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Research article

Using water scarcity footprint to choose the most suitable location for forest carbon sinks: A case study

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ABSTRACT

The reduction of greenhouse gas emissions is an urgent and internationally shared target. One of the existing measures to do so is carbon offsetting through afforestation. However, when designing afforestation projects meant to act as carbon sinks, the remaining environmental issues are usually overlooked, with the potential risk of shifting environmental burdens. This study uses the water scarcity footprint as an indicator to choose the most adequate location for afforestation.

To do so, a particular case study aimed at offsetting the carbon emissions of a canning company has been chosen. This multinational company has two main locations: Galicia (NW Spain), and La Unión (El Salvador). First, the annual carbon and water footprints of the production of the company's flagship product (a pack of 3 tuna cans) have been calculated. The carbon footprint has been calculated following the corresponding ISO 14067 and PAS 2050 recommendations. Then, an afforestation project aimed at offsetting those carbon emissions has been designed following the corresponding Spanish regulations, and its prospective water scarcity impacts have been calculated. Two potential locations for the afforestation measure (next to the two company facilities in Galicia and La Unión) were assessed regarding green water scarcity impacts, in order to choose the more sustainable location. If the afforestation project were located in El Salvador, its water scarcity footprint would be 30% higher than in Galicia, and thus Galicia has been chosen as the location for this offsetting action.

A sensitivity analysis has been carried out to evaluate how the use of different evapotranspiration values would affect the results, and the choice of the methodological approach used has been justified. Still, the approach used in this study has some limitations which have also been discussed, and ideas for its further improvement in subsequent studies have been presented.

The relevance of following a holistic approach when designing carbon offsetting projects has been stated. If an afforestation project was planned focusing only on its carbon absorption rate, it may result in a burden shift to other impact areas (such as the water scarcity considered here). Thus, by linking indicators, we make sure that the carbon footprint reduction achieved does not imply an unsustainable contribution to water scarcity.

1. Introduction

The urgency of acting against climate change has been recently proven by the Paris agreement (United Nations, 2015), in which numerous countries committed to the reduction of Greenhouse Gas (GHG) emissions. The first multinational agreement on the subject, the Kyoto Protocol (United Nations, 1998), defined the Clean Development Mechanism (CDM) to allow the companies or governments of industrialized countries to implement emission reduction projects in developing ones, and to receive carbon credits (named Certified Emission Reductions, CER) to meet their own reduction goals. Several types of projects can be used within the CDM framework, such as energy efficiency measures, GHG destruction projects or GHG removal by sinks (United Nations, 2014).

The carbon footprint (CF) is an indicator that measures the sum of GHG emissions and removals in a certain product system, which is expressed as CO_2 equivalents and based on the Life Cycle Assessment (LCA) methodology (ISO, 14067:2013). The CF is the most widespread environmental indicator, since it assesses the contribution of the product to climate change (one of the most pressing environmental issues), it helps identifying hotspots where reduction measures should be applied and it is also very

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intuitive and easily understood by non-expert users (Weidema et al., 2008).

Being food consumption a major contributor to GHG emissions (Watson et al., 2013), numerous studies have calculated the CF of food products, either aiming at identifying hotspots and proposing carbon reduction measures (Jensen and Arlbjørn, 2014; Roibás et al., 2018; Vázquez-Rowe et al., 2013) or at informing consumers through the numerous carbon labelling schemes available (Liu et al., 2016). In Spain, recent examples of the latter are the certification of the CF of bananas (AENOR, 2013), Iberian ham (Eurocarne, 2015) and milk (Feiraco, 2017).

Once the CF of a certain product or process has been determined, it can be offset by means of a GHG sink (i.e. a forest): afforestation and reforestation projects represent on average 0.2% of the overall CERs (UNEP-DTU, 2018).

The decision No 529/2013/EU of the European Parliament (2013) established the accounting rules applicable to GHG emissions and removals from the forestry sector in Europe. Based on that decision, the Spanish Government developed the regulation RD 163/2014 (MAPAMA, 2014), which created the *Spanish registry of carbon footprint, offsetting and CO_2 removal*. This Registry was meant to promote the calculation and subsequent reduction of the CF of Spanish organizations, as well as to encourage projects which improved Spain's sink capacity.

The information contained in RD 163/2014 was later on completed by the creation of a website (MAPAMA, 2017c) containing all the requirements and relevant information about the procedures to register and reduce CFs. Three different actions aimed at reducing the CF of companies were defined there: the first option allows companies to register their CF results and to commit to reduce them; the second option is aimed at the development of carbon sequestration projects, in which the companies can set afforestation or reforestation projects to create carbon sinks that offset their emissions; and the third option is similar to the second one, but the organizations do not set reductions projects by themselves, but buy their reductions from other existing projects.

All three actions are voluntary for all companies, and those that participate are awarded a label. Three different labels exist to indicate if a certain organization calculates, reduces and/or offsets their emissions.

After the development of the aforementioned regulations, the interest of the Spanish companies in calculating and offsetting their emissions increased, and several organizations and companies calculate and/or committee to reduce their CFs (MAPAMA, 2017a), and numerous forestry sinks are created in Spain.

The actions aimed at the measurement, reduction and offsetting of the GHG emissions of products and companies can undoubtedly help tackling climate change. However, when a carbon sequestration project is developed, only its ability to sequestrate carbon emissions is taken into account, thus neglecting other environmental impacts that its implementation may cause. Thus, only focusing on reducing CF may in practice result in a burden shift to other impact areas (Radonjic, 2016).

Forest ecosystems are major water users (Calder et al., 2008), and therefore they have a significant impact on local water cycles. The Water Footprint (WF) is a metric that quantifies the potential environmental impacts related to water (ISO, 14046:2016). This definition includes both the impacts affecting water availability (i.e. water scarcity footprint) and water quality (i.e. water degradation footprint). There are two main approaches to calculate WF (Quinteiro et al., 2018b): the Water Footprint Network approach (Hoekstra et al., 2011) and an impact-based LCA approach (Boulay et al., 2014). Both of them are further detailed in the methods section, along with the justification of the choice of the latter in this study. Numerous examples of the calculation of the water footprint of food products using both methodologies can be found in the literature (e.g. Mekonnen and Hoekstra (2011), Rivas Ibáñez et al. (2017) and Roibás et al. (2016) follow the WFN approach while Milài Canals et al. (2010), Pacetti et al. (2015) and Villanueva-Rey et al. (2018) use the impact-based one). A systematic review of existing WF studies following can be found in Quinteiro et al. (2018b).

In this study, the CF of the annual production of a canning company is calculated based on that of their flagship product, canned tuna. Even though the company is located in Galicia (NW Spain), some of its manufacturing processes take place in La Unión (El Salvador). This study is aimed at evaluating how offsetting the annual GHG emissions of the product through afforestation would affect water availability at the two potential offsetting locations (Galicia and La Unión), through the determination of the water scarcity footprints (WF_S). Moreover, and based on WF_S results, the best location for the offsetting project will be evaluated. It should be noted that this study is not meant to design an actual afforestation plan. Instead, it is a first approximation to the combination of both CF and WF_S indicators to evaluate carbon offsetting projects, and to choose the optimal location for them where several options are available.

This document is structured as follows: after this introduction, the second section details the methodology followed to calculate the CF and WF_S of canned tuna, to design the offsetting project and to calculate its expected WF_S; results are presented and discussed in sections three and four, respectively, and conclusions are shown in the fifth section.

2. Materials and methods

Within this section, a first subsection details the methodological approaches for the calculation of both the CF and the WF_S of the products obtained at the canning company, while a second one focuses on the design of the offsetting project, and third one on the calculation of its impacts.

2.1. Calculation of the carbon and water footprints of the annual production of canned tuna

This study starts from the determination of the CF of the flagship product of the tuna canning company in 2014: a pack of 3 cans. It should be noted that this 2014 based study is an update of an existing one from 2004 (Hospido and Tyedmers, 2005; Hospido et al., 2006), and whose revision was deemed necessary due to changes in the supply chain and the production processes (Fig. 1).

2.1.1. System description

In the 2004 study, a cradle-to-gate LCA of canned tuna was carried out, and the CF (among other environmental indicators but not water footprint) was calculated. At the time, tuna were caught in the Atlantic, Pacific and Indic oceans, and then unloaded at intermediate ports in Abidjan (Cote d'Ivoire), La Unión (El Salvador) and Mahé (Seychelles). From these ports, whole fish was taken to the company facilities in Carballo (Galicia, Spain) in reefer ships owned by the company. Last, tuna was processed (cut, cooked, canned and packed) into the final product (i.e. 3-packs). More detailed information about this study (system description, inventory data and results) can be found in Hospido and Tyedmers (2005) and Hospido et al. (2006).

In 2014, the aforementioned study was updated, adapted to the new supply chain, shown in Fig. 2. At the moment, the tuna is no longer caught in the Indic Ocean, being two of the fishing vessels of the company operating in the Atlantic Ocean and the remaining four in the Pacific. The former unload their captures in the port of Abidjan (Ivory Coast), from which they are sent to several ports in Galicia in a transport reefer vessel owned by the