies, academics and governments to identify, measure and evaluate the environmental impact and emission of a product or process in the supply chain (Guinee et al., 2011; Lee, 2011; Pennington et al., 2004; Rebitzer et al., 2004). LCA is intuitively appealing but Geisler et al. (2005), Lloyd and Ries (2007), Huijbregts et al. (2004) and many other scholars have highlighted that like any other assessment tools, there are inherent weaknesses in conducting an LCA study, for example, data uncertainty and variability (Finnveden et al., 2009). Reap et al. (2008) observed 15 limitations of LCA and shows that data availability and quality are critical factors that affect all phases of LCA. More specifically, McKinnon (2010) identified some practical weaknesses and costs associated with GHG emission auditing