Journal of Cleaner Production xxx (2015) 1–11

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Carbon footprint along the Ecuadorian banana supply chain: methodological improvements and calculation tool

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ARTICLE INFO

Article history:
Received 17 November 2014
Received in revised form
18 September 2015
Accepted 18 September 2015
Available online xxx

Keywords:
Fruit
Food
Transport
Cradle-to-grave
Nitrous oxide
Emission factors

ABSTRACT

Bananas are among the five most important food crops in the world, after wheat, rice, maize, and potatoes and Ecuador is a major banana producer and the world's leading banana exporter. A detailed carbon footprint assessment from cradle-to-grave of the Ecuadorian banana value chain was carried out. Special effort was made to adjust the emission factors to the local conditions, especially in those activities that were expected to contribute most to the whole footprint. The calculated carbon footprint of Ecuadorian bananas, inclusive of the consumption point in Spain, was 1.28 tonne CO_2e per tonne of banana. The results were also reported individually for the main contributors within the value chain. The values reported in this study are lower or in line with those available in the literature and the differences can be attributed to the use of different parameters – adjusted in the present study to the specific conditions of Ecuador. Farm stage was identified as the main contributor (22.1%) and significant differences were found between the environmental performance of conventional and organic farms, mainly due to the use of synthetic fertilizers in the former and the related nitrous oxide emissions. A carbon footprint Excel-based calculation tool was also developed, to allow Ecuadorian stakeholders to evaluate different operating conditions. The methodological adjustments developed in this study can be applied to future cases of similar characteristics. For example, the new emission factors obtained can be used to determine nitrous oxide emissions from managed soils in tropical countries; also of broader applicability are the emission factors that consider different load percentages and refrigerated conditions in transport stages. Moreover, the carbon footprint calculation tool will allow banana stakeholders to evaluate their environmental performance under varying conditions and to identify scope for mitigating greenhouse gas emissions.

1. Introduction

The first life cycle assessments (LCA) of food products were performed in the early 1990s, when the focus started to shift from food packaging to agricultural production and food processing (Durlinger et al., 2014). Among these pioneer assessments, Andersson (2000) evaluated the feasibility and limitations of the application of the LCA methodology to food products and production systems, concluding that LCA was a very valuable tool for incorporating environmental aspects in the development of more sustainable systems for the production and consumption of foods.

Food and agricultural LCAs became much more frequent during the following decade (Durlinger et al., 2014), mainly due to a higher public interest as consumers were and are increasingly aware of the environmental impacts of the food commodities they eat.

A few review studies have tried to summarize the results and findings of the vast amount of life cycle assessments of food products: Roy et al. (2009) performed a comprehensive review of LCA studies on agricultural and industrial food products; Bessou et al. (2013) carried out a similar analysis but focusing on perennial cropping systems; Cerutti et al. (2011) performed a review of the application of environmental assessment methods, including LCA, to fruit production systems. Two common findings of these studies can be highlighted:

- Great heterogeneity was found in the methodologies and data sources considered in the papers reviewed. The three reviews

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http://dx.doi.org/10.1016/j.jclepro.2015.09.074

Please cite this article in press as: Roibás, L., et al., Carbon footprint along the Ecuadorian banana supply chain: methodological improvements and calculation tool, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.09.074

concluded that further international standardization would enable direct comparison of different case studies and broaden their practical applications.

- The global warming (GW) impact category prevailed among those assessed in the papers reviewed, being the only impact pathway considered in many of them.

Regarding the former, several standards of special applicability to agricultural products have been published recently: Product Category Rules (EPD, 2015) of agricultural products aim to establish common and harmonized rules to ensure that similar procedures are used when creating environmental product declarations; while the Publicly Available Specification (PAS) for the assessment of life cycle greenhouse gas emissions from horticultural products (BSI, 2012) was created to adapt the PAS to these complex agricultural systems.

Concerning to the latter, the prevalence of GW assessments, although often seen as a shortcoming, can be easily explained by two factors: 1) the fact that the agricultural sector is known to be a major contributor to climate change, representing a 10–12% of the global anthropogenic emissions of greenhouse gases (IPCC, 2014); 2) the increasing resonance of carbon footprint (CF) of a certain product as an environmental indicator, defined as the total greenhouse gas emissions over its whole life cycle[1] (Carbon Trust, 2012). The widespread development of this indicator can be explained because it is very intuitive and easily understood by non-expert users (Weidema et al., 2008).

The carbon footprint assessment of plant-based products is often part of an effort to shift to more sustainable practices, both at the farm stage and along the supply chain. At the farm stage, this indicator has proven useful for the identification of hotspots and the comparison of different agricultural practices: the most outstanding example of opposing practices are conventional and organic farming: the latter places strict limits on synthetic pesticide and fertilizer use and encourages the use of on-site resources (European Commission, 2015); some other variables could be the degree of intensity of the agriculture: intensive agriculture increases productivity but also requires higher amounts of chemicals and fuels (Tilman et al., 2002); and farm sizes: increasing farm size usually implies more mechanization and consequently, a higher fuel consumption (Lorencowicz and Kocira, 2002). Some studies have already tackled the influence of these alternatives in the CF of agricultural products:

- Yuttitham et al. (2011) performed a CF assessment of sugarcane cultivation in several farms, concluding that the major source of impacts was fertilizer production and utilization, and finding that the farm size did not significantly affect the CF value.
- Schäfer and Blanke (2012) compared the CF of pumpkins from three farms of different characteristics: a conventional intensive farm, a conventional small farm and an organic farm, obtaining the lowest emissions per hectare for organic farming, and pointing out at N_2O emissions from nitrogen fertilization as the major contributors to the CF of the farm stage.
- Knudsen et al. (2014) compared the carbon footprints of different organic and one conventional arable crop rotations, also showing that average GHG emissions per hectare were significantly lower in the organic systems compared to the conventional ones, and highlighting the importance of including soil carbon changes in the CF assessment of crop rotations.

Not only the agricultural stage should be considered in CF assessments of food products, since in the particular case of crops produced in southern tropical countries and consumed in Nordic countries like Europe, non-negligible emissions are also produced during transoceanic transportation and other transport stages. For example, Sim et al. (2007) compared three imported products (Kenyan and Guatemalan beans; Brazilian and Chilean apples; and American watercress) delivered to the UK with their national counterparts and concluded that the global warming impact of imported beans was between 20 and 26 times that estimated for UK beans, mainly due to air transportation. In the case of apples, transport was found to be the dominant contributor to GW for Chilean and Brazilian apples shipped to the UK (72% and 90%). Regarding American watercress, air transport contributed 89% to GW.

The relevant contribution of transport stages (especially for air freight, but also for sea and road transports) was also highlighted by a LCA of numerous fruits and vegetables sold in Switzerland, either produced locally or transported from different countries (Stoessel et al., 2012).

Some recent studies assessed the CF of imported tropical fruits that were shipped to their destination countries: Ingwersen (2012) studied fresh pineapple produced in Costa Rica and sold in the United States, finding that 15% of the final value corresponded to fruit transport; while Brito de Figueirêdo et al. (2013) studied Brazilian yellow melon exported to Europe (mainly to the United Kingdom and the Netherlands), and found that transport emissions ranged from 9 to 16 percent of the total footprint, depending on the assumptions made at the farm stage.

Following the lead of the aforementioned studies, the present paper analyzes the carbon footprint of the whole value chain of bananas grown in Ecuador and consumed in Europe (Spain). At the farm gate, the environmental performance of organic and conventional systems will be compared, and also the possible influence of farm size in CF will be assessed. Special effort will be made to model transport stages, given their influence on the final figures found by other authors. To the best of our knowledge there are five reported studies that have evaluated the carbon footprint of bananas: Eitner et al. (2012) evaluated banana value chains starting from three Latin American countries; Iriarte et al. (2014) carried out a cradle-to-gate analysis of the Ecuadorian bananas taken to a European port; Luske (2010) performed a similar assessment for Costa Rican bananas; Svanes and Aronsson (2013) based their analysis on Luske's and expanded the scope up to cradle-to-grave; Lescot (2012) compiled four case studies from three different farms of unspecified location. All these papers place their final destinations in northern Europe, and only one includes consumption stage (Svanes and Aronsson, 2013). Of these, Ecuadorian plantations were studied by Eitner et al. (2012) and Iriarte et al. (2014). In the first study, CF calculations were conducted using the Footprint Expert Tool,[2] in which the assessment of farm emissions is based on average European data and process calculation lacked transparency as emission factors are not published, while the second study only considers data collected in a single farm in El Oro region.

This study reviewed the main contributions and weaknesses of the reported studies and performed more adapted CF assessment taking into account the actual conditions in Ecuador. In doing so, data from farming stage were collected in all three main banana producing provinces, namely Guayas, Los Ríos and El Oro, ensuring greater representativeness of the data. The second innovation consisted of adjusting the assessment of nitrous oxide (N_2O)

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[1] Carbon footprint and global warming impacts can be considered equivalent terms, both measuring the amount of greenhouse gases emitted to the atmosphere, but defined by different methodologies.

[2] http://www.carbontrust.com/software#footprintexpert.

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