Supplementary materials

Supplementary material 1.

The Norwegian LCA food database, version 01, 2024.

This dataset is a selection of foods that constitute the basis of the Norwegian diet.

Six impact categories are given: global warming potential (GWP100), eutrophication of freshwater, eutrophication of marine water, terrestrial acidification, water use and land use.

Values are given in units per 100 g of food, and are presented for average generic foods, if not noted otherwise.

- GWP100, global warming potential, kg CO_2 per 100 g of food.
- EF, eutrophication of freshwater, kg P eq. per 100 g of food.
- EM, eutrophication marine water, kg N eq. per 100 g of food.
- ACID, terrestrial acidification, kg SO_2 eq. Per 100g of food.
- WU, water use, m^3.
- LU, land use, m^2.

The foods are presented in 8 food groups:

Table 1 Beverages.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Apple juice	0.066	0	0	0.0003	0.006	0.028
Beer	0.065	0	0.0001	0.0003	0.001	0.023
Bottled water	0.032	0	0	0.0001	0.001	0.001
Coffee, filter	0.074	0	0.0001	0.0003	0.001	0.040
Liquor	0.280	0.0001	0	0.0008	0.005	0.009
Orange juice	0.187	0	0.0001	0.0007	0.046	0.055
Soda	0.032	0	0	0.0001	0.001	0.001
Tap water	0	0	0	0	0	0
Tea	0.013	0	0	0.0006	0.004	0.021

Wine	0.230	0	0.0001	0.0014	0.004	0.123

[a]Zero values are values below 0.001.

[b]Zero values are values below 0.0001.

Table 2 Dairy products.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Butter	1.043	0.0002	0.0018	0.0169	0.017	1.084
Cheese	1.200	0.0003	0.0005	0.0185	0.376	0.992
Ice cream	0.466	0	0.0007	0.0048	0.004	0.145
Milk, reduced fat	0.134	0	0	0.002	0.046	0.117
Milk, unspecified fat content	0.138	0	0	0.0021	0.046	0.121
Milk, whole fat	0.155	0	0	0.0023	0.046	0.141
Yoghurt	0.175	0	0.0001	0.0024	0.022	0.129

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 3 Fish and seafood.

Food item	GWP100, kg CO2/100 g [a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Caviar, Norwegian style	0.164	0	0.0007	0.0013	0.002	0.113
Cod, boiled	0.281	0.0001	0	0.0011	0.004	0.005

Cod, raw	0.168	0	0	0.0006	0.002	0.003
Fish patties, cooked	0.172	0	0.0001	0.0012	0.009	0.048
Haddock, boiled	0.281	0.0001	0	0.0011	0.004	0.005
Haddock, raw	0.168	0	0	0.0006	0.002	0.003
Herring, boiled	0.108	0	0	0.0004	0.004	0.007
Herring, raw	0.090	0	0	0.0003	0.003	0.006
Mackerel, boiled	0.134	0	0	0.0004	0.003	0.002
Mackerel, raw	0.112	0	0	0.0004	0.001	0.002
Saithe, boiled	0.281	0.0001	0	0.0011	0.004	0.005
Saithe, raw	0.168	0	0	0.0006	0.002	0.003
Salmon farmed, boiled	0.786	0.0002	0.0006	0.0034	0.001	0.478
Salmon farmed, raw	0.660	0.0002	0.0005	0.0028	0	0.401
Shrimps, cooked	1.550	0.0007	0.0008	0.0041	0.009	0.215

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 4 Fruit, berries, nuts, and seeds.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Almonds	0.519	0.0001	0.0020	0.0062	0.438	0.746
Apples	0.071	0	0.0001	0.0004	0.007	0.024
Cashewnuts	0.457	0.0003	0.002	0.0070	0.200	1.395
Grapes	0.130	0	0	0.0007	0.012	0.031
Hazelnuts	0.431	0.0001	0.0013	0.0034	0.162	1.128
Lemon	0.192	0	0.0001	0.0009	0.020	0.056
Mango	0.191	0	0.0001	0.0006	0.037	0.070

Orange	0.130	0	0.0001	0.0063	0.014	0.038
Peanuts	0.767	0	0.0006	0.0008	0.018	0.597
Pears	0.087	0	0	0.0003	0.018	0.012
Walnuts	0.157	0	0.0004	0.0010	0.039	0.347

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 5 Grain and grain products.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Biscuit	0.317	0	0.0005	0.0015	0.005	0.238
Bread	0.101	0	0.0007	0.0006	0.002	0.194
Cake	0.455	0	0.0008	0.0054	0.007	0.375
Muesli with fruits	0.175	0	0.0004	0.001	0.006	0.332
Oat grain	0.120	0	0.0008	0.0008	0.001	0.269
Pasta, cooked	0.048	0	0.0002	0.0006	0.046	0.074
Rice, cooked	0.214	0	0.0001	0.0011	0.016	0.046
Rice, dry, uncooked	0.632	0	0.0004	0.0031	0.040	0.138
Sweet pastry	0.211	0	0.0004	0.001	0.006	0.282
Wheat grain	0.128	0	0.0006	0.001	0.001	0.223

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 6 Meat, poultry, and egg.

Food item	GWP100, kg CO2/100g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Beef, cooked	3.662	0.0008	0.0006	0.0578	0.044	4.680
Beef, raw	2.563	0.0006	0.0004	0.0405	0.030	3.276
Lamb, mutton, chop, cooked	3.024	0.0002	0.0036	0.0225	0.205	8.894
Lamb, mutton, raw	2.297	0.0001	0.0027	0.0171	0.155	6.763
Meatballs, beef & pork, cooked	1.110	0.0003	0.0003	0.0147	0.028	1.517
Pork, cooked	0.558	0.0001	0.0003	0.0029	0.019	1.347
Pork, raw	0.453	0.0001	0.0002	0.0024	0.014	1.096
Sausage (pork and beef), heat-treated	0.577	0.0001	0.0003	0.0052	0.016	1.113
Sausage (pork and beef), raw	0.575	0.0001	0.0003	0.0052	0.015	1.113
Chicken meatballs, cooked	0.419	0.0002	0.0004	0.0035	0.014	0.682
Chicken, whole, cooked	0.560	0.0003	0.0006	0.0060	0.022	1.058
Chicken, whole, raw	0.447	0.0003	0.0005	0.0048	0.018	0.845
Sausage (chicken), heat-treated	0.256	0.0002	0.0003	0.0026	0.011	0.465
Sausage (chicken), raw	0.255	0.0002	0.0003	0.0026	0.010	0.465
Egg, boiled	0.279	0.0002	0.0003	0.0044	0.041	0.672
Egg, fried	0.321	0.0002	0.0003	0.0051	0.047	0.772
Egg, raw	0.245	0.0001	0.0002	0.0039	0.035	0.591

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 7 Vegetables, legumes, and vegetable products.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Avocado	0.204	0	0.0002	0.0011	0.062	0.103
Beans, canned	0.173	0	0.0002	0.0011	0.007	0.209
Broccoli, raw	0.052	0	0	0.0003	0.006	0.023
Carrot, boiled	0.033	0	0	0.0002	0.004	0.023
Carrot, raw	0.032	0	0	0.0001	0.004	0.023
Chickpeas (soaked, not dry)	0.147	0	0.0003	0.0002	0.005	0.491
Cucumber	0.216	0.0001	0	0.0006	0.022	0.008
Leek	0.022	0	0	0.0001	0.004	0.024
Lentils (soaked, not dry)	0.107	0.0002	0	0.0001	0.002	0.534
Lettuce	0.074	0	0.0001	0.0005	0.005	0.056
Linseed	0.199	0.0001	0.0006	0.0016	0.013	1.178
Maize	0.214	0	0.0006	0.0033	0.072	0.179
Onion	0.028	0	0	0.0001	0.004	0.020
Paprika	0.413	0	0	0.0003	0.021	0.010
Peas	0.146	0	0.0003	0.0002	0.004	0.491
Potato, boiled	0.034	0	0	0.0002	0.006	0.043
Potato, raw	0.031	0	0.0001	0.0002	0.004	0.043
Tofu	0.465	0	0.0001	0.0006	0.005	0.224
Tomato	0.157	0	0	0.0003	0.004	0.009
Tomato sauce	0.159	0	0.0001	0.0007	0.005	0.041
Vegetarian meat burger analogue	0.409	0	0.0002	0.0007	0.004	0.181
Vegetarian minced meat analogue	0.476	0	0.0001	0.0017	0.010	0.337
Vegetarian sausage analogue	0.545	0	0.0007	0.004	0.011	0.541
Zucchini, squash	0.301	0	0.0002	0.0006	0.013	0.040

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Table 8 Margarine, chocolate, condiment, sugar.

Food item	GWP100, kg CO2/100 g[a]	EF, kg P/100g[b]	EM, kg N/100g[b]	ACID, kg SO2/100g[b]	WU, m3/100g[a]	LU, m2/100g[a]
Margarine	0.214	0.0001	0.0027	0.0038	0.008	0.410
Chocolate	0.648	0.0002	0.0011	0.0063	0.006	0.710
Ketchup	0.158	0	0.0001	0.0006	0.011	0.077
Sugar	0.209	0	0.0003	0.0010	0.001	0.076

[a]Zero values are values below 0.001

[b]Zero values are values below 0.0001.

Supplementary material 2 Supplementary methods descriptions

Filling data gaps

Missing production data

Literature searches were performed for available data for similar foods in the same country or for the same food in a nearby geographical location. For example, environmental data for Norwegian apples were used as surrogate data for Norwegian pears. Secondly, the databases Agri-Footprint and EcoInvent in SimaPro software (version 9.0.0.49) included farm-stage processes that were used as sources for surrogate data. In addition, RIVM database (1) was used. Lastly, if no other alternative was found, the farm stage was modelled in SimaPro with processes from the EcoInvent and Agri-Footprint databases, using inventory data from publications found in the literature search. However, this modelling was necessary only for a small number of food items.

Missing processing data

Surrogate data for missing data on food processing were identified and compiled from scientific articles and LCA reports. If no data were found in the literature, standard values were created in SimaPro software (version 9.0.0.49), based on relevant inventory data and adapted to represent the country by choosing the most appropriate background processes for each country. For example, if the processing of a product was in Sweden, Swedish electricity and water mix and correct EUR-standard for vehicles in Sweden were implemented.

If not included in the original source data, post-harvest processes for fruit and vegetables were added that included transport to the processing facility, washing, sorting, packaging, and refrigeration, if applicable. A standard value for the packaging of fruit, vegetables, and berries was constructed based on inventory data from Svanes and Johnsen (2). In addition, for fruit and vegetables that are often available for 'self-picking' in food stores, consumer use of extra plastic bags at the food store was included.

Missing domestic transport

Domestic transport was defined as transport from wholesale to retail. For most of the Norwegian produce, information about the distance foods travel from wholesale to retail could not be obtained. Thus, a standard value for the average distance had to be generated. Data on transportation of commodities in Norway was compiled from different sources as shown in Table S1 and discussed within the project group.

Table S1 Available sourced data on domestic transport of food and commodities in Norway

Distance (km)	Reference source
183	Based on Statistics Norway (3), average transport for the last 10 years, transport of 'food products, beverages, tobacco and animal fodder'. Details about food for human consumption only were not available.
129	Estimate from Statistics Norway (4), based on the average estimate of transport of forestry, agriculture, and fisheries' goods and services within the last 10 years.

80	Based on Statistics Norway, (5), included the average transport of 'foodstuff in smaller vans'.
180	Based on the study by Svanes and Johnsen (2) on Norwegian apples and cherries, in which data on the average distance were collected from the main retail stores in Norway and included transport from wholesale to retail.
429	Based on Møller and Saxegård (6), included a weighted average of distances to different parts of Norway, depending on population size. The model was adjusted to account for transport from Oslo rather than Fredrikstad, as used by the authors. The unadjusted distance was 399 km, which was also discussed.

The average distance used for domestic transport between wholesale and retail was set to 180 km, based on the data collected from Norwegian retailers in Svanes and Johnsen (2). This was also supported by the transport statistics from Statistics Norway (3) (Table S1). No transport from retail to consumer was included owing to the high uncertainty associated with the transport, i.e., mode of transportation, distance, buying groceries on the way home from work, etc. For fish and seafood, the domestic distribution was estimated LCA study by SINTEF Ocean for certain fish types.

Missing international transport

Missing data on international transport were modeled in SimaPro software (version 9.0.0.49) with processes from EcoInvent. The distances and routes travelled were based on information from literature sources if available. If no information was found, the transport routes were estimated using Google Maps and the shortest route was selected. For sea transport, an online tool (Sea-distances.org) was used to calculate distances between ports for ocean freight. For transport from European countries to Norway, transport routes were estimated from the country´s capital or other important trading areas if identified. For transport from countries outside Europe, transport routes were estimated from the middle of the country or other important trading areas, if identified, to the coast, then by ship to Rotterdam, the Netherlands, and transport by lorry to Oslo, Norway (based on Møller & Saxegård (6)).

Transport by lorry, ship, train, and airfreight was included where relevant, depending on information found in the source literature. Transport by rail and air was identified for, and thus applied to, only a few food items.

Most foods were transported by lorry, especially within countries and within Europe. The standard size of the lorry chosen was 7.5-16 tons unless the literature stated otherwise. No return trip was added, because this was accounted for in the EcoInvent processes. The environmental impact of the transport was dependent on the European emission standard (EUR-standard) of the lorry. The EUR-standards ranged from EUR-3 to EUR-6 depending on the country of departure. The chosen emission standards for each geographical area and source of this information can be found in Table S2.

Table S2 European emission standards for lorries globally

EUR standard	Region	Source

6	Nordic countries and western Europe	Møller & Saxegård (6)
5	Eastern and central Europe. North America (assumed EUR-standard)	Møller & Saxegård (6)
4	Southern Europe	Timonen et al.(7); Møller & Saxegård (6)
3	Other countries	Møller & Saxegård(6)

The transport estimations were adjusted for ambient, chilled or frozen transport, by choosing the appropriate processes from EcoInvent. Transport by sea was used for longer distances, i. e., from North America to Europe, and the EcoInvent process for trans-oceanic ship was used for estimates. Transport by rail was mainly applied for produce transported from midwest USA to the coast for some grains. Airfreight was chosen only if specifically mentioned in the literature or in other sources/ statistics found. Airfreight to Rotterdam was chosen and then lorry onwards to Oslo, Norway.

Missing storage data at the wholesale, retail, and consumer levels

Standard values were defined for storing foods at the wholesale, retail, and consumer levels. Key documents in this process were Mogensen et al. (8) and Broekema et al. (9). No environmental impact values were added for ambient storage.

Missing data on consumer preparation

Standard values for heat treatment and cooking scenarios were established based on the literature (Table S3). The amount of electricity used was then estimated using literature sources (Table S4).

Table S3 Standardized cooking scenarios for food items at home

Food items	Cooking scenario	Source
Potatoes	Boiled	Munoz et al. (10) and Notarnicola et al. (2017) as cited in Bruno et al. (11)
Pasta, rice, pulses, beans	Boiled	
Coffee	Filter and boiled	
Egg	50% boiled and 50% fried	
Vegetables and fruits (heat-treated)	Boiled	Svanes (boiled carrots) (12)
Meat, poultry, and fish	Mixed value from 33% roasting, boiling and frying	(Mogensen et al., (beef) (8)

The environmental impact from consumer preparation was modeled in SimaPro using the EcoInvent process 'Electricity, low voltage (NO)| market for | Cut-off, S'. Water for boiling was also added if needed.

Shares of fruits, vegetables, and berries eaten raw and processed were based on national dietary data. The energy use for consumer preparation for boiling and oven baking (Thy Mors Energy (2014) as cited in Mogensen et al. 2020 (8) and frying (Broekema et al. 2019 (9)) was added where relevant.

Table S4 Heat treatment for different cooking methods

Food group	Preparation	Source
Vegetables, fruit, and berries	Boiling	Electricity used for boiling vegetables (by Thy Mors Energy (2014) as cited in Mogensen et al. (8))
	Oven baking	Oven baking (by Mogensen et al. (8))
	Frying	Average of frying on low heat (3 min) and high heat (7 min) (by Broekema et al. (9))
Potatoes	Boiling	Boiling potatoes for 20 min (by Broekema et al. (9))
	Frying	Pan frying potatoes for 3 min on low heat and 17 min on high heat (by Broekema et al. (9))
	Oven baking	Oven baking (by Mogensen et al. (8))
Meat, poultry, and fish	Oven baking	Oven baking (by Thy Mors Energy (2014) as cited in Mogensen et al. (8))
	Frying/boiling for 12 min	Pan frying by Institute of Technology (2017, personal communication as cited in Mogensen et al. (8))
Eggs	Boiling/frying	Eggs boiled for 5 min (by Broekema et al. (9)) with an average of high and low heat
Bakery goods	Oven baking for 30 min	Oven baking for 1 hour (by Thy Mors Energy (2014) as cited in Mogensen et al. (8))
Coffee	Filter coffee	Heating water in a coffee maker (by Thy Mors Energy (2014) as cited in Mogensen et al. (8))

LCA for fish

For salmon, data and assumptions, from the report of Winther et. al. (13) until after capture handling were used. For cod, herring, and mackerel, all inputs to fishing, such as fuel, refrigerants, bait, and equipment, were derived from Winther et. al. (13). For salmon and cod, domestic transport and chilled storage were included. Expanded polystyrene boxes carrying approximately 20 kg of fish each were used for distribution packaging, whereas a standard aluminum tray (60 g) with plastic film (10 g) was used for consumer packaging for 1 kg of fillets. For salmon and cod, the transport distances of 911 km and 1170 km were used, respectively. The distances were weighted averages based on the volumes and distances between the salmon farms and processing hub in the Oslo area. Truck transport and covered weight of ice and packaging were assumed, in addition to fish weight, while estimating emissions. Emissions from retail storage were estimated using the same approach as Winther et al. (13) for chilled storage, and 1 week of storage in a supermarket was assumed. The impact assessment method used was ReCiPe 2016 Midpoint (H) V1.03 / World (2010)H.

Overview of allocation methods in the compiled data

In the present study, economic allocation was used for 88% of the foods in the compiled database (Table S5). There were, however, a higher share of LCA studies with varying allocation methods for GWP100 compared with the other ICs. The compiled LCA studies had applied no allocation for 4% of the foods, mass allocation was applied for another 4% of the foods, mainly for fish products and pasta (GWP100), and a mix of economic and mass

allocation or biophysical allocation methods were found to have been applied for approximately 4% of foods.

Table S5 Percentages of allocation methods used for the compiled impact category (IC) values in the Norwegian life cycle assessment (LCA) food database version 01

Allocation method (%)	GWP100	EF	EM	ACID	WU	LU	Average
Economic	81	89	90	87	89	92	88
No allocation	8	4	2	4	2	1	4
Mass	5	3	3	4	5	3	4
Mixed[a]	5	4	4	4	4	4	4

GWP, global warming potential; EF, eutrophication freshwater; EM, eutrophication marine water; ACID, terrestrial acidification; WU, water use; LU, land use.

[a]Economic allocation and mass allocation or biophysical allocation in the original literature sources.

Market share information

Average values of the last 5 five years were used when possible. Market share information was compiled from the following sources:

- Opplysningskontoret for frukt og grønt (www.frukt.no): data on fruits, vegetables, berries and potatoes in Norway, including share of Norwegian produce.
- Landbruksdirektoratet (Norwegian Agriculture Agency, 2020): data on the production of Norwegian agricultural goods, imports and exports.
- Frukt- og grønnsaksgrossistenes servicekontor: Import statistics of fruits and vegetables in 2019.
- Statistics Norway, table 08801 (2021c): Import-statistics of foods.
- Chatham House (2021): Global trading map for many different food items.
- Sissel Flesland Markedsinformasjoner AS (2021)»

References for Supplementary material 2

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Supplementary material 3

References for the original studies identified in the compilation project.
Literature searches were performed for each food group/food item. The general search strategy was the name of food group or foodstuff AND ('LCA' OR 'Life cycle assessment' OR 'Life cycle analysis') AND geographical region. Searches were limited to articles published after 2009. If no products were found for the specified geographical region, a search without geographical region filter was performed. Relevant articles were also identified through screening of reference lists of already included articles, thus articles published before 2010 were also included. The reference list below presents the 261 articles and reports that constituted the basis of the literature source data.

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