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## Data Article

## SHARP-Indicators Database towards a public database for environmental sustainability



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## ABSTRACT

To initiate the achievement of an European-wide applicable public database for indicators of environmental sustainability of the diet, we developed the SHARP Indicators Database (SHARP-ID). A comprehensive description of the development of the SHARP-ID is provided in this article. In the SHARP-ID, environmental impact assessment was based on attributional life cycle analyses using environmental indicators greenhouse gas emission (GHGE) and land use (LU). Life cycle inventory data of 182 primary products were combined with data on production, trade and transport, and adjusted for consumption amount using conversions factors for production, edible portion, cooking losses and gains, and for food losses and waste in order to derive estimates of GHGE and LU for the foods as eaten. Extrapolations based on similarities in type of food, production system and ingredient composition were made to obtain estimates of GHGE and LU per kg of food as eaten for 944 food items coded with a unique FoodEx2-code of EFSA and consumed in four European countries, i.e. Denmark, Czech Republic, Italy and France. This LCA-food-item database can be linked to food intake data collected at the individual level in order to calculate the environmental impact of individual's diets. The application of this database to European survey data is described

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in an original research article entitled “Dietary choices and environmental impact in four European countries” (Mertens et al., 2019).

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## Specifications Table

Subject area	Nutrition sciences
More specific subject area	Diet-related environmental sustainability
Type of data	Figures and tables
How data was acquired	<ul style="list-style-type: none"> <li>- Raw data on the environmental impact of all the food's life cycle stages were extracted from existing public databases and from recent publications.</li> <li>- Life cycle inventory data of Agri-footprint and Ecoinvent were accessed using the software program SimaPro (Multi-user version 8.4.0.0).</li> <li>- Raw data on the environmental impact of all the food's life cycle stages were compiled to calculate environmental impact of the food as consumed using Microsoft Excel.</li> </ul>
Data format	Raw processed and analysed data, descriptive statistics The raw data are available on a data repository.
Experimental factors	Data taken from published sources were processed to provide estimates of GHGE and LU for assessing the environmental impact of an individual diet.
Experimental features	No experimental work was carried out; calculations were based on published data.
Data source location	Foods included in the SHARP-ID were based on the reported food intake of the four European countries included in the SUSFANS project, i.e. Denmark, Czech Republic, Italy and France, resulting in a list of 944 food items coded with a unique FoodEx2-code.
Data accessibility	Estimates of environmental impact for a food, as coded by the FoodEx2, are available on a data repository with the following doi <a href="https://doi.org/10.17026/dans-xvh-x9wz">https://doi.org/10.17026/dans-xvh-x9wz</a> . The associated file that includes all the calculations is available upon request for scientific applications. Contact point for further use is prof Pieter van 't Veer at the Division of Human Nutrition and Health, Wageningen University ( <a href="mailto:pieter.vantveer@wur.nl">pieter.vantveer@wur.nl</a> ). Reproduction and translation for non-commercial purposes are authorised, provided the source is acknowledged and the publisher is given prior notice and sent a copy.
Related research article	Mertens, E., A. Kuijsten, H.H.E. van Zanten, G. Kaptijn, M. Dofková, L. Mistura, L. D'Addezio, A. Turrini, C. Dubuisson, S. Havard, E. Trolle, J.M. Geleijnse, and P.v.t. Veer, Dietary choices and environmental impact in four European countries. <i>Journal of Cleaner Production</i> , 2019. <b>237</b> : p. 117827.

## Value of the Data

- The data serve to quantify the environmental impact of the diet in the consumer domain using highly-disaggregated food consumption data collected at the individual level. Using this consumption-oriented approach allows studying environmental impact of the diet with other diet-related aspects, like dietary quality, food preferences, food affordability, etc.
- The data permit comparisons of environmental impact of individual's diets within and between populations, if using comparable dietary assessment methods.
- The data provide a basis for new research undertakings that are directed to broadening the understanding of the interrelationships between environment, food, and health.

## 1. Data

The SHARP-Indicators Database (SHARP-ID) presented here constitute the basis for quantifying the environmental impact of an individual's diet, and this database has been applied to dietary survey data

of four European countries [1]. This database provides for each single food item an estimate on greenhouse gas emissions (GHGE) and land use (LU) per kg of food as eaten. Food items included in the SHARP-ID were based on the reported food intake of the four European countries included in the SUSFANS project [1,2], i.e. Denmark, Czech Republic, Italy and France. Intake data of these four countries were coded using FoodEx2 Exposure Hierarchy of the European Food Safety Authority (EFSA) [3,4], resulting in a list of 944 food items coded with a unique FoodEx2-code for which environmental footprint of the food product's life cycle was assessed using attributional life cycle analyses (LCA). Table 1 shows the summary descriptive statistics of GHGE (in kgCO<sub>2</sub>eq/kg food as eaten) and LU (in m<sup>2</sup>\*year/kg food as eaten) for different food groups. Starting from life cycle inventory data on primary products, estimates were obtained for GHGE and LU per kg of food as eaten by using appropriate conversions factors to reflect amount as consumed and including impacts from packaging, transport and home preparation. Life cycle inventory data were retrieved from Agri-Footprint 2.0 [5,6], Ecoinvent 3.3 [7], CAPRI [8], and supplemented by recent literature and technical reports (Fig. 1 and Table 2). Impacts of composite foods were estimated using the ingredients/primary products that make up the foods using recipes from the Dutch food composition table [9] or the first hit on internet. Conversion factors for production were taken from Bowman [10,11] and FAO [12], for edible part and for weight gain or losses during preparation from Bogner [13] and the Health Council of Belgium [14], and for food losses and waste from Broekema and Kuling, as documented in Ref. [15]. Impacts from packaging were retrieved from Ecoinvent 3.3 [7], using the most common packaging format, as reported by Ref. [16] (Table 3). Impacts from transport were retrieved from RVO [17], using information on trade and transport from FAOstat, BACI World Trade Database, GTAP and Geodis. Impacts from home preparation in energy use (MJ) were based on Foster [18] and Carlsson-Kanyama [19] (Table 4), and recalculated into GHGE (CO<sub>2</sub>eq) using the methods of Mombarg and Kool [20].

## 2. Experimental design, materials, and methods

### 2.1. Environmental impact of primary productions

Life cycle inventory data of Agri-Footprint 2.0 [5,6], Ecoinvent 3.3 [7] and CAPRI [8] were used as an input for the SHARP-ID and provided information on greenhouse gas emissions (GHGE) and land use (LU) of primary food products, i.e. environmental impacts until the farm gate. GHGE was expressed in kilogram CO<sub>2</sub>equivalents (kgCO<sub>2</sub>eq) per kg primary product, with 1 kgCH<sub>4</sub> equal to 25 kgCO<sub>2</sub>, and 1 kgN<sub>2</sub>O equal to 298 kgCO<sub>2</sub> (IPCC 2007). LU was expressed in m<sup>2</sup>\*year per kg primary product, and was calculated as 10000/yield. With SimaPro (Multi-user version 8.4.0.0), life cycle inventory data of Agri-footprint and Ecoinvent were accessed. Agri-footprint was used as a first data source, and was where needed supplemented by Ecoinvent and other data sources. For livestock products, i.e. all meat, milk and egg products, we used data from CAPRI, as these data cover an European average for these animal-sourced foods. Relevant recent literature and technical reports were used to fill data gaps, for example for fish products. For the FoodEx2-codes where no primary product data were available, extrapolations were made based similarities in cultivation and production method, and the producing country. Impacts between products and co-products were based on economic allocation for all foods, except for animal-sourced foods where nitrogen allocation was used because the nitrogen content serves as an indicator of the physical and causal relationship between products and emissions [8].

For composite foods, a break-down into their ingredients is needed before linking these to their corresponding primary products. Food items consisting of two or more primary products, for example grain-based products like bread, cookies and cakes, composite dishes like pizza, hamburger, goulash, soups and salads, and milk desserts like pudding and milkshake, etc. are regarded as a composite food; regardless whether they are prepared at home or manufactured. To calculate the environmental impact of a composite food, recipes taken from the Dutch food composition table [9] or the first hit on internet were used to break-down composite foods into its ingredients. Using the mass balance and the environmental impact of the ingredients, a weighted impact of the composite dish was calculated. In total, we used 42

**Table 1**

Average GHGE (in kgCO<sub>2</sub>/kg food as eaten) and average LU (in m<sup>2</sup>·year/kg food as eaten) for 17 food groups according to level 1 of the FoodEx2 Exposure Hierarchy. Values are means with their standard deviations.

Food groups according to level 1 of the FoodEx2 Exposure Hierarchy	Number of food items	GHGE		LU	
		Mean	(SD)	Mean	(SD)
Grains and grain-based products	139	3.9	(5.9)	5.8	(6.0)
Vegetable and vegetable products	109	1.8	(3.7)	0.8	(1.9)
Starchy root or tubers and products	14	0.8	(0.4)	0.8	(0.6)
Legumes, nuts and oilseeds	43	2.1	(1.9)	7.9	(13.6)
Fruit and fruit products	90	0.9	(0.6)	0.8	(0.7)
Meat and meat products	113	17.1	(9.5)	28.5	(17.4)
Fish and fish products	96	15.2	(16.7)	2.1	(4.3)
Milk and dairy products	111	11.5	(6.6)	11.5	(7.0)
Eggs and egg products	13	5.3	(5.3)	16.1	(17.0)
Sugar and confectionary	30	2.6	(2.7)	3.7	(3.6)
Animal and vegetable fats and oils	29	7.1	(9.1)	16.9	(13.8)
Fruit and vegetable juices	27	1.2	(0.5)	1.0	(0.9)
Water and water-based beverages	27	0.4	(0.1)	0.3	(0.2)
Alcoholic beverages	33	1.1	(0.3)	0.7	(0.2)
Coffee, cocoa, tea	30	1.5	(3.4)	1.6	(4.7)
Composite dishes	20	4.8	(2.5)	7.5	(4.2)
Miscellaneous	20	2.2	(1.2)	6.3	(6.9)

#### Direct mapping to primary products:

Agri-footprint 2.0 (2015):	142 FoodEx2-codes;
Ecoinvent 3.3 (2016):	105 FoodEx2-codes;
CAPRI (Weiss & Leip (2012)):	198 FoodEx2-codes;
Other LCA publications:	68 FoodEx2-codes;

Direct mapping to primary products using recipes: 81 FoodEx2-codes



#### Proxy value for primary products:

Agri-footprint 2.0 (2015):	73 FoodEx2-codes;
Ecoinvent 3.3 (2016):	84 FoodEx2-codes;
CAPRI (Weiss & Leip (2012)):	30 FoodEx2-codes;
Other LCA publications:	65 FoodEx2-codes;

Proxy value for recipes: 98 FoodEx2-codes

**Fig. 1.** Mapping foods to primary products from different life cycle inventory data sources.

different recipes, and a recipe was also used as a proxy for composite foods with comparable ingredient composition. All recipes for composite foods were assumed to be homogenous across Europe.

Fig. 1 shows the process of mapping food to primary products from different life cycle inventory data sources, and Table 2 shows for each food group of the FoodEx2-classification (at Level 1) their corresponding life cycle inventory data source used for quantifying environmental impact.

**Table 2**

Food groups of the foodEx2-classification (at Level 1) and their corresponding life cycle inventory data source used for quantifying environmental impact.

Level 1 food groups of the FoodEx2-classification system	Number of foods					Main data sources
	Total	via direct mapping	via proxy	via recipes	via proxy recipes	
Grains and grain-based products	137	48	9	25	55	Agri-footprint
Vegetable and vegetable products	109	44	65	–	–	Agri-footprint, Ecoinvent
Starch roots or tubers and products thereof	9	9	–	–	–	Agri-footprint
Legumes, nuts and oilseeds	42	25	17	–	–	Agri-footprint, other publications
Fruit and fruit products	90	35	45	8	2	Ecoinvent
Meat and meat products	107	81	26	–	–	CAPRI, other publications
Fish and fish products	93	41	52	–	–	Other publications
Milk and dairy products	110	102	3	3	2	CAPRI, other publications
Eggs and egg products	12	12	–	–	–	CAPRI, other publications
Sugar and confectionary	30	7	10	6	7	Agri-footprint
Animal and vegetables fats	29	17	6	2	4	Agri-footprint, Ecoinvent, CAPRI
Fruit and vegetable juices	27	13	14	–	–	Ecoinvent, Agri-footprint
Water and water-based beverages	27	9	1	17	–	Agri-footprint
Alcoholic beverages	34	21	–	1	12	Agri-footprint, Ecoinvent
Coffee, cocoa, tea	30	27	–	3	–	Ecoinvent,
Agri-footprint, other publications						
Composite dishes	38	10	2	13	13	Agri-footprint, CAPRI, other publications
Miscellaneous, including food products for young population, non-standard diets, seasoning and sauces	20	13	1	3	3	Ecoinvent, Agri-footprint

## 2.2. Environmental impact from production until consumption

### 2.2.1. Conversion factors to reflect amount as consumed

To calculate the environmental impact for foods as consumed, we applied conversion factors for production, for edible part, for weight gain or losses during preparation, and for food losses and waste at production and at consumption phase.

A production factor was applied for primary products that undergo further production processing to extend shelf life, to render palatability, edibility, safety, etc. Examples of this kind of products are wheat that is milled into flour, grapes that are dried to render raisins, fruits that are squeezed to render fruit juice. This kind of processing results in a mass change of the primary product (the production amount is not the same as the amount of retail), hence the need for a production factor. This production factor is usually higher than 1.0; with its magnitude depending on the primary product and its undergoing production process. Production factors, as documented by Bowman [10], were applied to convert a processed food item to its raw primary product as found at retail level; hereby only accounting for mass differences [11]. Technical production factors for products derived from milk, such as cream, cheese and butter, were taken from FAO [12]; because production yields of products derived from milk tend to vary between countries, as these are highly dependent on the composition of the raw milk, for example cheese yield is related to casein and fat content of the milk. None of the production factors accounted for water and energy consumed, however the latter was taken into account in a later stage by adding preparation at home to the GHGE of that food item.

Conversion factors for consumption refuse (e.g.: skin, peel, core, pits, trimming), weight losses and gains during preparation were applied for products where the amount bought at retail differs from the

**Table 3**  
Packaging and their associated foods.

Packaging material	Foods
Average of glass bottle and can (for 0.3L drinks)	Beer
Average of glass bottle and can (for 0.3L drinks), and PET bottle (for 1L drinks)	Soft drinks, fruit juices and water
Glass bottle (for 150g jam)	Jam, peanut butter, chestnut puree, honey
Average of glass bottle (for 500g dressing) and HDPE container (for 1L ketchup)	All kind of sauces, dressing and syrups
Average of HDPE container and glass bottle (for 500mL oil)	Oils
Glass bottle (for 500mL oil)	All kind of alcoholic beverages other than beer
PE bag (for 500g of pasta)	Pasta, rice, bread, coffee, tea, milk powder
PP bag (for 400g of cereals)	Cornflakes, candies
Drink carton (for 1L milk)	Milk, plant-based alternative for milk
HDPE container (for 1L ice cream)	Ice cream, sorbet, composite dishes like soups, goulash
HDPE container (for 400g margarine)	Margarine, spreadable cheese, composite salad dishes
PS container (for 2dL yoghurt)	Yoghurt, quark, dairy desserts, soft cheeses
PS container (for 500g meat)	Meat, fish, tofu, hard cheese, nuts
Pulp tray (for 10 eggs)	Eggs, composite pizza-like dishes like
PS bag (for fruit, vegetables, potatoes)	Fruit, vegetables, potatoes
Average of aluminium and tin can (for 500g food)	Canned fruit and vegetables
Average of aluminium and tin can (for 150g food)	Canned meat and fish, condensed milk

Abbreviations: PET, PolyEthylene Terephthalate, HDPE, High-Density PolyEthylene; PE, PolyEthylene; PP, PolyPropylene; PS, PolyStyrene.

**Table 4**  
Environmental impact of home preparation.

Way of home preparation	Foods
Boiling water	Coffee, tea, cocoa beverages
Boiling potatoes	Potatoes, soups, grains, vegetables, jams and juices, legumes, puddings
Frying	Fried dishes
Microwaving	Oat porridge
Oven baking	Bread products and cookies, dried eggs and dried vegetables
Roasting	Meat and fish products

amount of consumed. Examples of this kind of conversion factors are the adjustment of bananas for its peel (using a factor for edible portion), cooked vegetables for their raw amount (using a factor for weight loss during cooking), cooked rice for uncooked rice (using a factor for weight gain during cooking). Conversion factors were taken from Bognar [13] and from the Health Council of Belgium [14]. For processed foods, these kind of conversion factors were already included in the production factor.

Percentage of food losses and waste, estimated by Broekema et al. (2015) and Kuling et al. (2015), as documented in Ref. [15], were applied to further adjust consumption amount to production amount. Food losses included losses during storage, processing, packaging and transport, and losses at the supermarket and at home (i.e. losses of the edible parts of the food, i.e. waste). Percentage of food losses were estimated at the level of food groups, and food groups not included were assumed to have an average food loss percentage.

### 2.2.2. Environmental impact of packaging

For the packaging of food products, we included primary packaging (Table 3), but excluded secondary and tertiary packaging, such as carton boxes and pallets. The main reason for only including primary packaging was that this has the highest impact on the environment. Data on packaging were retrieved from Ecoinvent 3.0; using the most common packaging format for that food item, as reported by Ref. [16].

### 2.2.3. Environmental impact of transport

Trade and transport data were obtained from FAOstat, BACI World Trade Database and GTAP using reference year 2011; these data provided information about the countries of trade and its

corresponding amount, ratio imported domestically produced, and the ratio for mode of travel (air, water, land). Distances between trading countries were obtained from Geodist. Transport distances for imported food items were taken from the producing country of the raw primary product to the country that will manufacture/consume that raw primary product, and thus excluding transport within that country from retailers to home. For locally produced and locally consumed food items, distance for travelling by truck within an average European country was used. Emissions of transport by airplane, ship, and truck were taken from RVO [17]. Refrigeration of a vehicle adds 20% to the emissions; a chilled vehicle was assumed for all dairy, meat, vegetables (except for tubers) and fruit products. Chilled transport was not considered for composite dishes, processed foods, cacao, drinks, including sweet and alcoholic drinks, coffee and tea, and water, as they were assumed to be prepared at home and/or packaged in a tin/glass/can/bottle, and thus no need to be chilled.

#### 2.2.4. Environmental impact of food preparation

Values for home preparation were based on Foster [18] who based his values on Carlsson-Kanyama [19]; information was available for boiling, frying, oven baking, roasting and microwaving (Table 4). Energy use (MJ) was recalculated into GHGE (CO<sub>2</sub>eq) using the methods of Mombarg and Kool [20], and under the assumption that half the energy use was from gas and half from electricity. No values were assigned to alcoholic beverages, animal and vegetable fats and oils, salads of composite dishes, unprepared eggs, fruits except for jams, fruit and vegetables juices and nectars, flours, unprocessed breakfast cereals, nuts, milk and dairy products except for puddings, plant alternatives for milk, seasoning, sauces and condiments, except for white and tomato sauce, confectionary and water-based sweet desserts, vegetables and vegetables products regularly consumed as raw, water and water-based beverages; because not home-prepared and/or counted by food products with whom it is consumed together, and/or consumed as raw.

#### 2.3. Calculations of the final values of GHGE and LU, as included in the SHARP-ID

For each FoodEx2-code, total GHGE and LU per kg of food as eaten were calculated using the following formula, respectively:

$$\text{GHGE} = \text{GHGE at farm gate} \times \text{production factor} \times (1/\text{edible factor}) \times (1/\text{shrinkage, swelling factor}) \times (1/\text{losses, waste factor}) + \text{packaging} + \text{transport} + \text{preparation at home}$$

$$\text{LU} = \text{LU at farm gate} \times \text{production factor} \times (1/\text{edible factor}) \times (1/\text{shrinkage, swelling factor}) \times (1/\text{losses, waste factor})$$

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#### Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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