

Supporting Information for:

**Derived Environmental Impacts of Organic Fairtrade
Cocoa (Peru) Compared to Its Conventional Equivalent
(Ivory Coast) through Life-Cycle Assessment in the
Basque Country**

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Table S1. Inventory data for Ethiquable's Organic Agriculture and Fairtrade (OA&FT) Chocolate (72% cocoa).

OA&FT CHOCOLATE (1 kg)		
Description	Amount	Unit
INPUTS DURING INGREDIENTS PRODUCTION STAGE		
Carbon dioxide, in air	1.843003897	kg
Compost	2.7	kg
Energy, gross calorific value, in biomass	23.61385991	MJ
Entomopathogenic virus	1.00E-03	kg
Establishing orchard	0.013154667	Item(s)
Fruit tree seedling, for planting	0.013154667	Item(s)
Irrigation	1.522721425	m ³
Occupation, permanent crop, irrigated	22.611744	m ² *a
Planting tree	0.013154667	Item(s)
Transformation, from permanent crop, irrigated	0.375800373	m ²
Transformation, to permanent crop, irrigated	0.375800373	m ²
Transport, tractor and trailer, agricultural	0.001991916	t*km
Transport, tractor and trailer, agricultural	8.10E-06	t*km
Carbon dioxide, in air	1.843003897	kg
Packaging, for fertilisers	0.1	kg
Sheet rolling, aluminium	0.0073	kg
White lined chipboard carton	0.08	kg
Packaging film, low density polyethylene	0.005	kg
Sheet rolling, aluminium	0.0073	kg
White lined chipboard carton	0.08	kg
0:OA&FT_RAW_CANE_SUGAR	0.28	kg
INPUTS DURING PROCESSING STAGE		
Building, hall, steel construction	4.09E-07	m ²
Electricity, medium voltage	0.1614	kWh
Folding boxboard carton	0.006	kg
Natural gas liquids	0.0378	kg
Water, PE	0.0048	m ³
Wood pellet, measured as dry mass	0.008	kg
Electricity, medium voltage	0.18	kWh
Building, hall, steel construction	4.09E-07	m ²
Electricity, medium voltage, renewable energy products	0.64971	kWh
Natural gas liquids	0.528	kg

Water, PE	0.01397	m ³
Transport (Factory and Retail Distribution)		
Transport, freight, lorry, unspecified	759	kg*km
Transport, freight, sea, container ship	10002.35	kg*km
Transport, freight, lorry with refrigeration machine, cooling	369	kg*km
OUTPUTS IN INGREDIENTS PRODUCTION PHASE		
1.1_INGREDIENTS_DRY_COCOA_BEANS	1	kg
Waste wood, untreated	0.04564224	kg
Waste wood, untreated	4.14E-04	kg
Waste wood, untreated	0.01591738	kg
Waste wood, untreated	0.07203151	kg
Waste wood, untreated	0.00566717	kg
Waste wood, untreated	0.00240473	kg
Waste wood, untreated	0.00380168	kg
Waste wood, untreated	0.60553339	kg
Water	0.74118655	m ³
Water	0.15631093	m ³
Water	0.62522811	m ³
2_PACKAGING_MAT_AUX_TRANSPORT	1	kg
Aluminium waste	0.0025	kg
Carton waste	0.0025	kg
Packaging waste, plastic	0.02	kg
Packaging waste, plastic	0.0025	kg
OUTPUTS IN PROCESSING PHASE		
3.1_COCOA_PASTE_FABRICATION	0.6	kg
Biowaste	3.28	kg
3.3_COCOA_BUTTER_FABRICATION	1	kg
3_CHOCOLATE_FABRICATION	1	kg
4_TRANSPORT_FOR_DISTRIBUTION	1	kg

Table S2. Inventory data Conventional Agriculture (CA) Chocolate (72% cocoa).

CA CHOCOLATE (1 kg)		
Description	Amount	Unit
INPUTS DURING INGREDIENTS PRODUCTION STAGE		
Acetamide-anillide-compound, unspecified	0.007593973	kg
Ammonia, anhydrous, liquid	7.83E-04	kg
Ammonia, anhydrous, liquid	3.54E-04	kg
Ammonia, anhydrous, liquid	3.71E-05	kg
Ammonia, anhydrous, liquid	0.003920863	kg

Ammonia, anhydrous, liquid	1.82E-04	kg
Ammonia, anhydrous, liquid	0.00136256	kg
Ammonia, anhydrous, liquid	3.61E-04	kg
Ammonium nitrate	0.001572483	kg
Ammonium nitrate	0.004102927	kg
Ammonium nitrate	0.001208623	kg
Ammonium nitrate	0.00226734	kg
Ammonium sulfate	0.004011526	kg
Ammonium sulfate	0.001231	kg
Carbon dioxide, in air	1.843003897	kg
Copper oxide	0.007593973	kg
Cyclic N-compound	3.67E-04	kg
Energy, gross calorific value, in biomass	23.61385991	MJ
Establishing orchard	0.013154667	Item(s)
Fruit tree seedling, for planting	0.013154667	Item(s)
Inorganic nitrogen fertiliser, as N	9.50E-07	kg
Inorganic nitrogen fertiliser, as N	2.75E-05	kg
Inorganic nitrogen fertiliser, as N	3.71E-04	kg
Inorganic nitrogen fertiliser, as N	6.51E-05	kg
Inorganic nitrogen fertiliser, as N	1.77E-04	kg
Inorganic nitrogen fertiliser, as N	9.78E-06	kg
Inorganic nitrogen fertiliser, as N	2.26E-04	kg
Inorganic nitrogen fertiliser, as N	0.003484682	kg
Inorganic nitrogen fertiliser, as N	6.21E-05	kg
Inorganic nitrogen fertiliser, as N	6.49E-05	kg
Inorganic nitrogen fertiliser, as N	1.67E-04	kg
Inorganic nitrogen fertiliser, as N	7.12E-06	kg
Inorganic nitrogen fertiliser, as N	2.64E-05	kg
Inorganic nitrogen fertiliser, as N	1.71E-05	kg
Inorganic nitrogen fertiliser, as N	2.23E-04	kg
Inorganic nitrogen fertiliser, as N	2.38E-05	kg
Inorganic nitrogen fertiliser, as N	2.53E-04	kg
Inorganic nitrogen fertiliser, as N	5.18E-05	kg
Inorganic nitrogen fertiliser, as N	0.001828455	kg
Inorganic nitrogen fertiliser, as N	0.002404087	kg
Inorganic nitrogen fertiliser, as N	1.37E-04	kg
Inorganic nitrogen fertiliser, as N	1.98E-04	kg
Inorganic nitrogen fertiliser, as N	1.01E-04	kg
Inorganic nitrogen fertiliser, as N	6.21E-04	kg
Inorganic nitrogen fertiliser, as N	0.015262221	kg
Inorganic nitrogen fertiliser, as N	0.002009885	kg

Inorganic nitrogen fertiliser, as N	6.66E-05	kg
Inorganic nitrogen fertiliser, as N	2.84E-04	kg
Inorganic phosphorus fertiliser, as P2O5	5.69E-04	kg
Inorganic phosphorus fertiliser, as P2O5	4.52E-06	kg
Inorganic phosphorus fertiliser, as P2O5	1.90E-04	kg
Inorganic phosphorus fertiliser, as P2O5	3.18E-04	kg
Inorganic phosphorus fertiliser, as P2O5	7.11E-04	kg
Inorganic phosphorus fertiliser, as P2O5	9.39E-04	kg
Inorganic phosphorus fertiliser, as P2O5	8.34E-05	kg
Inorganic phosphorus fertiliser, as P2O5	6.44E-04	kg
Inorganic phosphorus fertiliser, as P2O5	0.004393367	kg
Inorganic phosphorus fertiliser, as P2O5	2.11E-05	kg
Inorganic phosphorus fertiliser, as P2O5	6.97E-04	kg
Inorganic phosphorus fertiliser, as P2O5	0.041077629	kg
Inorganic phosphorus fertiliser, as P2O5	2.07E-05	kg
Inorganic phosphorus fertiliser, as P2O5	3.40E-04	kg
Inorganic phosphorus fertiliser, as P2O5	2.95E-04	kg
Inorganic phosphorus fertiliser, as P2O5	5.48E-06	kg
Inorganic phosphorus fertiliser, as P2O5	1.47E-04	kg
Inorganic phosphorus fertiliser, as P2O5	3.77E-05	kg
Inorganic phosphorus fertiliser, as P2O5	0.004458521	kg
Inorganic phosphorus fertiliser, as P2O5	1.02E-04	kg
Inorganic phosphorus fertiliser, as P2O5	6.54E-04	kg
Inorganic phosphorus fertiliser, as P2O5	5.48E-04	kg
Inorganic phosphorus fertiliser, as P2O5	0.002900409	kg
Inorganic phosphorus fertiliser, as P2O5	2.33E-04	kg
Inorganic phosphorus fertiliser, as P2O5	0.00596244	kg
Inorganic phosphorus fertiliser, as P2O5	4.48E-04	kg
Inorganic phosphorus fertiliser, as P2O5	1.18E-04	kg
Inorganic phosphorus fertiliser, as P2O5	0.010525606	kg
Inorganic potassium fertiliser, as K2O	4.52E-05	kg
Inorganic potassium fertiliser, as K2O	1.24E-04	kg
Inorganic potassium fertiliser, as K2O	9.14E-05	kg
Inorganic potassium fertiliser, as K2O	0.001133272	kg
Inorganic potassium fertiliser, as K2O	2.69E-04	kg
Inorganic potassium fertiliser, as K2O	6.17E-05	kg
Inorganic potassium fertiliser, as K2O	1.95E-05	kg
Inorganic potassium fertiliser, as K2O	1.03E-05	kg
Inorganic potassium fertiliser, as K2O	9.12E-06	kg
Inorganic potassium fertiliser, as K2O	7.36E-07	kg
Inorganic potassium fertiliser, as K2O	0.001012471	kg

Inorganic potassium fertiliser, as K ₂ O	8.11E-05	kg
Inorganic potassium fertiliser, as K ₂ O	6.97E-06	kg
Inorganic potassium fertiliser, as K ₂ O	3.13E-05	kg
Inorganic potassium fertiliser, as K ₂ O	2.63E-05	kg
Inorganic potassium fertiliser, as K ₂ O	3.00E-05	kg
Inorganic potassium fertiliser, as K ₂ O	9.17E-05	kg
Inorganic potassium fertiliser, as K ₂ O	5.65E-05	kg
Inorganic potassium fertiliser, as K ₂ O	5.38E-04	kg
Inorganic potassium fertiliser, as K ₂ O	2.43E-05	kg
Inorganic potassium fertiliser, as K ₂ O	2.62E-05	kg
Inorganic potassium fertiliser, as K ₂ O	0.001898197	kg
Inorganic potassium fertiliser, as K ₂ O	2.48E-05	kg
Inorganic potassium fertiliser, as K ₂ O	6.60E-05	kg
Inorganic potassium fertiliser, as K ₂ O	3.56E-06	kg
Inorganic potassium fertiliser, as K ₂ O	0.007325551	kg
Inorganic potassium fertiliser, as K ₂ O	7.00E-04	kg
Inorganic potassium fertiliser, as K ₂ O	1.63E-05	kg
Irrigation	1.522721425	m ³
Occupation, permanent crop, irrigated	18.84312136	m ² *a
Organophosphorus-compound, unspecified	8.53E-05	kg
Packaging, for fertilisers	0.41301913	kg
Packaging, for pesticides	0.031279894	kg
Phosphate rock, beneficiated	0.019050115	kg
Phosphate rock, beneficiated	8.63E-05	kg
Phosphate rock, beneficiated	2.53E-04	kg
Phosphate rock, beneficiated	2.53E-04	kg
Planting tree	0.013154667	Item(s)
Potassium chloride	0.005403356	kg
Potassium chloride	0.065153729	kg
Potassium sulfate	0.008378178	kg
Potassium sulfate	0.001764895	kg
Transformation, from permanent crop, irrigated	0.375800373	m ²
Transformation, to permanent crop, irrigated	0.45096	m ²
Transport, tractor and trailer, agricultural	8.10E-06	t*km
Transport, tractor and trailer, agricultural	0.001991916	t*km
Urea	0.002576436	kg
Urea	0.016433111	kg
Urea	0.002078327	kg
Urea	0.014032709	kg
Packaging film, low density polyethylene	0.02	kg
Packaging, for fertilisers	0.15	kg

Folding boxboard carton	0.006	kg
Packaging film, low density polyethylene	0.005	kg
Sheet rolling, aluminium	0.0073	kg
White lined chipboard carton	0.08	kg
Sugar, from sugarcane	0.278	kg
Vegetable oil, refined	0.002	kg
INPUTS DURING PROCESSING STAGE		
Building, hall, steel construction	4.09E-07	m ²
Electricity, medium voltage	0.1614	kWh
Natural gas liquids	0.0378	kg
Water, PE	0.0048	m ³
Wood pellet, measured as dry mass	0.008	kg
Building, hall, steel construction	4.09E-07	m ²
Electricity, medium voltage	0.6497	kWh
Natural gas liquids	0.528	kg
Water, PE	0.01397	m ³
White lined chipboard carton	0.08	kg
Transport (Factory and Retail Distribution)		
Transport, freight, lorry, unspecified	299	kg*km
Transport, freight, sea, container ship	5645.62	kg*km
Transport, freight, lorry with refrigeration machine, cooling	432.58	kg*km
OUTPUTS IN INGREDIENTS PRODUCTION PHASE		
1.1_INGREDIENTS_DRY_COCOA_BEAN	1	kg
1.3_PESTICIDES/FERTILISERS_EMISSIONS	0.367575703	kg
Waste wood, untreated	0.005667172	kg
Waste wood, untreated	0.045642241	kg
Waste wood, untreated	0.003801682	kg
Waste wood, untreated	4.14E-04	kg
Waste wood, untreated	0.605533392	kg
Waste wood, untreated	0.072031509	kg
Waste wood, untreated	0.002404733	kg
Waste wood, untreated	0.015917376	kg
Water	0.741186553	m ³
Water	0.156310926	m ³
Water	0.625228109	m ³
2_PACKAGING_MAT_AUX_TRANSPORT	1	kg
Packaging waste, plastic	0.04	kg
Packaging waste, plastic	0.0025	kg
Aluminium waste	0.0025	kg
Carton waste	0.0025	kg

OUTPUTS IN PROCESSING PHASE		
3.1_COCOA_PASTE_FABRICATION	0.6	kg
biowaste	3.28	kg
3.3_COCOA_BUTTER_FABRICATION	1	kg
3_CHOCOLATE_FABRICATION	1	kg
4_TRANSPORT_FOR_DISTRIBUTION	1	kg

Table S3. Inputs and outputs for 0.71 kg of cocoa paste input needs.

Inputs efficiency for cocoa paste		
Material	Unit	Amount
Raw cocoa	kg	13.05
Dry cocoa beans	kg	3.51
Polyethylene bags	kg	0.005
Cardboard	kg	0.006



Figure S1. Chocolate bar (150 g) from Ethiquable, “Noir dessert corsé 72% de cacao équitable & bio”.

Table S4. Ingredients for 1 kg of Organic and Fairtrade (OA&FT) Chocolate (72%).

1 kg OA&FT Chocolate recipe (72%)		
Ingredient	Unit	Amount
Cocoa paste	kg	0.71
Cocoa butter	kg	0.01
Raw cane sugar	kg	0.28

Table S5. Ingredients for 1 kg of Conventional Agriculture (CA) Chocolate (72%)

1kg CA Chocolate recipe (72%)		
Ingredient	Unit	Amount
Cocoa paste	kg	0.71
Cocoa butter	kg	0.01
Cane sugar	kg	0.278
Vegetable lecithin	kg	0.002

Table S6. Breakdown of Transport and Packaging results by GWP impact category.

Transport, Packaging and Auxiliary Material in CA (Scenario 1)				
Absolute	Relative	Process	Amount	Unit
2.37%	100.00%	Transport, Packaging and Auxiliary Material in OA&FT (Scenario 1)	0.187	kg CO2-Eq
0.81%	34.18%	market for packaging film, low density polyethylene packaging film, low density polyethylene Cutoff, U - GLO	0.064	kg CO2-Eq
0.74%	31.22%	market for transport, freight, sea, container ship transport, freight, sea, container ship Cutoff, U - GLO	0.058	kg CO2-Eq
0.59%	24.89%	market for transport, freight, lorry, unspecified transport, freight, lorry, unspecified Cutoff, U - RoW	0.047	kg CO2-Eq
0.23%	9.70%	market for packaging, for fertilisers packaging, for fertilisers Cutoff, U - GLO	0.018	kg CO2-Eq
Transport, Packaging and Auxiliary Material in OA&FT (Scenario 2)				
Absolute	Relative	Process	Amount	Unit
10.85%	100.00%	Transport, Packaging and Auxiliary Material in CA (Scenario 2)	0.366	kg CO2-Eq
3.76%	34.65%	market for white lined chipboard carton white lined chipboard carton Cutoff, U - RoW	0.127	kg CO2-Eq
3.51%	32.35%	market for transport, freight, lorry, unspecified transport, freight, lorry, unspecified Cutoff, U - RoW	0.119	kg CO2-Eq
3.06%	28.20%	market for transport, freight, sea, container ship transport, freight, sea, container ship Cutoff, U - GLO	0.103	kg CO2-Eq
0.36%	3.32%	market for packaging, for fertilisers packaging, for fertilisers Cutoff, U - GLO	0.012	kg CO2-Eq
0.14%	1.29%	market for sheet rolling, aluminium sheet rolling, aluminium Cutoff, U - GLO	0.005	kg CO2-Eq