denkstatt GmbH
Hietzinger Hauptstraße 28
1130 Vienna, Austria

T +43 1 786 89 00
E office@denkstatt.at
www.denkstatt.eu

Methodology of Barry Callebaut's Corporate Carbon Footprint - Summary

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Authors: Harald Pilz (denkstatt), Theresa Fuchs (Barry Callebaut)

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1 Introduction

The following text summarizes the most important methods and data sources used for calculating Barry Callebaut's corporate and product carbon footprint data. On corporate level, results are calculated for every fiscal year (September to August). On product level, the carbon footprint can be calculated for any given recipe. Calculations on product level are built on the same methods and data sources as the corporate carbon footprint model, but they aggregate numbers per kg for each specific ingredient needed for a certain product, instead of summing up absolute numbers for a fiscal year.

2 System boundaries

General methodical guidelines applied are the Organisational Environmental Footprint (OEF) and the Product Environmental Footprint (PEF) guidelines of the European Commission[1], as well as the GHG Protocol methodology[2]. Therefore the system boundaries ("reporting boundaries" according to ISO_14064-1 2019) are "cradle to gate of customer" and include scopes 1, 2, and 3. This means that the corporate carbon footprint covers all processes involved in the life-cycle of the production of all products of Barry Callebaut. In this system, the processes within organisational boundaries (operated/controlled by Barry Callebaut [ISO_14064-1 2019]) can be differentiated from all other upstream and downstream processes (see Figure 1):

Within organisational boundaries

- Barry Callebaut's cocoa factories, chocolate factories, and specialty factories
- Intercompany transports of products (cocoa products and industrial chocolate) as well as transports of products to customers, which are organised by Barry Callebaut
- Office energy in headquarters in Zurich, Chicago, and Singapore, plus business flights booked by these headquarters

Upstream value chain within reporting boundaries

- Cocoa farming, including impacts of land use change (LUC)
- Production of non-cocoa ingredients (sugar, milk powder, oils and fats, nuts and specialties etc.), including impacts of LUC
- Transport of cocoa beans, cocoa products, and non-cocoa ingredients, including transport of products in between Barry Callebaut's factories
- Processes to extract, refine, and deliver raw materials, fuels, and electricity
- Production of packaging for cocoa beans, cocoa products, non-cocoa ingredients, and industrial chocolate

Downstream value chain within reporting boundaries

- Transport of products (cocoa products and industrial chocolate) to customers, which are organised by external parties[3]

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013H0179

[2] https://ghgprotocol.org/standards

[3] Currently transports organised by Barry Callebaut and by external parties are not presented separately.

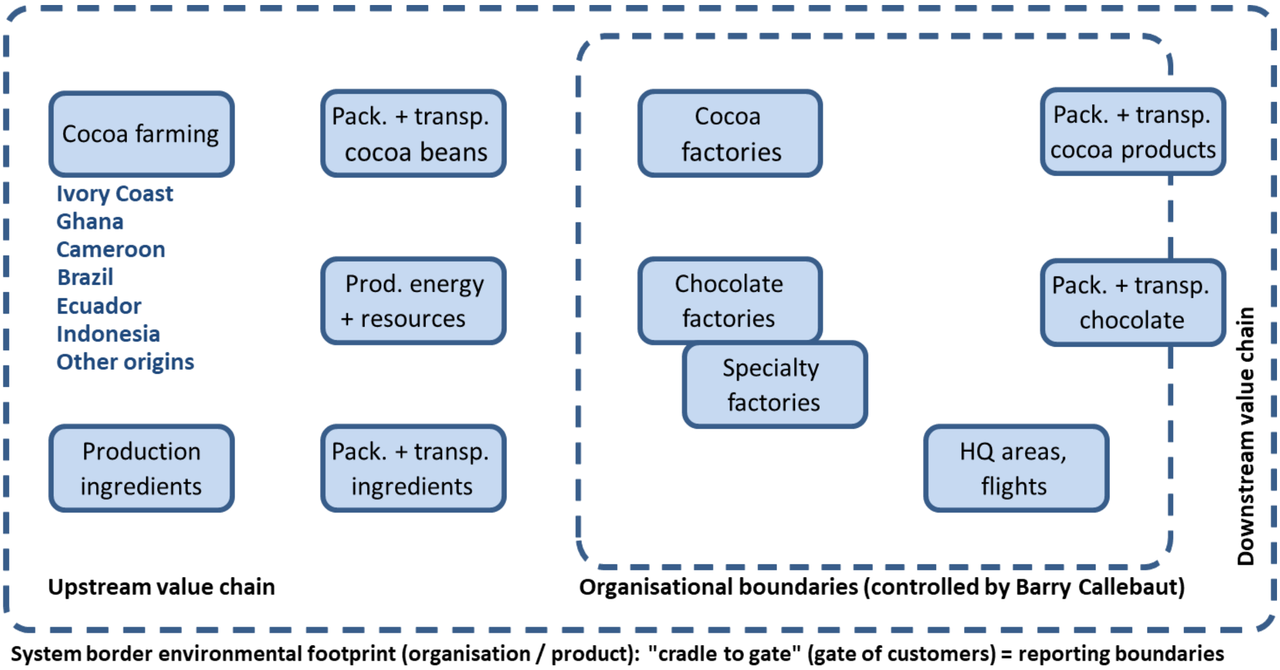

Figure 1: Investigated system showing included processes of the cocoa and chocolate value chain. Abbreviations: Packaging and transport (Pack. + transp.), Production (Prod.), headquarters (HQ). Transports of cocoa and chocolate products to customers are partly organised by external parties; these are therefore part of the downstream value chain.

In Table 1 the investigated processes in the cocoa and chocolate value chain are grouped according to their relevance for Barry Callebaut's corporate carbon footprint.

Relevance of processes in the value chain for Barry Callebaut's corporate carbon footprint (sorted by relative contribution of each process to total corporate carbon footprint)		
High contribution	**> 25 %**	Cocoa farming LUC, Dairy
Medium contribution	**5 – 25 %**	Non-cocoa ingredients LUC, non-cocoa ingredients beside dairy, cocoa farming, transports
Low contribution	**0.5 – 5 %**	Factories of Barry Callebaut, purchased cocoa products, packaging
Negligible	**< 0.5 %**	Offices (office energy & business flights)

Table 1: Relevance of processes in the value chain for Barry Callebaut's corporate carbon footprint, sorted by relative contribution to total corporate carbon footprint

3 Primary data inputs from Barry Callebaut

Basic data inputs to calculate the corporate carbon footprint are provided by Barry Callebaut annually for the respective fiscal year (FY): Volumes processed and produced (cocoa beans by sourcing countries, purchased cocoa products, non-cocoa ingredients split into 32 sub-categories), data on energy and water consumption in all factories of Barry Callebaut (including data on supplier-specific electricity mixes), data on recovery routes for cocoa bean shells, and data on transport. Due to their minor relevance in the total corporate carbon footprint, the data on packaging, office energy, and air travel are only updated every five years (next update for FY 20/21).

Based on these inputs, a detailed input-output mass balance is established. Volumes and energy data of new factories are included in the corporate carbon footprint if data on sold products of these factories are included as well. The input-output mass balance is the basis of all further corporate carbon footprint calculations, while specific recipes are the basis for product carbon footprint calculations.

4 Carbon footprint methodology and databases/references

4.1 Land use change (LUC) related to cocoa farming

Currently LUC (i.e. impacts of deforestation[4]) related to cocoa farming is the most relevant share within the total corporate carbon footprint of Barry Callebaut. **Direct LUC** (dLUC) is quantified based on the "Natural Climate Solutions (NCS) Guidance" (Quantis 2019)[5].

Calculations of the dLUC impact of cocoa beans consider

- a time horizon of 20 years
- all carbon pools (above ground biomass AGB, below ground biomass BGB, soil organic carbon SOC, dead organic matter DOM) in forests and cocoa farms
- data for different typical systems of cocoa farming, called "cocoa farming archetypes"[6]; for each of the six most relevant sourcing countries, three different cocoa farming archetypes are considered; data relevant for LUC calculations are yields and farm gate prices[7] for cocoa and non-cocoa crops in between cocoa trees; these values were updated in 2018 by leading agronomists of Barry Callebaut and Mars
- conservative[8] estimations of wood utilisation in case of deforestation, split into logging and fuelwood; farm gate prices of logs and fuelwood
- economic allocation of the total dLUC impact to cocoa, wood use, and non-cocoa crops
- linear depreciation of the total impact allocated to cocoa over the 16 years of cocoa production within the relevant 20 years since farm establishment (no cocoa yield in years 1 – 4).

For approximately 85 % of the total cocoa bean sourcing volume (Ivory Coast, Ghana, Cameroon, Indonesia), carbon stock losses due to cocoa farming is quantified based on an overlay of satellite data (Global Forest Watch) and GIS data of mapped cocoa farms. For approximately 10 % of cocoa beans (Brazil, Ecuador), carbon stock losses are based on average deforestation intensities (loss of above ground biomass AGB per hectare) as given by Global Forest Watch for relevant cocoa growing regions, and conservatively estimated shares of tree cover loss in the total cocoa farm area. For the remaining less than 5 % of cocoa beans (all other countries), a weighted average of the LUC impact for the 6 most relevant sourcing countries is used.

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[4] Deforestation is the most relevant LUC impact for cocoa framing. Degradation of wetlands, and changes from grassland or annual cropland to perennial cropland are rare.

[5] Quantis (2019): Natural Climate Solutions (NCS) Guidance. https://quantis-intl.com/metrics/initiatives/accounting-for-natural-climate-solutions/

[6] Cocoa farming archetypes represent typical systems of cocoa farming, described by data for yields and farmer prices for cocoa and non-cocoa crops in between cocoa trees, data for fertiliser and pesticide use, water for irrigation, etc.

[7] Farm gate prices are needed for the economic allocation of LUC impacts between different products from the same land.

[8] Estimations of utilised wood volumes are rather low. As a result, LUC impacts of cocoa are rather overestimated than underestimated.

4.2 Land use change (LUC) related to non-cocoa ingredients

Currently LUC related to non-cocoa ingredients is not among the three most important impact categories in the total corporate carbon footprint of Barry Callebaut. LUC impacts are considered for the following non-cocoa ingredients: dairy products (LUC is mostly related to soy in feed for cows), cane sugar, palm (kernel) oil, soy lecithin, coconut oil, and sunflower oil. The respective values are taken from the World Food LCA database, version 3.4 (May 2019).

4.3 Dairy and other non-cocoa ingredients

GHG emissions related to dairy products (milk powder, whey powder, butter oil, other dairy) are currently the second most important contribution to the total corporate carbon footprint of Barry Callebaut. The carbon footprint of all other non-cocoa ingredients is significantly lower. Dairy, sugar, and oils together are responsible for 95 % of the total carbon footprint of all non-cocoa ingredients, which means that data quality is most relevant for these three groups of ingredients.

The CO_2e emission factors for non-cocoa ingredients are taken from the World Food LCA database, version 3.4 (May 2019) for raw milk, beet and cane sugar, palm (kernel) oil, soy lecithin, coconut oil, and sunflower oil. CO_2e emission factors for some smaller volumes of other non-cocoa ingredients (nuts, sweeteners, additives, specialties, flavours) are taken from Ecoinvent database, version 3.3 and from specific LCA studies[9].

For raw milk, specific carbon footprint factors can be considered for 24 - 37 different sourcing countries. For the other most relevant non-cocoa ingredients, the number of country specific datasets varies between 3 and 7. In addition to these generic CO_2e factors (GWP 31), also supplier specific carbon footprint data are used for approximately 20 % of all non-cocoa ingredients (mostly for dairy; also beet and cane sugar), as well as reduced CO_2e emission factors for certified or organic ingredients (organic cane sugar, organic dairy). Respective background methodologies are checked regarding sufficient consistency, before being used for Barry Callebaut's CCF.[10]

The carbon footprint of dairy products is calculated by allocation of carbon footprint data for raw milk to different subsequent products (cream, skimmed milk, whey, skimmed milk powder, full cream milk powder, etc.) based on the dry mass content of the products. This allocation approach is consistent with the methodologies of the International Dairy Federation (IDF)[11] and the PEFCR for dairy products[12]. Data for respective mass flows and energy consumption in dairy factories, as well as carbon footprint for transports to dairy factories were extracted from a study by IFEU[13].

4.4 Cocoa farming

Effects considered for calculating the carbon footprint of cocoa farming, and respective source of data:

- Fertiliser production and use: Only small impact in West Africa, higher impact for "high input farms" in Brazil, Ecuador and Indonesia. Emission factors taken from WFLDB version 3.4.
- Impacts from degradation of cocoa pod husks in piles (CH_4 and N_2O emissions): Emission factors are based on WFLDB version 3.5 and on specific amendments for Barry Callebaut's context made by

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[9] Sabzevari et al. (2015) for Hazelnuts; Marvinney et al. (2014) for Almonds; Vercalsteren et al. (2012) for liquid glucose; own calculations for Vanilla, based on WFLDB data for green vanilla beans

[10] Internal guidance documents describe basic principles to be followed for sufficient consistency.

[11] https://www.fil-idf.org/idf-standing-committee-environment/life-cycle-assessment/carbon-footprint/

[12] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR-DairyProducts_2018-04-25_V1.pdf

[13] IFEU (2014): Umweltbilanz von Milcherzeugnissen – Status quo und Ableitung von Optimierungspotentialen.

denkstatt in 2019. Impacts are partly compensated by carbon sequestration via pod husk composting; respective assumptions are chosen in a very conservative way.
- Indirect N_2O emissions from leaching of SOC and associated nitrogen: Calculations are based on the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories".
- Seedlings and orchard: taken from WFLDB version 3.4.

4.5 Transport

GHG emissions from transporting cocoa beans and non-cocoa ingredients are estimated by modelling typical transport routes via truck and ship for each product group. The respective distances are combined with relevant volumes and with emission factors from Ecoinvent version 3.4. For truck transport of cocoa beans, an average of all four truck classes is used (3.5 – 7.5 t, 7.5 – 16 t, 16 t – 32 t, > 32 t); for non-cocoa ingredients only the biggest truck type is used due to big volumes delivered.

For calculating the carbon footprint of cocoa and chocolate transports, Barry Callebaut developed a refined tool in 2018. It combines specific data on distances, transported volumes, transport modes (ship, truck type, liquid / solid standard / solid cooled), and payload utilisation of trucks, with GHG emission factors specific to each transport situation. The GHG emission factors consider truck size, actual payload utilisation, and share of empty trips. Data sources are actual fuel consumptions provided by transport companies, fuel consumptions listed in CLECAT/DSLV (2012)[14], and emission factors from Ecoinvent version 3.4.

4.6 Factories

Data on energy consumption in Barry Callebaut's factories (electricity, gas, externally produced steam, fuel oil, cocoa bean shells, wood chips) are transformed to GHG emissions by using CO_2e factors covering scopes 1, 2, and 3. Reference databases are Ecoinvent version 3.4 and IEA 2016 (International Energy Agency).

For factories in a liberalised electricity market, specific energy mixes are used to calculate site-specific CO_2e factors for electricity (market based approach). Contracts on using 100 % renewable electricity and on using 100 % biogas are considered as well.

Bean shell recovery and disposal

Internal energy recovery of bean shells is automatically reflected in reduced gas consumption. Benefits of external bean shell recovery options are estimated based on the following assumptions: External energy recovery from bean shells substitutes natural gas; utilisation of bean shells for soil improvement material considers only carbon sequestration of composting (no substitution effect); utilisation of bean shells for feed production assumes substitution of maize with a substitution factor of 0.5 (i.e. 50 % less value of feed, compared to maize). For all external recovery routes, only 50 % of the total benefit is allocated to Barry Callebaut as credit ("open loop" recycling and recovery[15]). Effects of landfilling bean shells (carbon sequestration and CH_4 emissions) are based on models for degradation of organic waste in landfills. Since FY 18/19, no cocoa bean shells have been landfilled.

Purchased cocoa products

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[14] CLECAT/DSLV (2012): Calculating GHG emissions for freight forwarding and logistics services in accordance with EN 16258

[15] In LCA methodologies (like the PEF and OEF methodologies) recycling and energy recovery of waste is linked to credits due to substituted primary production or substituted fossil fuels. For the corporate and product carbon footprint data of Barry Callebaut these credits are calculated based on the "circular footprint formula" of the EU (see reference for PEF methodology above and https://ec.europa.eu/environment/eussd/pdf/Webinar%20CFF%20Circular%20Footprint%20Formula_final-shown_8Oct2019.pdf). For CDP reporting such credits are excluded.

Purchased cocoa products, not produced in factories of Barry Callebaut, are associated with the same weighted average cradle to gate carbon footprint as cocoa products produced by Barry Callebaut.

4.7 Packaging and offices

Packaging materials are considered for cocoa beans, cocoa products, non-cocoa ingredients, and chocolate produced. Carbon footprint calculations consider production and waste management of packaging materials. Respective CO_2e data are based on Ecoinvent version 3.3.

Office heating in the headquarters in Zurich, Chicago, and Singapore, plus flights booked by these headquarters contribute only marginally to the total corporate carbon footprint of Barry Callebaut, but are taken into account.

5 Differences between OEF/PEF[16]/LCA methodology and GHG protocol methodology

Results are presented for each of the described activities/processes along the value chain, and are alternatively split into scopes 1, 2 and 3, based on GHG protocol methodology. For CDP reporting, credits from external cocoa bean shell recovery are excluded from scope 3 emissions. Credits of packaging recycling should be excluded as well, but this is neglected because the respective credits are less than 0.1 percent of the corporate carbon footprint.

6 Data quality and uncertainty of results

Table 2 shows the estimated data quality and uncertainty of carbon footprint impacts calculated for processes in the value chain of Barry Callebaut, sorted by relative contribution to total corporate carbon footprint.

For the quantification of LUC impacts of cocoa farming an overlay analysis of satellite data (Global Forest Watch) and GIS data of more than 125,000 mapped cocoa farms was carried out, and calculations were based on latest available methodologies. The uncertainty of the resulting LUC impacts is still high, because of remaining questions due to limited satellite resolution, and because of unknown deforestation intensity for indirect sourcing, especially related to cocoa from protected areas. Due these uncertainties, the originally measured impacts were increased by safety factors, adding between 74 % and 205 % to the originally measured LUC impact for direct sourcing.

The uncertainty of LUC impacts for non-cocoa ingredients is still high, because the calculation of these LUC impacts in the WFLDB is not yet based on the latest methodical recommendations of the NCS Guidance, and will presumably go through several improvements in the near future.

Nevertheless uncertainties partly compensate each other, as the results for the individual processes in the value chain can both increase and decrease. A Montecarlo-Simulation[17] based on the uncertainty ranges listed below shows that there is a **90 % probability that the total corporate carbon footprint will lie within a range of ± 15 % of the calculated standard result**.

[16] Organisational Environmental Footprint (OEF), Product Environmental Footprint (PEF)

[17] A Montecarlo Simulation assumes that the probability for deviations from the main result is equally distributed within the given uncertainty ranges.

Process	Contribution to corporate carbon footprint	Data quality: Very good, good, fair, poor[18]; reference year of data inputs	Uncertainty of inputs, corresponding uncertainty of total CCF[19] results
Land use change (LUC) related to cocoa farming	**> 25 %**	**Fair for <u>total cocoa LUC</u>; 2018**	Total estimated uncertainty: ± 50 % → **± 17 % for total CCF**
		Good *for direct sourcing from CI, GH, CM, ID;* ***2018****; overlay of satellite data and GIS data of mapped cocoa farms; remaining uncertainties are related to resolution of satellite images and translation into AGB. A safety factor of 90 % on average (varying for each country) was applied to the raw results.*	*Estimated uncertainty: ± 40 %*
		Fair *for indirect sourcing from CI, GH, CM, ID;* ***2018****; remaining uncertainties of extrapolation from direct to indirect sourcing are significant. A safety factor of 44 % on average (varying for each country) was applied to the results for direct sourcing.*	*Estimated uncertainty: ± 60 %*
		Good *for BR and EC;* ***2018****; region specific LUC impacts*	*Estimated uncertainty: ± 40 %*
		Fair *for other origins;* ***2018****; (weighted average of 6 most relevant countries)*	*Estimated uncertainty: ± 60 %*
Production of dairy ingredients	**> 25 %**	**Very good**; **2018**; source is WFLDB 3.4, country specific for > 90 % of total volume	Estimated uncertainty: ± 10 % → **± 3 % for total CCF**
Production of non-cocoa ingredients excl. dairy	**5 – 25 %**	**Good**; **2018**; sources are mostly WFLDB 3.4 or Ecoinvent 3.4; country specific for > 70 % of total volume	Estimated uncertainty: ± 20 % → ± 2 % for total CCF
Land use change (LUC) related to non-cocoa ingredients	**5 – 25 %**	**Fair**; **2018**; LUC model in the WFLDB is not yet crop-specific and not yet based on the latest methodical recommendations of the NCS Guidance	Estimated uncertainty: ± 50 % → **± 3 % for total CCF**
Cocoa farming	**5 – 25 %**	**Fair**; **2018**; very good for effects of fertilizers, poor for impacts from degradation of cocoa pod husks, fair for indirect N_2O emissions from leaching	Estimated uncertainty: ± 30 % → ± 2 % for total CCF
Transport activities	**5 – 25 %**	**Good**; **2019**; very good for transport of cocoa and chocolate (based on detailed data for every transport activity); fair to good for transports of cocoa beans and non-cocoa ingredients (calculated for typical routes and distances)	Estimated uncertainty: ± 20 % → ± 2 % for total CCF
Cocoa and chocolate factories	**0.5 – 5 %**	**Very good**; **2019**; Primary data input from all factories of Barry Callebaut	Estimated uncertainty: ± 5 % → ± 0.2 % for total CCF
Production of purchased cocoa products	**0.5 – 5 %**	**Fair**; **2018**; summary of LUC cocoa, cocoa farming, transport and cocoa factories	Estimated uncertainty: ± 40 % → ± 0.1 % for total CCF

[18] See GHG Protocol Product Standard https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

[19] CCF = Corporate Carbon Footprint

Process	Contribution to corporate carbon footprint	Data quality: Very good, good, fair, poor[20]; reference year of data inputs	Uncertainty of inputs, corresponding uncertainty of total CCF[21] results
Production and recovery of packaging	**0.5 – 5 %**	**Good**; **2016**; Primary data on packaging; typical data for carbon footprint of packaging materials	Estimated uncertainty: ± 20 % → ± 0.3 % for total CCF
Office energy & business flights	**< 0.5 %**	Good for business flights; 2016; Fair for office energy; 2016	Negligible influence

Table 2: Estimated data quality and uncertainty of the carbon footprint impacts calculated for processes in the value chain of Barry Callebaut, sorted by relative contribution to total corporate carbon footprint

[20] See GHG Protocol Product Standard https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

[21] CCF = Corporate Carbon Footprint