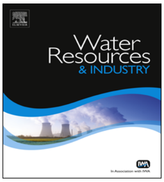
Water Resources and Industry 1–2 (2013) 37–48

Contents lists available at ScienceDirect

Water Resources and Industry

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



Carbon and water footprint analysis of a soap bar produced in Brazil by Natura Cosmetics

I.C.M. Francke [a],*, J.F.W. Castro [b]

[a] Natura Cosméticos, Rodovia Anhanguera s/n° km 30,5, 07750-000 Cajamar, SP, Brazil
[b] Geoklock Consultoria e Engenharia Ambiental, Av. Nações Unidas, 13.797 B.2 14° andar 04794-000, São Paulo, SP, Brazil

ARTICLE INFO

Keywords:
Sustainability strategy
Carbon footprint
Water footprint
Environmental indicator

ABSTRACT

Water shortage represents one of the main threats to life on our planet. Indeed, over the last five years, society and corporate businesses alike have expressed increasing concern about the long-term sustainability of water resources while climate change and freshwater scarcity became important issues for building a consistent sustainability strategy. Here we investigated the relationships between the carbon and water footprints (CF and WF, respectively) of one product from Natura Cosméticos, a leading cosmetic company in Latin America. Our main goal was to determine how to deal synergistically with these environmental pressure indicators in order to help building future strategies that are more sustainable. Our analysis reveals that the total for the CF of the Macadamia soap bar (450 g) was 741 g CO_2e, while the WF was 1.581 l, 1.587 l, and 3.672 l for the green, blue, and gray components, respectively. We found that at the formulation step, the soap has accumulated 84% of the total CF and 99% of the green component of WF while it accumulated only 6% of total blue WF component and 10% of the gray WF component. Our results reveal that the major volumes accounting for blue and gray occur in the use and disposal phase of the product, when the soap is no longer under Natura's outreach. The use and disposal of this product represent 70% of the total WF and only 16% of the CF. WE also found that carbon and water footprints were significantly high in the farming stage, mainly because of the use of fertilizers for palm cultivation. This study reveals some relevant aspects of the carbon and water

---

* Corresponding author. Tel.: +55 11 4446 2863; fax: +55 11 4446 2774.
E-mail addresses: ines.francke@natura.net, ines.francke@me.com (I.C.M. Francke).

2212-3717
http://dx.doi.org/10.1016/j.wri.2013.03.003

footprints and represents an important step for the integration of different environmental pressure indicators for developing novel sustainability strategies that can also be used to increase consumer perception of all environmental aspects of the company operations.

1. Introduction

Water shortage represents one of the main threats to life on our planet. Over the last five years, society and corporate businesses alike have expressed increasing concern about the long-term sustainability of water resources [1]. Thus, climate change and freshwater scarcity became important issues for building a consistent sustainability strategy. However, a conflict between other environmental impact indicators and freshwater use reduction efforts may occur, because of eventual trade-offs.

Carbon footprint (CF) is an indicator of anthropogenic greenhouse gas (GHG) emissions, which according to the Intergovernmental Panel for Climate Change (IPCC) are related to climate change [2]. The water footprint (WF) is a consumption indicator of freshwater use that quantifies direct and indirect volumes. It is a multidimensional indicator that shows consumption and polluted water volumes, specified geographically and temporally. The indicator has three components: the green, blue, and gray water footprints [3].

The carbon and water footprint concepts should complement each other, addressing climate change and freshwater scarcity issues [4]. Indeed, a sustainable strategy has to contemplate both footprints in a way that facilitates impact assessment. However, the first perception when evaluating CF and WF simultaneously is usually their inverse relationship. A clear example is energy and its different sources. For instance, hydroelectricity has a high WF and low CF, on the other hand, fossil fuels have low WF and high CF. This is an obstacle to achieving a consistent sustainability strategy and demands further analysis. The similarities and differences between the two footprints need to be recognized in order to design wise sustainability strategies.

Here we investigated the relationships between the carbon and water footprints of one product from Natura Cosméticos, a cosmetic company in Latin America. The concept of water footprint was fully applied throughout the production line of the product here analyzed, the *Todo Dia Macadamia* soap bar. In this study, we considered not only the supply chain and production processes associated to this product, but also the consumer use and disposal phase. Our main goal was to determine how to deal synergistically with these environmental pressure indicators in order to help building future strategies that are more sustainable.

2. Methods and data

The *Todo Dia Macadamia* soap bar (here referred to simply as “soap”) is sold as a 5-unit package, including 450 g of soap and 26 g of cardboard packaging.

The main ingredient of the soap is a sodium salt derived from vegetable palm oil. This component represents 90% of total soap noodle. The remaining 10% is composed of specific ingredients such as water, starch, organic sugar, titanium dioxide, optical brightener, macadamia oil, and others.

2.1. Product life cycle

The quantification of carbon footprint (CF) and water footprint (WF) associated to the soap was based on the product life cycle inventory (Fig. 1), considering one package of soap as a functional unit. The stages evaluated in the study followed the product life cycle and are described below. In addition, the same production system was used in the analysis of CF and WF.

2.1.1. Farming

The vegetal palm oil used for soap production was obtained from a tropical plantation of palm trees (*Elaeis guineensis*) located in Pará state, Amazon basin, Brazil. Palms are fertilized but not irrigated,

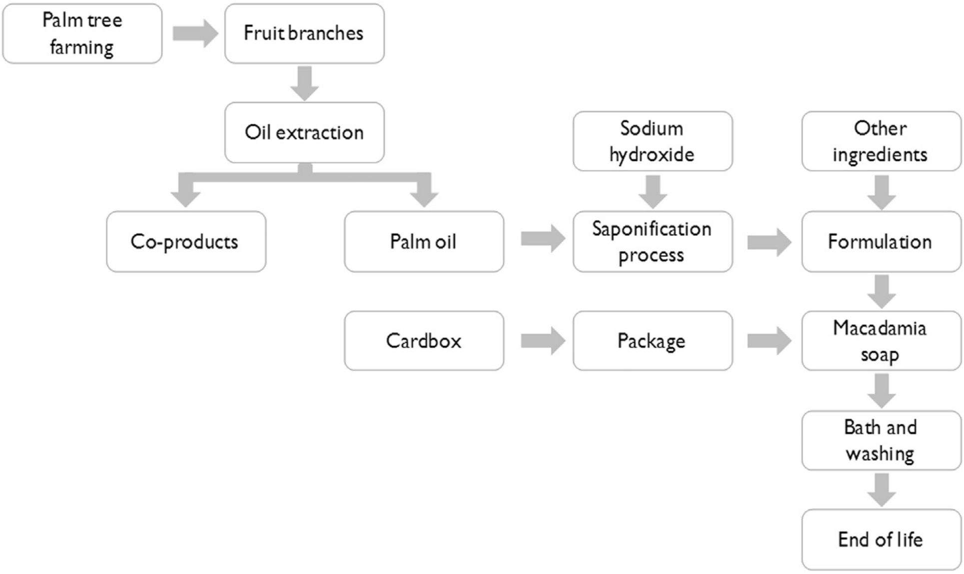


Fig. 1. Schematic representation of the product life cycle.

and palm fruit branches are cropped manually and submitted to the oil extraction process, as described below.

2.1.2. *Oil extraction and refining*

The oil extraction process consists of mechanical press extraction of the pre-cooked palm fruits. The crude palm oil (CPO) extracted is refined and sent to saponification.

2.1.3. *Saponification*

During the saponification process the refined palm oil is submitted to the chemical reaction with sodium hydroxide, resulting in a carboxylic acid salt. This material has surfactant properties and is the base of most soaps. The production is sent to final processing in a third-party supplier of the company.

2.1.4. *Manufacturing and distribution*

The soap bar is formulated adding other ingredients (see above) to the soap noodle.

The WF of supporting operations including factory and office water consumption and the WF associated to energy sources and fuels were partially accounted for, considering the proportion of the soap mass produced. Fuel consumption for transportation of the final product to sale representatives was also considered in this stage, since the sale happens through direct personal presentation, demonstration, and sale of products and services to consumer (direct sales business model). Marketing and supporting materials (magazines and card boxes) were not included in the calculation.

2.1.5. *Product use and disposal*

At the final stage of the product life cycle, the soap is used by consumers for bathing and hand washing. Both activities demand water, which is usually provided by a local water supplier. To meet this demand, water is taken from the catchment area, treated and filtered by the water supplier before being pumped to consumer houses. This process demands energy and varies by region.

Table 1 lists ingredients present in the soap and aggregated input values of soap life cycle inventory.

Table 1
Aggregated input values of soap life cycle inventory.

Materials	
Palm fruit (brunches)	1.53 kg
Fertilizers (NPK)	0.04 kg
Package (cardboard)	0.03 kg
Sodium hydroxide	0.09 kg
Other ingredients	0.04 kg
Energy	
Diesel	0.080 l
Electricity	0.357 kWh
Ethanol	0.013 l
Liquefied petroleum gas	0.006 kg
Natural Gas	0.004 m^3
Heavy oil	0.005 l
Gasoline	0.004 l
Electricity—use average BR	2103 kWh
Electricity—disposal average BR	0.168 kWh

In our calculations, we considered the average energy demanded by water suppliers to provide water to consumers. In addition, the main water basin transfers required by the metropolitan areas of Rio de Janeiro, São Paulo, Salvador, and Fortaleza were considered [5].

The energy used to heat water was not considered because it is not a requirement to use the soap. The amounts of water evaporated during bathing and hand washing was not considered either.

After use, the soap and the water used in the shower is flushed away as domestic effluent. Depending on the region, the effluent can reach the water body directly without any treatment or go through an effluent treatment station (ETS) before returning to the water body. This study considered the average fraction of effluent treated, based on Brazilian sanitation data [6]. The oil component of the soap was defined as the main ingredient potentially associated with changes in the quality of water resources.

2.2. *Carbon footprint*

The carbon footprint method described by PAS 2050 was developed for assessing the GHG emissions of goods and services throughout their life cycle and addresses a single indicator for climate change [2]. It quantifies the emissions from all stages in the product life cycle such as extraction, production, use, and disposal, and is defined as a cradle-to-grave approach [7].

CF is calculated based on the GHG emissions identified and quantified in the stages of the system boundary. The most common and important GHGs are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Refrigerant fluids and specific products such as sulfur hexafluoride are also considered GHGs.

The CF result is presented as mass of carbon dioxide equivalents (CO_2e). All GHG emissions associated to the product were considered in terms of the global warming potential (GWP), which converts the amount of gases to an equivalent carbon dioxide warming potential, converting all the GHG emission to CO_2e. The GWP of carbon dioxide, the main GHG, is 1; for methane it is 21, and for nitrous oxide it is 298. In this article, the results are presented as mass of carbon dioxide equivalent per unit of product.

To determine the CF of the soap here analyzed, we used the following sources of emission factors to estimate the GHG emissions: guidelines for national greenhouse gas inventories [8]; energy content of fuels from Brazilian national energy balance [9]; emissions of electricity generation [10]; and life cycle database modeled for GHG emissions [11] (Table 2).

GHG emissions were calculated based on data collected from the direct suppliers (Table 1) and complemented with data obtained from life cycle database Ecoinvent when non available [11].

Table 2
Energy emission factors.

Source	kg CO_2e/unit	References
Diesel	2456 l	[8,9,11]
Electricity	0.051 kWh	[10]
Ethanol	0.321 l	[8,9,11]
Gasoline	2159 l	[8,9,11]
Natural gas	2555 m^3	[8,9,11]
Heavy oil	3209 l	[8,9,11]
LPG	3600 kg	[8,9,11]

In the disposal phase, it was assumed that the organic carbon of the soap is degraded in aerobic conditions, forming only carbon dioxide and no methane. This results in zero GHG emissions in this phase because the vegetal carbon source (non-fossil) is not regarded as CF, according to the methodology here employed.

2.3. *Water footprint*

The definitions and methodology applied to assess the amount of water used were those described by Hoekstra et al. [3].

2.3.1. *Green water footprint*

The green water footprint refers to the volume of rain water evapotranspirated by agricultural products. In this study, palm farming was the main green water footprint contributor. The amount of water evapotranspirated by the palm farming process was obtained from supplier measurements in the field.

2.3.2. *Blue water footprint*

The blue water footprint refers to water from ground-surface water bodies that is lost either by evaporation, transfer to another catchment area or incorporation into a product. To determine the value of blue water footprint, we assumed that 2.2 m^3 would be used during consumption of one macadamia soap unit (five bars). This volume corresponds to the average water demand for using the soap in the shower. The WF of this stage was calculated based on the losses and transfer of water from different river basins to provide this volume of water. In Brazil, the average fraction of water loss in the water supply system from withdrawal to distribution and return to the water body is 38% [6]. In addition, the average percentage of water supply from other rivers for urban use is 20% [5]. Based on these data and on Water Footprint concepts (assuming the transferred and water loss as a consumption and thus associated to blue WF). for each 1 m^3 of water demanded by the consumer, the blue water footprint is 0.58 m^3.

2.3.3. *Gray water footprint*

The gray water footprint is defined as the volume of freshwater required to assimilate a load of pollutants. All the components are presented as volume of freshwater such as litres or cubic meters [3]. To determine gray WF, product mass was used as a measure of pollutant load (L) converted to a BOD_5 (biochemical oxygen demand) value in the disposal phase. Pollutant load was estimated based on the carbon content in the molecular chains of the soap composition by theoretical oxygen demand method [12]. In addition, we assumed that the packaging material did not reach water bodies, being either recycled or disposed in a landfill.

An efficiency rate of 80% was considered for effluent treatment facilities. In addition, an average percentage of 34% was considered for wastewater treatment in Brazil [5]. The assimilation capacity (C_{max}–C_{nat}) value was defined as the maximum admissible concentration (C_{max}=120 mg BOD_5/l) minus the natural concentration of the water resource (C_{nat}), considered to be 5 mg BOD_5/l, as described in national legislation [13].

2.3.4. Other considerations

The three WF components (green, blue, and gray) were obtained from the supply-chain water footprint developed by Natura in 2011, according to Zhang et al. [14]. The WF of the other ingredients was calculated based on primary data obtained through a survey done with the main suppliers and completed by a supporting database [14].

Consumption of electricity and fuels was also considered in the study. Water footprint values for electricity production in Brazil were obtained through a combination of data from the average generation of main Brazilian electricity sources [15] and water footprint data described by Gerbens-Leenes et al. [16] and Mekonnen and Hoekstra [17,18]. Electricity from hydropower plants represents 73% of the total power capacity in 2011 in the country. Evaporation of main reservoirs that supply the Brazilian grid described by Mekonnen and Hoekstra [18] were assumed as blue water of hydropower sector (140 l/kWh). The WF of fossil fuel sources (16% of capacity) were calculated based on data described by Gerbens-Leenes et al. [16], resulting in an average consumption of 1.5 l/kWh for petroleum-based source. Using the same method, the blue WF was obtained for coal (0.6 l/kWh), and nuclear (0.3 l/kWh) energy. Wind sources has no WF associated according to Gerbens-Leenes [16]. Power plants generation using biomass were included in the calculations. For black liquor and general biomass source 220 l of green water were assumed as the average [16]. The WF of bagasse of sugar cane electricity plants was based on the global average WF described by Mekonnen and Hoekstra [17], resulting in 90, 37 and 8 l/kWh of green, blue and gray WF, respectively. The average WF value calculated for 1 kWh of national grid electricity was 7.8 l of green WF, 105 l of blue WF and 0.5 l of gray WF.

As for the WF of fossil fuels and biofuels (including biodiesel from soybeans and ethanol from sugar cane), the data were obtained from the combination of water footprint values described by Gerbens-Leenes et al. [16], Mekonnen and Hoekstra [17], and information on heating value gathered from the Brazilian National Energy Balance [9]. The primary energy average WF (excluding biomass) adopted from Gerbens-Leenes [16] was equally allocated as blue and gray WF. Table 3 presents the obtained WF values of fuels.

3. Results and discussion

According to the definition of Life Cycle Assessment (LCA), CF and WF are not environmental impact indicators but rather environmental pressure indicators [19,20] because they do not represent the changes taking place in the environment. Nevertheless, both measures may be considered in the discussion on sustainability and equitable human activity. In this study, we investigated the relationships between the carbon and water footprints of Natura's *Todo Dia Macadamia* soap bar to determine how to deal synergistically with these environmental pressure indicators to gain knowledge that may allow us to move towards a more sustainable future.

Table 3
Water footprint of fuels.

Fuel	Unit	Green WF (l/unit)	Blue WF (l/unit)	Gray WF (l/unit)	References	
Heavy oil	l	–	18.8	18.8	[9,16]	Crude oil
LPG	kg	–	2.5	2.5	[9,16]	Natural gas
Diesel oil	l	–	18.8	18.8	[9,16]	Crude oil
Biodiesel (Soy)	l	10,825.0	374.0	198.0	[9,17]	Soybeans biodiesel
Gasoline	l	–	17.6	17.6	[9,16]	Gasoline; crude oil
Ethanol	l	1400.0	575.0	132.0	[9,17]	Ethanol from sugar cane
Natural gas	m^3	–	2.0	2.0	[9,16]	Natural gas

Our analysis reveals that the total for the CF of the Macadamia soap bar (450 g) was 741 g CO_2e, while the WF was 1.581 l, 1.587 l, and 3.672 l for the green, blue, and gray components, respectively.

The main inputs and their contribution to CF and WF are indicated in the flow chart (Fig. 2). Each process step is presented as the cumulative CF and WF values. At the formulation step, the soap has accumulated 84% of the total CF and 99% of the green component of WF. The soap accumulated only 6% of total blue WF component and 10% of the gray WF component. The use and disposal of this product represent 70% of the total WF and only 16% of the CF. Note that the major volumes accounting for blue and gray occur in the use and disposal phase, when the product is no longer under Natura's outreach. This information is crucial in order to invest in strategies and marketing approaches aimed at educating users on the most environmentally friendly disposal alternatives for this product.

The contribution to total CF and WF of each stage of the product life cycle is shown in Fig. 3. Green water footprint is mainly related to the evapotranspiration of palm farming, which occurs in the Amazonia forest, a region of intensive rainfall. Thus, this indicator has to be carefully analyzed, as the value does not necessarily represent an impact to the water availability if the region is taken in consideration. In the disposal stage, the high values of gray WF might be explained by the fact that in Brazil a large fraction of the effluents is not treated by wastewater treatment facilities before discharge into the water bodies, thus increasing the impact to the environment.

Fig. 4 shows use and disposal scenarios for Macadamia soap in three Brazilian regions: average Brazilian region (BR), São Paulo state (SP), and the Amazonas state (AM). The variations in values among the analyzed regions are due to differences in energy consumption rates from water suppliers and wastewater treatment facilities in each county or region. Fig. 5 shows the average Brazilian scenario of 34% wastewater treatment in the disposal phase and compares it to a 100% wastewater treatment scenario.

In this study, we found that carbon and water footprints were significantly high in the farming stage, mainly because of the use of fertilizers for palm cultivation (Fig. 2). The CF of fertilizers is high due to the high energy demand of the production process. Moreover. N_2O fugitive emissions occur at the palm plantation, contributing to GHG emissions. Additionally, fertilizers have high WF because of water pollution in the production process and leaching of nitrogen to water resources when applied in cultivation [21].

Considering that fertilizers represent relevant water and carbon environmental pressure indicators, an important strategy for sustainability to be adopted should be reducing the use of fertilizers in the supply chain. Any reduction in the use of fertilizers would be reflected in smaller carbon and water footprints. However, a lack of nutrients may demand more water consumption by the plant [22].

The organic farming approach, excluding the use of synthetic pesticides and chemical fertilizers and relying on techniques such as crop rotation, green manure, compost, and biological pest control, could be one path towards reducing the footprint associated to the product. In the case of the soap here analyzed, the CF could be reduced by minimizing GHG emissions in the production process. As for the WF, the greater nitrogen retention in the soil through the use of natural fertilizers could reduce the nitrogen leaching rate to water bodies [22,23].

Energy consumption is also an important topic regarding both carbon and water footprints. Fossil fuels are energy sources releasing great amounts of greenhouse gases, but that usually require small water volumes in their value chain. Conversely, some of the main renewable energy sources depend on intensive water consumption. In fact, biofuels and reservoir hydropower plants have a large WF. Biofuels such as ethanol from sugar cane or biodiesel from soy oil demand large amounts of water either through evapotranspiration (green WF), irrigation of farm fields (blue WF), or use of chemical pesticides and fertilizers (gray WF). As for reservoir hydropower plants, their large surface area leads to large amounts of evaporated water, changing the local availability of water resources. The exceptions to the high WF of renewable energy sources are wind, solar radiation, and run-off river hydropower plants.

The replacement of fossil fuels with biofuels in Natura's Carbon Reduction Program [24] may have led to lower CF but larger WF, considering the vegetal origin of biofuels. Thus, in this particular case a conflict between the two environmental indicators raises the question of which indicator deserves priority and there is no simple answer. Nowadays, replacing fossil fuels by renewable energy sources is considered a more sustainable choice [24]. But this directly leads to larger WF. As such, the WF of

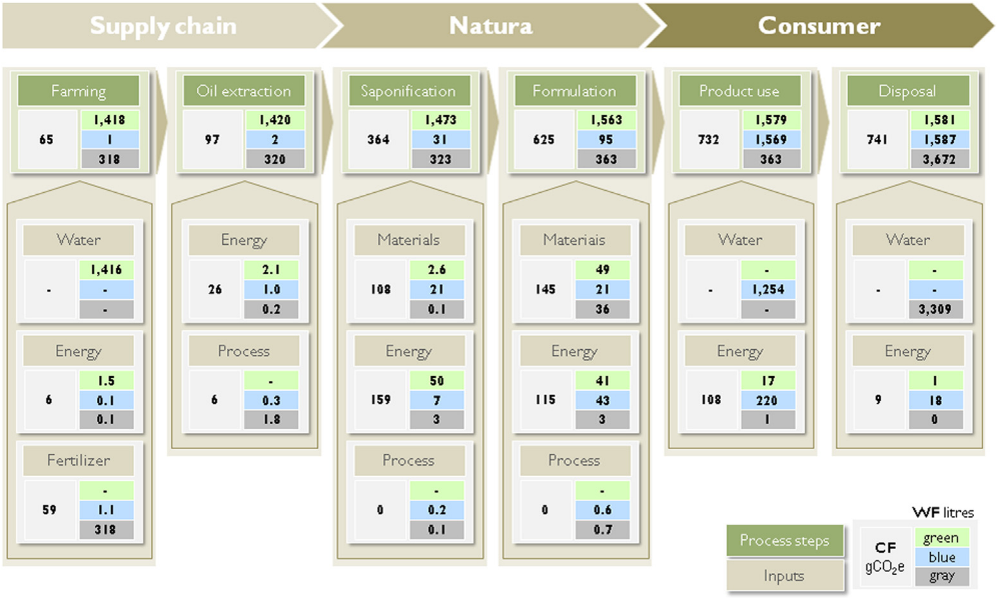


Fig. 2. Flow chart of Macadamia soap CF and WF values. CF values are presented in grams of CO_2e and WF values in litres. Values in process boxes are cumulative.

alternative energy sources has to be carefully chosen to ensure that they will not contribute to water scarcity in a specific production location. In a water-stressed region, fossil fuels could be the best choice, considering that water is essential for food production.

To reduce CF, the energy source in one of the company plants has recently changed from heavy oil to biomass. Indeed, the new energy source is expected to reduce 98% of GHG emissions at the boiler, representing a 42-fold reduction in carbon footprint. Nonetheless, the environmental gain in CF is counterbalanced by a larger WF because water is required for biomass production. Based on average values [16] for biomass (61 m/GJ) and on crude oil (1 m/GJ), the WF had a 61-fold increase. In addition, farming location must also be considered. If the region has a rainfall pattern that does not supply the farming needs, then green WF of the product may cause negative impacts because it may compete with local water availability.

The disposal stage of a cosmetic product may represent a significant impact on the environment, depending on the formulation of the product and location of the final user. The change in water quality occurs when the product wastewater reaches the water body without receiving any previous treatment. To assimilate this pollution, a certain amount of water is required, which was quantified as gray water in this study.

Previous wastewater treatment is necessary to reduce the impacts in the disposal phase, but it depends on local sanitation conditions. Wastewater treatment plants reduce the pollution load in effluents as presented in Fig. 5, and the percentage of effluent treated varies according to the region where consumers live. Thus, current Brazilian water supply and sanitation conditions were considered in this analysis. Among the specific characteristics considered are the many people still living in urban slums and rural areas without access to piped water or sanitation; water scarcity in the north of Brazil; water pollution, especially in the southeast; and the low percentage of collected and treated wastewater (35%) [25].

We found that WF is similar for all three scenarios in the use phase (Fig. 4). The blue WF quantified water losses in the water supply system from catchment to distribution and return to the water body. In addition, it considered the water transferred from other river basins and also the water evaporated by hydropower reservoirs to generate the electricity used by water suppliers was also

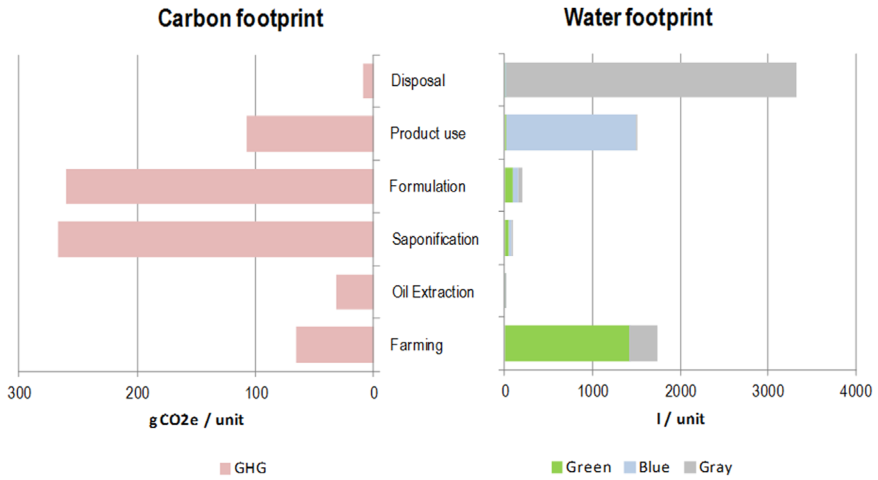


Fig. 3. CF and WF of each stage in the Macadamia soap life cycle. CF has one indicator (GHG emissions), whereas WF has three (blue, gray and water). CF and WF are not comparable. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

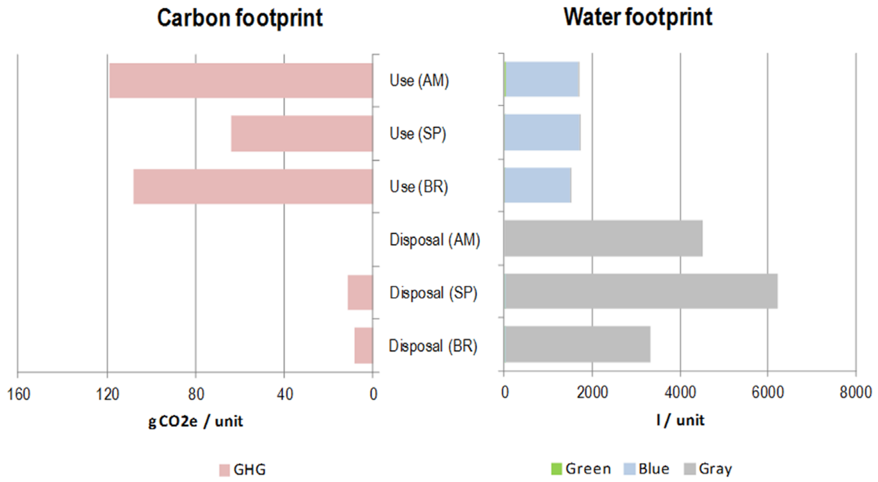


Fig. 4. Disposal scenarios for Macadamia soap in three Brazilian regions. AM: Amazonia State, SP: São Paulo State, BR: Brazil.

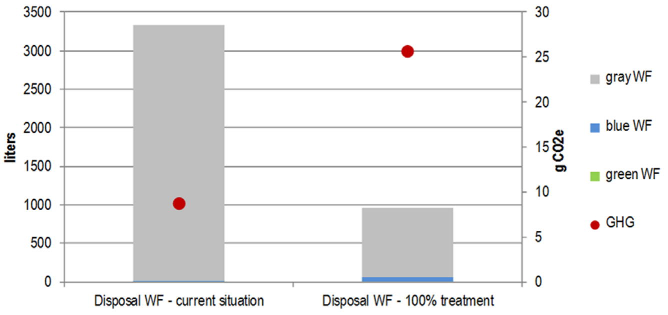


Fig. 5. Wastewater treatment effect on water and carbon footprint of Macadamia soap.

included in the WF estimate. Currently, the São Paulo state transfers 38% of water from one river basin to another. but low water losses occurs in the system [5]. The opposite occurs in the Amazonas state, which does not rely on water transfers, but suffers high water losses during the water supply process.

CF had different results for all scenarios in the use phase, reflecting the energy efficiency rates of the water supply system in each region (Fig. 4). The Amazonas state demands more electricity per cubic meter than São Paulo in order to provide water to inhabitants, and therefore has larger CF. The low CF in the disposal phase for São Paulo state and Brazil (average) are due to low electricity consumption at wastewater treatment plants. CF for Amazonas in this stage was zero, because there are no treatment plants in the region[6]. Thus, all wastewater is discharged directly into water bodies. However, the Amazonas state had lower gray WF than São Paulo, even though a significant percentage of wastewater is treated in São Paulo (over 40%) [6]. This difference in WF levels between the two states can be explained by the assimilative capacity of water bodies. In Amazonas, water bodies can assimilate almost twice the pollution of that in São Paulo [13]. This finding reflects the local capacity of water resources to endure pollutants.

To reduce gray WF energy input is necessary to endure the wastewater treatment process, with a direct effect on blue water and GHG emissions. The trade-offs in WF and CF values can be better interpreted if we consider the average Brazilian scenario of 34% wastewater treatment in the disposal phase and compare it to a 100% wastewater treatment scenario, which would result in a 2400 l reduction in gray WF and a 35 l increase in blue WF (Fig. 5). Considering the water footprint concept, promoting the treatment of all wastewater would result in a 73% reduction in freshwater appropriation expressed as gray WF in the disposal phase, and 35% in total product WF. Regarding CF, this new scenario would represent an extra 17 g of CO_2e, which would result in a 2% increase in total soap GHG emissions.

Estimates of CF and WF values depend on the availability of data on every step of the life cycle of the product. In this study, most data were collected directly from suppliers and from the company operations. Data were also extracted from databases such as Ecoinvent [11] in order to fill existing gaps. The use of average global values instead of regional values might add uncertainties to the results, since these values might vary for the same material, depending on the extraction method and/or production location.

Carbon footprint is an indicator of anthropogenic GHG emissions related to global warming and climate change. The produced emissions contribute to global impact. Thus, the region where the emission occurs is irrelevant but not the amount of GHG released in the atmosphere, which results in higher GHG concentrations, and affect, the whole environment. This fact makes offsetting impacts through emissions trading possible.

Water footprint is used to quantify the amount of freshwater consumed and polluted by human activities, and not the impacts in run-off and water quality of water resources. The water footprint sustainability assessment is based on human appropriation of water and water availability in the environment. Water availability varies significantly with region and time of year. Thus, the timing and place of water consumption is extremely relevant for sustainability assessment. Parameters such as vulnerability of the water system at a specific time or number of consumers in a specific place are crucial to define the impacts on water resources. That type of information is important to sustainability assessment and requires a better understanding of water use and the characteristics of each locale before formulation of wise policy responses. Thus, different than CF, timing and place are two parameters that restrict the option of “water offsetting” because a reduction in water consumption in one region cannot compensate for water scarcity in another.

When choosing ingredients based on environmental indicators, it is important to consider that CF is assessed globally, and thus all reductions are beneficial. However, when replacing an ingredient based on lower WF, further information on timing and place is needed to better understand the results, because WF is a geographical and temporal indicator. Thus, an ingredient with lower WF that is produced in a vulnerable region may not be the best choice.

The company commitment to the Carbon Program already poses some intense challenges that require critical knowledge. For instance, yearly managing of GHG emissions requires constant analysis. Nevertheless, the extension of our efforts is limited by external decisions such as the composition of the Brazilian energy matrix, defined by governmental policies, that considers not only carbon, but also water and solid waste management strategies.

This case study reveals some relevant aspects of the carbon and water footprints and represents an important step for the integration of different environmental pressure indicators for developing novel sustainability strategies that can also be used to increase consumer perception of all environmental aspects of the company operations.

Sustainability strategies aiming to achieve higher efficiency rates are a wise choice, as they reduce the pressure on natural resources. This reduction can be promoted in all production stages by using technologies that demand less energy, reducing material losses in manufacturing, or selecting environmentally efficient materials—with smaller footprints. Further studies should focus on integrating all environmental aspects in order to lead to a more sustainable path.

4. Conclusions

The carbon and water footprint assessment of the Macadamia soap led to valuable knowledge and internal reflections regarding the improvement of the company sustainability strategy for environmental impact management. Despite the fact that the two pressure indicators seem to be divergent, CF and WF actually complement each other, promoting awareness of climate change and freshwater scarcity issues.

Also, the ongoing Carbon Reduction Program is compatible with a freshwater corporate strategy, according to the water footprint methodology applied in this study. The example of heavy oil replacement with biomass — a renewable energy source — is a good practice, even though total WF increased significantly. The higher water demand does not result in negative impacts, because rainfall is abundant in the region the company plant is located. Thus, the use of renewable energy sources such as biofuels can represent a sustainable choice when water demand does not contribute to water scarcity. This will depend on what region water is being extracted from. Moreover, the CF and WF of energy sources may promote the use of other sources such as wind power with lower carbon and water footprint.

Furthermore, the results associated to the use of fertilizers at the farming stage bring an interesting overview of how Carbon and Water pressure indicators may complement each other and support the establishment of a more sustainable supply chain for the industry. The use of fertilizers demands high energy consumption in its production process, increasing the CF. In the other hand, a significant number appears also in the WF due to water pollution and leaching of nitrogen into water resources when applied to the soil. Thus, reduction in the use of fertilizers or alternative techniques, such as organic farming, would lead to smaller carbon and water footprints..

In the scenario evaluated, another interesting aspect is found in the use stage. The soap requires water to be assimilated after used by a consumer. Consequently, a large grey WF is generated in the disposal phase that is no longer under company's outreach. Even though ecodesign practices may increase a product's performance, the real issue still remains at large, since sanitation services must be provided by the government. Having access to safe drinking water and sanitation is central to living a life in dignity and upholding human rights, as declared by the United Nations (UN, 2010 [26]).

The main challenge ahead is to develop tools that enable the management of two different pressure indicators with the complexity of carbon and water, providing relevant information in real time and directing the corporate strategy towards a more sustainable business.

References

[1] Natura Annual Report, ⟨http://natura.infoinvest.com.br/enu/s-15-enu.html⟩ (retrieved on April 13th 2012), 2011.
[2] IPCC—Intergovernmental Panel on Climate Change, Climate Change 2007: Synthesis Report, Spain, 2007.
[3] A.Y. Hoekstra, A.K. Chapagain, M.M. Aldaya, M.M. Mekonnen, The Water Footprint Assessment Manual: Setting the Global Standard, Earthscan, London, UK, 2011.
[4] E.A. Erchin, A.Y. Hoekstra, Carbon and Water Footprints—Concepts, Methodologies and Policy Responses, Side Publications Series 04, 2012, UNESCO, France.

[5] ANA, Agência Nacional de Águas. Atlas Brasil: Abastecimento Urbano de Água - Panorama Nacional Volume 1", Brasília/DF. Ministério do Meio Ambiente, 2010.

[6] Ministério das Cidades, Diagnóstico dos Serviços de Água e Esgoto – 2009,. ⟨http://www.snis.gov.br/PaginaCarrega.php?EWRErterterTERTer=89⟩ (retrieved on January 09th 2012. 09:00:00), 2009.

[7] Publicly Available Specification—PAS 2050:2011, Specification for the assessment of the life cycle greenhouse gas emissions of goods and services, BSI, 2011.

[8] IPCC—Intergovernmental Panel on Climate Change, IPCC Guidelines for National Greenhouse Gas Inventories, Japan, 2006.

[9] EPE Empresa de Pesquisa Energética, National Energy Balance 2011: Base year 2010.

[10] Brazilian Science and Technology Ministry (MCT), ⟨http://www.mct.gov.br/⟩.

[11] Ecoinvent 2.1 database—Life cycle inventories, Ecoinvent v2.1 database and modeled via software SimaPro® 7.3 for IPCC 2007 single issue impact method, ⟨http://www.ecoinvent.ch/⟩.

[12] Von Sperling, Marcos, Introdução à qualidade das águas e ao tratamento de esgotos, Princípios do tratamento biológico de água residuárias. 3° edição, vol. 1, Departamento de Engenharia Sanitária e Ambiental; Universidade Federal de Minas Gerais, Belo Horizonte, ISBN 85-7041-114-6, 2005.

[13] CONAMA, Resolução no 430. de 13 de maio de 2011—Ministério do Meio Ambiente, Conselho Nacional do Meio Ambiente, 2011.

[14] G.P. Zhang, A.Y. Hoekstra, D. Tickner (Eds.), UNESCO-IHE, Delft, the Netherlands, 2012. Plant under Pressure Conference, London, 26 March 2012.

[15] ANEEL, Agência Nacional de Energia Elétrica, "Banco de Informações de Geração", ⟨www.aneel.gov.br⟩ (retrieved on July 4th 2011), 2011.

[16] P.W. Gerbens-Leenes, A.Y. Hoekstra, Th.H. Van Der Meer, Water footprint of bio-energy and other primary energy carriers, UNESCO-IHE, Delft, The Netherlands, 2008 Value of Water Research Report Series no. 29.

[17] M.M. Mekonnen, A.Y. Hoekstra, The water footprint of electricity from hydropower, UNESCO-IHE, Delft, The Netherlands, 2011 Value of Water Research Report Series no. 51.

[18] M.M. Mekonnen, A.Y. Hoekstra, The blue water footprint of electricity from hydropower, Hydrology and Earth System Sciences 16 (1) (2012) 179–187.

[19] J. Rotmans, H.J.M. De Vries (Eds.), Perspectives on Global Change: The TARGETS Approach, Cambridge University Press, Cambridge, UK, 1997.

[20] UNEP (United Nations Environment Programme), Global Environmental Outlook 5: Environment for the Future We Want, UNEP, Nairobi, 2012.

[21] A.K. Chapagain, A.Y. Hoekstra, H.H.G. Savenije, R. Gautam, The water footprint of cotton consumption: an assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries, Ecological Economics 60 (1) (2006) 186–203.

[22] Ana Primavesi, Manejo ecológico do solo: a agricultura em regiões tropicais, Nobel, São Paulo, 1997.

[23] T.N. Ferreira (Coord.), R.A. Schwarz (Coord.), E.V., Streck (Coord.), Solos: manejo integrado e ecológico - elementos básicos. EMATER/RS, Porto Alegre, 2000.

[24] Natura Cosméticos. Programa Carbono Neutro (accessed October 2.10.2012).

[25] ANA, Agência Nacional de Águas, Conjuntura dos recursos hídricos no Brasil—Informe 2011", Brasília/DF, Ministério do Meio Ambiente, 2011.

[26] United Nations, (UN). "Resolution adopted by the General Assembly" Resolution A/RES/64/292, in: Proceedings of the United Nations Plenary Meeting, 28 July, 2010.