Supporting Information 1 (SI-1)

Bridging Nutritional and Environmental Sustainability Within Planetary Boundaries in Food Life Cycle Assessments: SWOT Review and Development of the Planet Health Conformity Index

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List of Abbreviations

AR	Argentina
BR	Brazil
CA	Canada
CZ	Czech Republic
DE	Deutschland (Germany)
EC	Ecuador
ES	Espana (Spain)
FR	France
GHGs	Greenhouse gas emissions
GLO	Global
GWP	Global Warming Potential
HGH	Heated greenhouse
IT	Italy
L	Liter
LCA	Life Cycle Assessment
MM	Market Mix
MPUFAs	Mono- and polyunsaturated fatty acids
MUFA s	Monounsaturated fatty acids
n.a.	not applicable
nFU	Nutritional functional unit
NL	Netherlands
nLCA	Nutritional Life Cycle Assessment
N-min	Application of mineral nitrogen fertilizer
NRD9.3	Nutrient Rich Diet Index 9.3
NRF9.3	Nutrient Rich Food Index 9.3
NuPlaBos	Nutrient related Planetary Boundaries
OF	Open field
PC-L	Planet Conformity-Label
PHC	Planet Health Conformity
PHC-L	Planet Health Conformity Label
PL	Poland
P-min	Application of mineral phosphorous fertilizer
PUFAs	Poly-unsaturated fatty acids
RoW	Rest of the world
SFA	Saturated Fatty Acids
SWOT	Strengths, Weaknesses, Opportunities and Threats
UA	Ukraine
UGH	Unheated greenhouse
US	United States
VN	Vietnam

1. SWOT Analysis of the Literature

The literature reviewed provided a comprehensive overview of the strengths and weaknesses of nutritional functional units (nFUs), as well as their potential opportunities and threats, which have been assembled in a SWOT analysis (SI, Table 1). For strengths and weaknesses, an LCA perspective was applied, while opportunities and threats were compiled based on a public health perspective.

Regarding strengths, it can be concluded that nFUs offer a wide range of possible inclusions concerning both environmental aspects and nutritional concerns. Various environmental impacts and a range of nutrients can be included. Furthermore, nFUs can be set with specific nutritional recommendations and dietary backgrounds. Weaknesses are related to the inter-comparability of functional units due to their diversity. While single-nutrient and single-environmental-impact FUs might lack proper detail, the inclusion of various nutrients and environmental impacts could lead to great complexity, which might hinder result evaluation. Additionally, while complex scores are a powerful tool to combine various aspects into one value, they might lack detail and obscure potentially important aspects.

Table S1. SWOT analysis of nutritional functional units in food LCAs.

Strengths of nFUs in LCAs		
References	No.	Strengths
Smetana et al. 2015, Grant and Hicks 2018, Cooreman-Algoed et al. 2020, Schade et al. 2020, Filippin et al. 2023, Battle-Bayer et al. 2020a, Battle-Bayer et al. 2020b and Saget et al. 2021	S1	The nFUs applied include multiple environmental impacts, including midpoint and endpoint categories and planetary boundaries.
Eseteve-Llorens et al. 2019a, Saarinen et al. 2017, Batlle-Bayer et al. 2019, Esteve-Llorens et al. 2019b and Green et al. 2021	S2	The nFUs combine multiple nutrients in one FU with both encouraging and/or limiting nutrients.
Smetana et al. 2015, Coelho et al. 2016, Schade et al. 2020, Battle-Bayer et al. 2019 and Battle-Bayer et al. 2020a	S3	The nFUs were set with regard to daily nutrient requirements, essential nutrients and caloric energy.
Coelho et al. 2016 and Stylianou et al. 2016	S4	The nFUs evaluate and consider average and individual diets.
Grant and Hicks 2018 and Fresán et al. 2019	S5	The nLCAs include a comparison of mass-based and nutrient-based units and, thus, evaluate the "standard" LCA approach.
McAuliffe et al. 2018 and Fresán et al. 2019	S6	The nFUs applied account for nutritional compositions of individual food groups produced under multiple production systems and, thus, include product quality.
McAuliffe et al. 2023, Sonesson et al. 2017 and Green et al. 2021	S6a	Digestible indispensable amino acids were explicitly expressed in the nFU.
Cooreman-Algoed et al. 2020	S7	Environmental impacts were expressed per product, per meal or per whole diet.
Klarmann 2022 (Eaternity)	S8	The Daily Food Unit (DFU) reflects a normalization factor for comparing different consumption amounts of various food items from a climate perspective.
Sonesson et al. 2019	S9	The influence of selected food items within different diets was analyzed in the context of environmental and nutritional terms.

Weaknesses of nFUs in LCAs		
References	No.	Weaknesses
Smetana et al. 2015, Stylianou et al. 2016 and Saget et al. 2021	W1	The scope of nutrients considered in a nutrient score was rather small.
Stylianou et al. 2016, Grant and Hicks 2018, McAuliffe et al. 2018, Esteve-Llorens et al. 2019a, Fresán et al. 2019, McAuliffe et al. 2023, Sonesson et al. 2017, Saarinen et al. 2017, Batlle-Bayer et al. 2019, Esteve-Llorens et al. 2019b and Sonesson et al. 2019	W2	The scope of environmental impacts considered was rather small (e.g. only considering GWP).
Coelho et al. 2016	W3	Environmental impacts are expressed solely as percentages.
Coelho et al. 2016, Esteve-Llorens et al. 2019a, Filippin et al. 2023, Klarmann 2022 (Eaternity) and Esteve-Llorens et al. 2019b	W4	The nutritional impact assessment/(micro)nutrient analysis was not integrated into the environmental impact assessment.
Grant and Hicks 2018, Fresán et al. 2019 and McAuliffe et al. 2023	W5	Food product quality evaluations (e.g. protein quality) was not conducted.
McAuliffe et al. 2018	W6	Single-nutrient FUs might not reflect the overall value of the product for human nutrition.
Cooreman-Algoed et al. 2020 and Schade et al. 2020	W7	Micronutrients were not considered in the nLCA.
McAuliffe et al. 2023	W8	No alignment with dietary nutrient requirements.
McAuliffe et al. 2023 and Saget et al. 2021	W9	The scope of foods considered was rather small.
Klarmann 2022 (Eaternity) and Hallström et al. 2019	W10	No weighing of nutrients/dietary aspects.
Klarmann 2022 (Eaternity)	W11	No scientific publication on the method used.
Klarmann 2022 (Eaternity)	W12	Usage of non-standardized aspects (e.g. amount of water and dry weight).
Sonesson et al. 2017	W13	The integration of product quality is difficult to apply for comparison means.
Sonesson et al. 2019, Batlle-Bayer et al. 2020a and Batlle-Bayer et al. 2020b	W14	A high level of method complexity makes it difficult to apply in further studies.

Opportunities of nFUs in LCAs		
References	No.	Opportunities
Smetana et al. 2015	O1	The nFU reduces/eliminates mass differentiations between final products.
Smetana et al. 2015	O2	The nFU reflects the actual function of food products (provide specific nutrients/nourishment).
Smetana et al. 2015	O3	Consideration of energy-based FU reflects one basic function of food, namely energy supply.
McAuliffe et al. 2018	O4	It is possible to account for product quality to better understand the value of a farming system to society (on-farm changes can drastically alter the nutritional composition of food products).
McAuliffe et al. 2018	O5	There is a rising importance and interest of the effects of farming systems on food quality.
Cooreman-Algoed et al. 2020	O6	The analysis at the meal level is convenient for food service operators.
Sonesson et al. 2017	O7	The integration of dietary context as well as nutritional quality is beneficial for both producers and consumers.

Sonesson et al. 2017	O8	Even a simple, single-issue nFU already provides a broader basis for discussions than a mass-based FU alone, even if it does not give a complete picture of the relation of environmental sustainability and nutrition.
Saarinen et al.2017	O9	Nutrient indices facilitate the ranking of foods in terms of dietary and environmental effects.
Hallström et al. 2019	O10	Better public dietary advice can be given, if nutrient/health impacts are reflected in the FU of the LCA.
Green et al. 2021	O11	nFU can account for micronutrient deficiencies, nutrient diversity and environmental impacts at the same time.

Threats of nFUs in LCAs		
References	No.	Threats
Smetana et al. 2015	T1	The FU used in the study (e.g. PDCAAS) might not be very intuitive and applicable for consumers.
Stylianou et al. 2016	T2	From an epidemiological point, the CONE-LCA-approach is interesting; however, as epidemiological data related to single food products are limited (in terms of GBD framework), the approach is not applicable to a broader set of foods.
McAuliffe et al. 2018	T3	The nFU bares the risk of inappropriately linked parameters (farming inputs, yield, chemical composition of food product and nutritional composition of final product).
Fresán et al. 2019 and McAuliffe et al. 2018	T4	The overall nutritional/health quality of foods might not be reflected in the used nFU.
McAuliffe et al. 2023	T5	The development of comprehensive nFU should not be biased through economic/lobby interests.
Klarmann 2022 (Eaternity) and Hallström et al. 2019	T6	A complex score is more difficult to understand and to communicate.
Sonesson et al. 2017	T7	The nFU can hardly ever give a complete understanding of the relations between environmental sustainability and nutrition.
Saarinen et al.2017	T8	Single-issue nFUs mostly do not reflect harmful effects of additional nutrients in a product.
Hallström et al. 2019	T9	High-quality data on nutritional content and life cycle inventory of food products are needed.
Sonesson et al. 2019, Batlle-Bayer et al. 2019, Filippin et al. 2023, Esteve-Llorens et al. 2019a and Batlle-Bayer et al. 2020a	T10	An analysis on the diet level hinders conclusions/nutritional decisions of stakeholders on single products.

2. Core Aspects to be Considered in the Design of nFUs

In general, indices rank foods according to their nutrient content and/or ecological quality, thus implying how observed foods fulfill dietary and environmental recommendations. Nutrient indices can feature encouraging nutrients, limiting nutrients or a combination of both while encouraging nutrients might be capped when exceeding a specific recommended intake (Saarinen et al. 2017). To guide the process of determining specific nutrient-based functional units, a basic framework of aspects to consider was followed, as described below. In this context, Hallström et al. (2019) established five points to contemplate in terms of nutritional assessment: the selection of (anti-)nutrients, algorithm design, whether the reference amount is mass or energy based, if weighting is applied, and whether nutrients should be capped. The "points of differentiation" framework proposed by

Green et al. (2023) additionally reflected on the implementation of the dietary context, the selection of analyzed foods (all food groups or group specific), the decision for validated (peer-reviewed publication) or unvalidated indices and the examination of data quality. However, some of these points are still difficult to implement into a nutritional score (e.g., data quality) and were, thus, not considered in the process of determining a nutritional index in this study. Consequently, the following points were elaborated:

(i) Nutrient selection

It is challenging for complex nutrient scores to properly portray food products which contain considerable amounts of both desirable and non-desirable nutrients (e.g. PUFA-rich fish that might contain toxic substances). At the same time, the assessment of products which have a high amount of a certain nutrient but otherwise lack nutrients is problematic (Hallström et al. 2019). Another aspect to consider is the number of included nutrients, as a certain weighting is already applied through their selection (see Weighting). For simplicity reasons, certain nutrients might be excluded from the score if they naturally correlate with other essential nutrients (in particular, if different types of input data are used, for example, Nutri-Score: content of fruits AND content of fiber in a food product). Green et al. (2021) argues that protein, magnesium, zinc and phosphorus habitually correlate with many nutrients. The decision of including or excluding disqualifying nutrients needs to be considered carefully. Disqualifying nutrients can lower a nutritional index either by incorporating their overconsumption or by recording the percentage of a maximal reference value (Green et al. 2023). McLaren et al. (2021) support the inclusion of limiting nutrients, as they affect food products' nutritional quality.

(ii) Algorithm design

Algorithm design signifies the selection of mathematical methods to determine a score that can include the summation of nutrients or nutritional sub-scores, e.g. the application of the arithmetic mean among nutrients and/or the application of the median.

(iii) Weighting

Weighting can be applied to allow for a more sophisticated aggregation of single values into a final score, applicable in both nutritional and environmental contexts. For example, whereas no weighting is applied within the calculation of the Nutri-Score (all nutrients are considered equally), the calculation of the nutriRECIPE uses a distance-to-target approach to valorize nutrients with higher public health relevance (fiber, vitamin D, iodide, etc.) (Schlarbaum et al., 2022). Additionally, the Product Environmental Footprint (EUC 2021) uses a weighting of the included impact categories. However, there is no universally accepted method for weighting (McLaren et al. 2021, Green et al. 2023). Therefore, weighting is case-specific and should ideally reflect the objective of the index.

(iv) Energy standardization

Energy standardization makes the food independent of portion size and, thus, increases comparability (Green et al. 2021). It, thus, is considered as one form of weighting that should be applied to compare food items across food groups. In contrast, energy standardization should be omitted if the formula already includes weighting based on micronutrients or if a diet-level analysis is performed (Green et al. 2023).

(v) Capping

Capping might be applied to avoid biased results due to extreme values, which are generally generated by index models using linear correlation functions (e.g., a twofold supply of vitamin C signifies a twofold index/health outcome). Capping is, therefore, a practical measure to truncate unreasonably low or high results and to keep the possible results within limits. Capping is less important

if the index model is based on biological functions using input–outcome curves that actually occur in nature (e.g., an inverted U-curve in the case of vitamin C with a substance-specific minimum, optimum and maximum).

(vi) Selection of analyzed food products

The choice of model also needs to reflect the purpose of the study question, as food products satisfy multiple nutritional needs. Thus, a nutritional score can be useful to facilitate comparing a wide range of food products. However, the selection of food products analyzed also shapes the elaboration of the nutrient index. Thus, a food group-specific selection might result in a different selection of (dis)qualifying nutrients than a complete food basket analysis (McLaren et al. 2021).

(vii) Dietary context of the target population

To generate meaningful results, the design of the food index should reflect the impact of the background diet of the considered target population. For example, an index specifically designed for vegans should include different input parameters (see “Nutrient selection”) reflecting the quality of the background diet compared to omnivores. Moreover, by the choice of the algorithm design, weighting and capping the influence of the dietary context can be incorporated in the index (Sonesson et al. 2019, Green et al. 2023).

Table S2. Nutrient-related planetary boundaries (GHG emissions): g CO_{2e} per nutrient.

Boundary Transgression		<0.5			1			2			4			>4		
Label		A	LB	UB	B	LB	UB	C	LB	UB	D	LB	UB	E	LB	UB
Energy	per 100 kcal	38.1	35.8	41.1	76.1	71.5	82.2	152.2	143.1	164.4	304.4	286.1	328.8	304.4	286.1	328.8
Protein	per g	10.4	9.8	11.2	20.8	19.6	22.5	41.6	39.1	44.9	83.2	78.2	89.9	83.2	78.2	89.9
SFAs	per g	35.4	33.3	38.2	70.8	66.5	76.4	141.6	133.1	152.9	283.1	266.1	305.8	283.1	266.1	305.8
MPUFAs	per g	17.7	16.6	19.1	35.4	33.3	38.2	70.8	66.5	76.4	141.6	133.1	152.9	141.6	133.1	152.9
MDS	per g	15.2	14.3	16.4	30.4	28.6	32.9	60.9	57.2	65.8	121.8	114.5	131.5	121.8	114.5	131.5
Fiber	per g	25.4	23.8	27.4	50.7	47.7	54.8	101.5	95.4	109.6	202.9	190.8	219.2	202.9	190.8	219.2
Vitamin B1	per mg	634.2	596.1	684.9	1268.4	1192.3	1369.9	2536.8	2384.6	2739.7	5073.6	4769.2	5479.5	5073.6	4769.2	5479.5
Vitamin B2	per mg	543.6	511.0	587.1	1087.2	1022.0	1174.2	2174.4	2043.9	2348.3	4348.8	4087.8	4696.7	4348.8	4087.8	4696.7
Vitamin B6	per mg	507.4	476.9	547.9	1014.7	953.8	1095.9	2029.4	1907.7	2191.8	4058.9	3815.3	4383.6	4058.9	3815.3	4383.6
Folate	per mg	2536.8	2384.6	2739.7	5073.6	4769.2	5479.5	10147.1	9538.3	10958.9	20294.3	19076.6	21917.8	20294.3	19076.6	21917.8
Vitamin B12	per µg	190.3	178.8	205.5	380.5	357.7	411.0	761.0	715.4	821.9	1522.1	1430.7	1643.8	1522.1	1430.7	1643.8
Vitamin C	per mg	6.9	6.5	7.5	13.8	13.0	14.9	27.7	26.0	29.9	55.3	52.0	59.8	55.3	52.0	59.8
Vitamin D	per µg	152.2	143.1	164.4	304.4	286.1	328.8	608.8	572.3	657.5	1217.7	1144.6	1315.1	1217.7	1144.6	1315.1
Vitamin E	per mg	54.4	51.1	58.7	108.7	102.2	117.4	217.4	204.4	234.8	434.9	408.8	469.7	434.9	408.8	469.7
NaCl	per g	202.9	190.8	219.2	405.9	381.5	438.4	811.8	763.1	876.7	1623.5	1526.1	1753.4	1623.5	1526.1	1753.4
Calcium	per mg	0.8	0.7	0.8	1.5	1.4	1.6	3.0	2.9	3.3	6.1	5.7	6.6	6.1	5.7	6.6
Magnesium	per mg	2.2	2.0	2.3	4.3	4.1	4.7	8.7	8.2	9.4	17.4	16.4	18.8	17.4	16.4	18.8
Iron	per mg	50.7	47.7	54.8	101.5	95.4	109.6	202.9	190.8	219.2	405.9	381.5	438.4	405.9	381.5	438.4
Zinc	per mg	76.1	71.5	82.2	152.2	143.1	164.4	304.4	286.1	328.8	608.8	572.3	657.5	608.8	572.3	657.5
Iodine	per µg	3.8	3.6	4.1	7.6	7.2	8.2	15.2	14.3	16.4	30.4	28.6	32.9	30.4	28.6	32.9

LB—lower bound

UP—upper bound

Table S3. Nutrient-related planetary boundaries (land use): m² per nutrient.

Boundary Transgression		<0.5			1			2			4			>4		
Label		A	LB	UB	B	LB	UB	C	LB	UB	D	LB	UB	E	LB	UB
Energy	per 100 kcal	0.10	0.08	0.11	0.20	0.17	0.23	0.40	0.33	0.46	0.79	0.67	0.91	0.79	0.67	0.91
Protein	per g	0.03	0.02	0.03	0.05	0.05	0.06	0.11	0.09	0.12	0.22	0.18	0.25	0.22	0.18	0.25
SFAs	per g	0.09	0.08	0.11	0.18	0.16	0.21	0.37	0.31	0.42	0.74	0.62	0.85	0.74	0.62	0.85
MPUFAs	per g	0.05	0.04	0.05	0.09	0.08	0.11	0.18	0.16	0.21	0.37	0.31	0.42	0.37	0.31	0.42
MDS	per g	0.04	0.03	0.05	0.08	0.07	0.09	0.16	0.13	0.18	0.32	0.27	0.37	0.32	0.27	0.37
Fiber	per g	0.07	0.06	0.08	0.13	0.11	0.15	0.26	0.22	0.30	0.53	0.45	0.61	0.53	0.45	0.61
Vitamin B1	per mg	1.65	1.40	1.90	3.30	2.79	3.81	6.60	5.58	7.61	13.19	11.16	15.22	13.19	11.16	15.22
Vitamin B2	per mg	1.41	1.20	1.63	2.83	2.39	3.26	5.65	4.78	6.52	11.31	9.57	13.05	11.31	9.57	13.05
Vitamin B6	per mg	1.32	1.12	1.52	2.64	2.23	3.04	5.28	4.46	6.09	10.55	8.93	12.18	10.55	8.93	12.18
Folate	per mg	6.60	5.58	7.61	13.19	11.16	15.22	26.38	22.32	30.44	52.77	44.65	60.88	52.77	44.65	60.88
Vitamin B12	per µg	0.49	0.42	0.57	0.99	0.84	1.14	1.98	1.67	2.28	3.96	3.35	4.57	3.96	3.35	4.57
Vitamin C	per mg	0.02	0.02	0.02	0.04	0.03	0.04	0.07	0.06	0.08	0.14	0.12	0.17	0.14	0.12	0.17
Vitamin D	per µg	0.40	0.33	0.46	0.79	0.67	0.91	1.58	1.34	1.83	3.17	2.68	3.65	3.17	2.68	3.65
Vitamin E	per mg	0.14	0.12	0.16	0.28	0.24	0.33	0.57	0.48	0.65	1.13	0.96	1.30	1.13	0.96	1.30
NaCl	per g	0.53	0.45	0.61	1.06	0.89	1.22	2.11	1.79	2.44	4.22	3.57	4.87	4.22	3.57	4.87
Calcium	per mg	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02
Magnesium	per mg	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.04	0.05	0.05	0.04	0.05
Iron	per mg	0.13	0.11	0.15	0.26	0.22	0.30	0.53	0.45	0.61	1.06	0.89	1.22	1.06	0.89	1.22
Zinc	per mg	0.20	0.17	0.23	0.40	0.33	0.46	0.79	0.67	0.91	1.58	1.34	1.83	1.58	1.34	1.83
Iodine	per µg	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.03	0.05	0.08	0.07	0.09	0.08	0.07	0.09

LB—lower bound

UP—upper bound

Table S4. Nutrient-related planetary boundaries (blue water use): liters per nutrient.

Boundary Transgression		<0.5			1			2			4			>4		
Label		A	LB	UB	B	LB	UB	C	LB	UB	D	LB	UB	E	LB	UB
Energy	per 100 kcal	19.0	7.6	30.4	38.1	15.2	60.9	76.1	30.4	121.8	152.2	60.9	243.5	152.2	60.9	243.5
Protein	per g	5.2	2.1	8.3	10.4	4.2	16.6	20.8	8.3	33.3	41.6	16.6	66.6	41.6	16.6	66.6
SFAs	per g	17.7	7.1	28.3	35.4	14.2	56.6	70.8	28.3	113.2	141.6	56.6	226.5	141.6	56.6	226.5
MPUFAs	per g	8.8	3.5	14.2	17.7	7.1	28.3	35.4	14.2	56.6	70.8	28.3	113.2	70.8	28.3	113.2
MDS	per g	7.6	3.0	12.2	15.2	6.1	24.4	30.4	12.2	48.7	60.9	24.4	97.4	60.9	24.4	97.4
Fiber	per g	12.7	5.1	20.3	25.4	10.1	40.6	50.7	20.3	81.2	101.5	40.6	162.4	101.5	40.6	162.4
Vitamin B1	per mg	317.1	126.8	507.4	634.2	253.7	1014.7	1268.4	507.4	2029.4	2536.8	1014.7	4058.9	2536.8	1014.7	4058.9
Vitamin B2	per mg	271.8	108.7	434.9	543.6	217.4	869.8	1087.2	434.9	1739.5	2174.4	869.8	3479.0	2174.4	869.8	3479.0
Vitamin B6	per mg	253.7	101.5	405.9	507.4	202.9	811.8	1014.7	405.9	1623.5	2029.4	811.8	3247.1	2029.4	811.8	3247.1
Folate	per mg	1268.4	507.4	2029.4	2536.8	1014.7	4058.9	5073.6	2029.4	8117.7	10147.1	4058.9	16235.4	10147.1	4058.9	16235.4
Vitamin B12	per µg	95.1	38.1	152.2	190.3	76.1	304.4	380.5	152.2	608.8	761.0	304.4	1217.7	761.0	304.4	1217.7
Vitamin C	per mg	3.5	1.4	5.5	6.9	2.8	11.1	13.8	5.5	22.1	27.7	11.1	44.3	27.7	11.1	44.3
Vitamin D	per µg	76.1	30.4	121.8	152.2	60.9	243.5	304.4	121.8	487.1	608.8	243.5	974.1	608.8	243.5	974.1
Vitamin E	per mg	27.2	10.9	43.5	54.4	21.7	87.0	108.7	43.5	174.0	217.4	87.0	347.9	217.4	87.0	347.9
NaCl	per g	101.5	40.6	162.4	202.9	81.2	324.7	405.9	162.4	649.4	811.8	324.7	1298.8	811.8	324.7	1298.8
Calcium	per mg	0.4	0.2	0.6	0.8	0.3	1.2	1.5	0.6	2.4	3.0	1.2	4.9	3.0	1.2	4.9
Magnesium	per mg	1.1	0.4	1.7	2.2	0.9	3.5	4.3	1.7	7.0	8.7	3.5	13.9	8.7	3.5	13.9
Iron	per mg	25.4	10.1	40.6	50.7	20.3	81.2	101.5	40.6	162.4	202.9	81.2	324.7	202.9	81.2	324.7
Zinc	per mg	38.1	15.2	60.9	76.1	30.4	121.8	152.2	60.9	243.5	304.4	121.8	487.1	304.4	121.8	487.1
Iodine	per µg	1.9	0.8	3.0	3.8	1.5	6.1	7.6	3.0	12.2	15.2	6.1	24.4	15.2	6.1	24.4

LB—lower bound

UP—upper bound

Table S5. Nutrient-related planetary boundaries (N-min application): g per nutrient.

Boundary Transgression		<0.5			1			2			4			>4		
Label		A	LB	UB	B	LB	UB	C	LB	UB	D	LB	UB	E	LB	UB
Energy	per 100 kcal	0.7	0.5	1.1	1.4	1.0	2.1	2.7	2.0	4.3	5.5	4.0	8.5	5.5	4.0	8.5
Protein	per g	0.2	0.1	0.3	0.4	0.3	0.6	0.7	0.5	1.2	1.5	1.1	2.3	1.5	1.1	2.3
SFAs	per g	0.6	0.5	1.0	1.3	0.9	2.0	2.5	1.8	4.0	5.1	3.7	7.9	5.1	3.7	7.9
MPUFAs	per g	0.3	0.2	0.5	0.6	0.5	1.0	1.3	0.9	2.0	2.5	1.8	4.0	2.5	1.8	4.0
MDS	per g	0.3	0.2	0.4	0.5	0.4	0.9	1.1	0.8	1.7	2.2	1.6	3.4	2.2	1.6	3.4
Fiber	per g	0.5	0.3	0.7	0.9	0.7	1.4	1.8	1.3	2.8	3.7	2.6	5.7	3.7	2.6	5.7
Vitamin B1	per mg	11.4	8.2	17.8	22.8	16.5	35.5	45.7	33.0	71.0	91.3	66.0	142.1	91.3	66.0	142.1
Vitamin B2	per mg	9.8	7.1	15.2	19.6	14.1	30.4	39.1	28.3	60.9	78.3	56.5	121.8	78.3	56.5	121.8
Vitamin B6	per mg	9.1	6.6	14.2	18.3	13.2	28.4	36.5	26.4	56.8	73.1	52.8	113.6	73.1	52.8	113.6
Folate	per mg	45.7	33.0	71.0	91.3	66.0	142.1	182.6	131.9	284.1	365.3	263.8	568.2	365.3	263.8	568.2
Vitamin B12	per µg	3.4	2.5	5.3	6.8	4.9	10.7	13.7	9.9	21.3	27.4	19.8	42.6	27.4	19.8	42.6
Vitamin C	per mg	0.1	0.1	0.2	0.2	0.2	0.4	0.5	0.4	0.8	1.0	0.7	1.5	1.0	0.7	1.5
Vitamin D	per µg	2.7	2.0	4.3	5.5	4.0	8.5	11.0	7.9	17.0	21.9	15.8	34.1	21.9	15.8	34.1
Vitamin E	per mg	1.0	0.7	1.5	2.0	1.4	3.0	3.9	2.8	6.1	7.8	5.7	12.2	7.8	5.7	12.2
NaCl	per g	3.7	2.6	5.7	7.3	5.3	11.4	14.6	10.6	22.7	29.2	21.1	45.5	29.2	21.1	45.5
Calcium	per mg	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.2
Magnesium	per mg	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.2	0.5	0.3	0.2	0.5
Iron	per mg	0.9	0.7	1.4	1.8	1.3	2.8	3.7	2.6	5.7	7.3	5.3	11.4	7.3	5.3	11.4
Zinc	per mg	1.4	1.0	2.1	2.7	2.0	4.3	5.5	4.0	8.5	11.0	7.9	17.0	11.0	7.9	17.0
Iodine	per µg	0.1	0.0	0.1	0.1	0.1	0.2	0.3	0.2	0.4	0.5	0.4	0.9	0.5	0.4	0.9

LB—lower bound

UP—upper bound

Table S6. Nutrient-related planetary boundaries (P-min application): g per nutrient.

Boundary Transgression		<0.5			1			2			4			>4		
Label		A	LB	UB	B	LB	UB	C	LB	UB	D	LB	UB	E	LB	UB
Energy	per 100 kcal	0.06	0.05	0.12	0.12	0.09	0.24	0.24	0.18	0.49	0.49	0.37	0.97	0.49	0.37	0.97
Protein	per g	0.02	0.01	0.03	0.03	0.02	0.07	0.07	0.05	0.13	0.13	0.10	0.27	0.13	0.10	0.27
SFAs	per g	0.06	0.04	0.11	0.11	0.08	0.23	0.23	0.17	0.45	0.45	0.34	0.91	0.45	0.34	0.91
MPUFAs	per g	0.03	0.02	0.06	0.06	0.04	0.11	0.11	0.08	0.23	0.23	0.17	0.45	0.23	0.17	0.45
MDS	per g	0.02	0.02	0.05	0.05	0.04	0.10	0.10	0.07	0.19	0.19	0.15	0.39	0.19	0.15	0.39
Fiber	per g	0.04	0.03	0.08	0.08	0.06	0.16	0.16	0.12	0.32	0.32	0.24	0.65	0.32	0.24	0.65
Vitamin B1	per mg	1.01	0.76	2.03	2.03	1.52	4.06	4.06	3.04	8.12	8.12	6.09	16.24	8.12	6.09	16.24
Vitamin B2	per mg	0.87	0.65	1.74	1.74	1.30	3.48	3.48	2.61	6.96	6.96	5.22	13.92	6.96	5.22	13.92
Vitamin B6	per mg	0.81	0.61	1.62	1.62	1.22	3.25	3.25	2.44	6.49	6.49	4.87	12.99	6.49	4.87	12.99
Folate	per mg	4.06	3.04	8.12	8.12	6.09	16.24	16.24	12.18	32.47	32.47	24.35	64.94	32.47	24.35	64.94
Vitamin B12	per µg	0.30	0.23	0.61	0.61	0.46	1.22	1.22	0.91	2.44	2.44	1.83	4.87	2.44	1.83	4.87
Vitamin C	per mg	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.03	0.09	0.09	0.07	0.18	0.09	0.07	0.18
Vitamin D	per µg	0.24	0.18	0.49	0.49	0.37	0.97	0.97	0.73	1.95	1.95	1.46	3.90	1.95	1.46	3.90
Vitamin E	per mg	0.09	0.07	0.17	0.17	0.13	0.35	0.35	0.26	0.70	0.70	0.52	1.39	0.70	0.52	1.39
NaCl	per g	0.32	0.24	0.65	0.65	0.49	1.30	1.30	0.97	2.60	2.60	1.95	5.20	2.60	1.95	5.20
Calcium	per mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.02
Magnesium	per mg	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.06	0.03	0.02	0.06
Iron	per mg	0.08	0.06	0.16	0.16	0.12	0.32	0.32	0.24	0.65	0.65	0.49	1.30	0.65	0.49	1.30
Zinc	per mg	0.12	0.09	0.24	0.24	0.18	0.49	0.49	0.37	0.97	0.97	0.73	1.95	0.97	0.73	1.95
Iodine	per µg	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.05	0.05	0.04	0.10	0.05	0.04	0.10

LB—lower bound

UP—upper bound

Table S7. PHC Indices for Global Warming Potential with corresponding PHC Labels.

Food Product	Arithmetic mean, average (uncapped)		Arithmetic mean (capped at PB conformity factor 4 (D<E))		Arithmetic mean (capped at PB conformity factor 4 (D<E)) weighted		Median (uncapped)		Median (capped at PB conformity factor 4 (D<E))		**Median (capped at PB conformity factor 4 (D<E)) weighted**		kg CO_{2e}/NR F9.3 capped
Wheat	434.79	E	1.11	C	1.14	C	0.27	A	0.27	A	0.21	A	0.02
Rice	436.60	E	2.12	D	2.06	D	1.69	C	1.69	C	1.56	C	0.15
Barley	434.71	E	1.04	C	1.11	C	0.37	A	0.37	A	0.32	A	0.03
Maize	435.00	E	1.26	C	1.28	C	0.22	A	0.22	A	0.20	A	0.04
Rye	435.04	E	1.14	C	1.14	C	0.20	A	0.20	A	0.18	A	0.03
Oats	434.77	E	1.06	C	1.07	C	0.21	A	0.21	A	0.19	A	0.03
Potato	37.81	E	1.33	C	1.36	C	0.31	A	0.31	A	0.43	A	0.03
Sugar	3135.74	E	3.81	D	3.80	D	295.65	E	4.00	E	4.00	E	n.a.
Beans (OF)	99.22	E	1.89	C	1.81	C	0.67	B	0.67	B	0.51	B	0.07
Peas (OF)	33.54	E	1.14	C	1.16	C	0.43	A	0.43	A	0.40	A	0.03
Almond	440.47	E	1.65	C	1.61	C	0.64	B	0.64	B	0.56	B	0.08
Cashew nut	452.31	E	2.63	D	2.48	D	3.15	D	3.14	D	2.30	D	0.59
Walnut	448.66	E	1.43	C	1.39	C	0.49	A	0.49	A	0.48	A	0.14
Soybean	104.40	E	1.31	C	1.31	C	0.33	A	0.33	A	0.32	A	0.07
Groundnut	437.37	E	1.40	C	1.36	C	0.48	A	0.48	A	0.48	A	0.12
Sunflower seed	776.88	E	1.21	C	1.16	C	0.19	A	0.19	A	0.17	A	0.05
Rapeseed	487.77	E	1.61	C	1.65	C	0.36	A	0.36	A	0.29	A	0.04
Coconuts	33.22	E	0.82	B	0.82	B	0.21	A	0.21	A	0.17	A	n.a.
Sesame seed	437.27	E	1.52	C	1.54	C	0.46	A	0.46	A	0.45	A	0.08
Olives	434.98	E	1.21	C	1.22	C	0.53	B	0.53	B	0.40	A	0.06
Soybean oil	6521.43	E	3.36	D	3.36	D	254.58	E	4.00	E	4.00	E	n.a.
Sunflower seed oil	2845.05	E	3.34	D	3.34	D	95.26	E	4.00	E	4.00	E	1.55
Rapeseed oil	6497.32	E	3.35	D	3.35	D	145.73	E	4.00	E	4.00	E	0.46
Palm kernel oil	6589.42	E	3.40	D	3.40	D	295.65	E	4.00	E	4.00	E	n.a.
Palm oil	1663.93	E	3.39	D	3.39	D	295.65	E	4.00	E	4.00	E	n.a.
Coconut oil	6271.02	E	3.39	D	3.38	D	172.46	E	4.00	E	4.00	E	n.a.
Olive oil	4484.59	E	3.34	D	3.31	D	77.39	E	4.00	E	4.00	E	0.40
Tomato (HGH and UHG)	37.73	E	2.37	D	2.27	D	2.64	D	2.48	D	2.29	D	0.21
Onion (OF)	33.92	E	1.43	C	1.43	C	0.71	B	0.71	B	0.63	B	0.16
Cabbage (OF)	33.78	E	1.18	C	1.23	C	0.39	A	0.39	A	0.29	A	0.02
Carrot (OF)	33.38	E	0.97	B	0.98	B	0.29	A	0.29	A	0.28	A	0.09
Cucumber (HGH)	55.52	E	3.91	D	3.84	D	12.78	E	4.00	E	4.00	E	2.11
Pumpkin (OF)	33.78	E	1.29	C	1.34	C	0.35	A	0.35	A	0.28	A	0.04
Lettuce (OF)	33.67	E	1.20	C	1.28	C	0.42	A	0.42	A	0.35	A	0.03
Spinach (OF)	33.44	E	0.90	B	0.92	B	0.14	A	0.14	A	0.13	A	0.01
Orange	34.24	E	1.38	C	1.43	C	0.47	A	0.47	A	0.41	A	0.02
Lemon	33.87	E	1.24	C	1.25	C	0.79	B	0.79	B	0.67	B	0.03
Peach	35.42	E	1.50	C	1.47	C	0.69	B	0.69	B	0.85	B	0.08
Banana	33.68	E	1.06	C	1.09	C	0.31	A	0.31	A	0.31	A	0.10
Apple	34.22	E	1.46	C	1.47	C	1.07	C	1.07	C	0.86	B	0.16
Pineapple	763.98	E	1.51	C	1.49	C	0.57	B	0.57	B	0.59	B	0.07
Dates	40.30	E	2.86	D	2.68	D	4.05	E	3.81	D	3.62	D	n.a.
Grapes	34.06	E	1.32	C	1.36	C	0.56	B	0.56	B	0.44	A	n.a.
Coffee	491.34	E	3.15	D	3.06	D	6.22	E	3.85	D	3.77	D	0.33
Cocoa	431.24	E	2.91	D	2.77	D	4.79	E	3.97	D	3.70	D	0.79
Tea	435.32	E	1.44	C	1.44	C	0.83	B	0.83	B	0.79	B	0.04
Wine	836.01	E	2.60	D	2.55	D	7.37	E	4.00	E	4.00	E	0.27
Beer	830.87	E	2.00	C	1.99	C	1.01	C	1.01	C	1.35	C	0.08
Meat, cattle	4033.34	E	3.87	D	3.84	D	33.10	E	4.00	E	4.00	E	6.20
Meat, dairy cow	578.79	E	3.52	D	3.37	D	9.53	E	4.00	E	4.00	E	1.78
Meat, sheep	4005.46	E	3.30	D	3.16	D	6.42	E	4.00	E	4.00	E	4.34
Meat, pig	1162.23	E	2.23	D	2.14	D	1.60	C	1.60	C	1.25	C	0.71
Meat, chicken	121.99	E	1.61	C	1.58	C	1.37	C	1.37	C	1.08	C	0.23
Butter	2480.66	E	3.63	D	3.66	D	98.54	E	4.00	E	4.00	E	n.a.
Cream	277.57	E	2.99	D	2.90	D	5.91	E	4.00	E	4.00	E	n.a.
Eggs	416.02	E	0.96	B	0.95	B	0.43	A	0.43	A	0.43	A	0.12
Cow milk	167.87	E	2.81	D	2.72	D	3.09	D	3.09	D	2.80	D	2.76

Table S8. PHC Indices for land use with corresponding PHC Labels.

Food Product	Arithmetic mean, average (uncapped)		Arithmetic mean (capped at PB conformity factor 4 (D<E))		Arithmetic mean (capped at PB conformity factor 4 (D<E)) weighted		Median (uncapped)		Median (capped at PB conformity factor 4 (D<E))		**Median (capped at PB conformity factor 4 (D<E)) weighted**		m²/NRF9.3
Wheat	167056.70	E	1.27	C	1.27	C	0.42	A	0.42	A	0.32	A	0.08
Rice	167056.90	E	1.47	C	1.49	C	0.65	B	0.65	B	0.60	B	0.15
Barley	167056.54	E	1.18	C	1.24	C	0.51	B	0.51	B	0.45	A	0.11
Maize	167056.88	E	1.37	C	1.40	C	0.29	A	0.29	A	0.26	A	0.12
Rye	167057.62	E	1.46	C	1.47	C	0.46	A	0.46	A	0.43	A	0.16
Oats	167056.99	E	1.28	C	1.30	C	0.48	A	0.48	A	0.44	A	0.15
Potato	12639.21	E	1.31	C	1.35	C	0.30	A	0.30	A	0.41	A	0.06
Sugar	1205663.8	E	3.81	D	3.81	D	113710.40	E	4.00	E	4.00	E	n.a.
Beans (OF)	12720.90	E	2.02	D	1.94	C	0.87	B	0.87	B	0.66	B	0.24
Peas (OF)	12636.57	E	1.93	C	1.92	C	1.30	C	1.30	C	1.22	C	0.21
Almond	167060.92	E	1.59	C	1.51	C	0.51	B	0.51	B	0.45	A	0.13
Cashew nut	172322.85	E	2.20	D	2.13	D	1.81	C	1.81	C	1.32	C	0.89
Walnut	172321.58	E	1.72	C	1.64	C	0.94	B	0.94	B	0.92	B	0.68
Soybean	12673.90	E	1.19	C	1.23	C	0.18	A	0.18	A	0.18	A	0.09
Groundnut	167057.72	E	1.23	C	1.23	C	0.27	A	0.27	A	0.27	A	0.17
Sunflower seed	298666.02	E	1.36	C	1.33	C	0.40	A	0.40	A	0.35	A	0.18
Rapeseed	187131.87	E	1.57	C	1.62	C	0.31	A	0.31	A	0.25	A	0.08
Coconuts	12636.27	E	1.70	C	1.66	C	1.02	C	1.02	C	0.83	B	n.a.
Sesame seed	167060.18	E	1.44	C	1.40	C	0.65	B	0.65	B	0.64	B	0.28
Olives	167058.19	E	2.14	D	2.00	C	1.80	C	1.80	C	1.36	C	0.54
Soybean oil	2499284.2	E	3.35	D	3.35	D	66331.07	E	4.00	E	4.00	E	n.a.
Sunflower seed oil	1090197.4	E	3.35	D	3.35	D	32849.67	E	4.00	E	4.00	E	1.04
Rapeseed oil	2494018.1	E	3.35	D	3.35	D	36640.02	E	4.00	E	4.00	E	0.64
Palm kernel oil	2534367.2	E	3.34	D	3.34	D	113710.40	E	4.00	E	4.00	E	n.a.
Palm oil	598851.49	E	3.34	D	3.34	D	18951.73	E	4.00	E	4.00	E	n.a.
Coconut oil	2410606.9	E	3.58	D	3.57	D	66331.07	E	4.00	E	4.00	E	n.a.
Olive oil	1721933.1	E	3.36	D	3.36	D	18951.73	E	4.00	E	4.00	E	4.54
Tomato (HGH and UHG)	12634.65	E	0.61	B	0.64	B	0.09	A	0.09	A	0.08	A	0.02
Onion (OF)	12635.08	E	1.03	C	1.09	C	0.39	A	0.39	A	0.35	A	0.23
Cabbage (OF)	12634.93	E	0.87	B	0.90	B	0.19	A	0.19	A	0.14	A	0.03
Carrot (OF)	12635.00	E	0.96	B	0.96	B	0.28	A	0.28	A	0.27	A	0.22
Cucumber (HGH)	12635.05	E	1.00	C	1.07	C	0.32	A	0.32	A	0.36	A	0.14
Pumpkin (OF)	12635.52	E	1.34	C	1.36	C	0.38	A	0.38	A	0.32	A	0.11
Lettuce (OF)	12634.69	E	0.65	B	0.67	B	0.10	A	0.10	A	0.09	A	0.02
Spinach (OF)	12634.81	E	0.67	B	0.68	B	0.08	A	0.08	A	0.07	A	0.01
Orange	12635.93	E	1.39	C	1.45	C	0.49	A	0.49	A	0.43	A	0.07
Lemon	12635.59	E	1.29	C	1.30	C	0.85	B	0.85	B	0.72	B	0.07
Peach	12638.42	E	1.75	C	1.71	C	1.05	C	1.05	C	1.30	C	0.31
Banana	12635.39	E	1.15	C	1.16	C	0.33	A	0.33	A	0.33	A	0.28
Apple	12636.83	E	2.00	C	1.90	C	1.83	C	1.83	C	1.46	C	0.71
Pineapple	293401.98	E	1.48	C	1.47	C	0.53	B	0.53	B	0.55	B	0.16
Dates	12636.63	E	1.86	C	1.79	C	1.17	C	1.17	C	1.06	C	n.a.
Grapes	12635.78	E	1.37	C	1.40	C	0.59	B	0.59	B	0.47	A	n.a.
Coffee	167080.33	E	2.43	D	2.33	D	2.65	D	2.58	D	2.24	D	0.26
Cocoa	161447.62	E	2.45	D	2.22	D	2.88	D	2.88	D	2.48	D	0.55
Tea	167058.19	E	1.88	C	1.86	C	1.85	C	1.79	C	1.72	C	0.16
Wine	321080.33	E	2.63	D	2.57	D	7.86	E	4.00	E	4.00	E	0.75
Beer	319395.10	E	2.17	D	2.19	D	1.49	C	1.49	C	1.99	C	0.31
Meat, cattle	162976.82	E	3.65	D	3.66	D	14.07	E	4.00	E	4.00	E	6.60
Meat, dairy cow	203574.37	E	2.73	D	2.54	D	3.60	D	3.53	D	2.72	D	1.75
Meat, sheep	4150.47	E	3.32	D	3.20	D	6.65	E	4.00	E	3.97	D	11.70
Meat, pig	1103.84	E	2.21	D	2.12	D	1.52	C	1.52	C	1.18	C	1.75
Meat, chicken	171.76	E	1.98	C	1.93	C	1.93	C	1.93	C	1.53	C	0.83
Butter	622.78	E	3.27	D	3.28	D	24.74	E	4.00	E	4.00	E	n.a.
Cream	154.35	E	2.58	D	2.39	D	3.28	D	3.28	D	2.64	D	n.a.
Eggs	535.34	E	1.10	C	1.09	C	0.56	B	0.56	B	0.55	B	0.40
Cow milk	45.40	E	1.27	C	1.25	C	0.84	B	0.84	B	0.76	B	1.94

Table S9. PHC Indices for blue water use with corresponding PHC Labels.

Food Product	Arithmetic mean, average (uncapped)		Arithmetic mean (capped at PB conformity factor 4 (D<E))		Arithmetic mean (capped at PB conformity factor 4 (D<E)) weighted		Median (uncapped)		Median (capped at PB conformity factor 4 (D<E))		**Median (capped at PB conformity factor 4 (D<E)) weighted**		L/NRF9.3
Wheat	868.69	E	0.30	A	0.67	B	0.00	A	0.00	A	0.00	A	0.01
Rice	869.01	E	0.98	B	1.03	C	0.24	A	0.24	A	0.22	A	10.72
Barley	868.69	E	0.67	B	0.67	B	0.00	A	0.00	A	0.00	A	0.05
Maize	868.74	E	0.71	B	0.73	B	0.02	A	0.02	A	0.01	A	1.29
Rye	868.69	E	0.67	B	0.67	B	0.00	A	0.00	A	0.00	A	0.02
Oats	868.69	E	0.67	B	0.67	B	0.00	A	0.00	A	0.00	A	0.03
Potato	65.99	E	0.67	B	0.68	B	0.02	A	0.02	A	0.03	A	0.73
Sugar	6269.46	E	3.35	D	3.35	D	591.29	E	4.00	E	4.00	E	n.a.
Beans (OF)	65.77	E	0.51	B	0.51	B	0.00	A	0.00	A	0.00	A	0.04
Peas (OF)	65.70	E	0.45	A	0.45	A	0.00	A	0.00	A	0.00	A	0.03
Almond	895.28	E	2.60	D	2.46	D	2.77	D	2.77	D	2.42	D	136.47
Cashew nut	899.24	E	2.39	D	2.30	D	2.34	D	2.34	D	1.71	C	220.27
Walnut	896.72	E	1.44	C	1.40	C	0.51	B	0.51	B	0.50	B	71.14
Soybean	67.40	E	0.60	B	0.62	B	0.01	A	0.01	A	0.01	A	0.78
Groundnut	869.03	E	0.89	B	0.90	B	0.05	A	0.05	A	0.05	A	6.66
Sunflower seed	1553.06	E	0.89	B	0.89	B	0.00	A	0.00	A	0.00	A	0.10
Rapeseed	973.08	E	1.11	C	1.11	C	0.00	A	0.00	A	0.00	A	0.03
Coconuts	65.70	E	0.44	A	0.44	A	0.00	A	0.00	A	0.00	A	n.a.
Sesame seed	869.36	E	1.09	C	1.10	C	0.10	A	0.10	A	0.10	A	8.61
Olives	869.20	E	1.18	C	1.21	C	0.42	A	0.42	A	0.32	A	24.27
Soybean oil	12996.76	E	3.24	D	3.21	D	344.92	E	4.00	E	4.00	E	n.a.
Sunflower seed oil	5668.97	E	2.51	D	2.53	D	170.82	E	4.00	E	4.00	E	0.57
Rapeseed oil	12968.85	E	2.68	D	2.69	D	190.53	E	4.00	E	4.00	E	0.18
Palm kernel oil	13178.71	E	3.33	D	3.33	D	591.29	E	4.00	E	4.00	E	n.a.
Palm oil	3113.94	E	2.23	D	2.23	D	98.55	E	4.00	E	4.00	E	n.a.
Coconut oil	12535.07	E	2.89	D	2.89	D	344.92	E	4.00	E	4.00	E	n.a.
Olive oil	8961.49	E	3.34	D	3.31	D	116.62	E	4.00	E	4.00	E	196.88
Tomato (HGH and UHG)	66.17	E	0.91	B	1.00	B	0.25	A	0.25	A	0.24	A	10.08
Onion (OF)	66.08	E	0.82	B	0.88	B	0.25	A	0.25	A	0.22	A	27.77
Cabbage (OF)	66.18	E	0.78	B	0.81	B	0.20	A	0.20	A	0.15	A	5.90
Carrot (OF)	66.69	E	1.14	C	1.15	C	0.54	B	0.54	B	0.52	B	80.34
Cucumber (HGH)	66.25	E	0.99	B	1.05	C	0.31	A	0.31	A	0.35	A	25.38
Pumpkin (OF)	66.81	E	1.36	C	1.38	C	0.41	A	0.41	A	0.34	A	22.49
Lettuce (OF)	65.89	E	0.64	B	0.66	B	0.10	A	0.10	A	0.08	A	3.00
Spinach (OF)	65.75	E	0.37	A	0.49	A	0.01	A	0.01	A	0.01	A	0.29
Orange	69.20	E	1.90	C	1.87	C	1.19	C	1.19	C	1.04	C	30.72
Lemon	68.96	E	2.28	D	2.19	D	2.52	D	2.52	D	2.12	D	39.94
Peach	78.28	E	2.77	D	2.65	D	3.37	D	3.03	D	3.42	D	191.77
Banana	69.23	E	1.55	C	1.53	C	1.31	C	1.31	C	1.30	C	213.29
Apple	73.08	E	2.85	D	2.74	D	5.76	E	3.18	D	3.08	D	428.57
Pineapple	1526.13	E	1.11	C	1.17	C	0.22	A	0.22	A	0.23	A	12.99
Dates	102.58	E	3.89	D	3.86	D	20.06	E	4.00	E	4.00	E	n.a.
Grapes	68.26	E	1.92	C	1.92	C	1.18	C	1.18	C	0.94	B	n.a.
Coffee	871.19	E	1.23	C	1.29	C	0.27	A	0.27	A	0.23	A	5.05
Cocoa	843.39	E	1.89	C	1.74	C	1.62	C	1.62	C	1.40	C	59.12
Tea	872.76	E	1.84	C	1.81	C	3.46	D	1.82	C	1.80	C	57.23
Wine	1672.15	E	3.03	D	2.91	D	15.60	E	4.00	E	4.00	E	286.65
Beer	1660.85	E	1.56	C	1.56	C	0.00	A	0.00	A	0.00	A	0.05
Meat, cattle	865.14	E	1.30	C	1.27	C	0.23	A	0.23	A	0.18	A	21.99
Meat, dairy cow	1058.80	E	0.98	B	0.99	B	0.06	A	0.06	A	0.05	A	5.68
Meat, sheep	128.30	E	1.10	C	1.09	C	0.21	A	0.21	A	0.16	A	69.52
Meat, pig	32.54	E	0.83	B	0.85	B	0.04	A	0.04	A	0.03	A	9.95
Meat, chicken	11.95	E	0.54	B	0.56	B	0.13	A	0.13	A	0.11	A	11.12
Butter	15.64	E	1.33	C	1.27	C	0.62	B	0.62	B	0.64	B	n.a.
Cream	3.07	D	0.33	A	0.32	A	0.07	A	0.07	A	0.05	A	n.a.
Eggs	31.19	E	0.48	A	0.48	A	0.03	A	0.03	A	0.03	A	4.43
Cow milk	1.04	C	0.25	A	0.25	A	0.02	A	0.02	A	0.02	A	8.60

Table S10. PHC Indices for N-min application with corresponding PHC Labels.

Food Product	Arithmetic mean, average (uncapped)		Arithmetic mean (capped at PB conformity factor 4 (D<E))		Arithmetic mean (capped at PB conformity factor 4 (D<E)) weighted		Median (uncapped)		Median (capped at PB conformity factor 4 (D<E))		**Median (capped at PB conformity factor 4 (D<E)) weighted**		g N/NRF9.3
Wheat	24132.18	E	1.84	C	1.92	C	1.15	C	1.15	C	0.87	B	1.55
Rice	24130.96	E	1.19	C	1.22	C	0.48	A	0.48	A	0.45	A	0.78
Barley	24131.36	E	1.60	C	1.68	C	1.05	C	1.05	C	0.92	B	1.57
Maize	24132.42	E	1.77	C	1.91	C	0.72	B	0.72	B	0.64	B	2.11
Rye	24132.18	E	1.55	C	1.64	C	0.54	B	0.54	B	0.50	A	1.27
Oats	24131.48	E	1.36	C	1.45	C	0.57	B	0.57	B	0.53	B	1.23
Potato	1834.32	E	1.66	C	1.73	C	0.59	B	0.59	B	0.81	B	0.85
Sugar	174153.21	E	3.84	D	3.74	D	16424.84	E	4.00	E	4.00	E	n.a.
Beans (OF)	2054.58	E	2.41	D	2.49	D	2.32	D	2.32	D	1.76	C	1.76
Peas (OF)	1825.69	E	1.15	C	1.16	C	0.44	A	0.44	A	0.41	A	0.50
Almond	24147.48	E	2.22	D	2.22	D	1.79	C	1.79	C	1.56	C	3.17
Cashew nut	24905.28	E	3.75	D	3.63	D	10.72	E	4.00	E	4.00	E	36.37
Walnut	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.00
Soybean	1830.28	E	0.88	B	0.93	B	0.02	A	0.02	A	0.02	A	0.09
Groundnut	24131.70	E	1.17	C	1.24	C	0.22	A	0.22	A	0.22	A	0.98
Sunflower seed	43140.97	E	1.25	C	1.44	C	0.23	A	0.23	A	0.21	A	0.73
Rapeseed	27033.80	E	1.99	C	2.10	D	1.11	C	1.11	C	0.90	B	1.89
Coconuts	1825.08	E	0.54	B	0.53	B	0.06	A	0.06	A	0.05	A	n.a.
Sesame seed	24131.73	E	1.21	C	1.30	C	0.22	A	0.22	A	0.22	A	0.66
Olives	24132.11	E	1.96	C	2.05	D	1.49	C	1.49	C	1.13	C	3.07
Soybean oil	361007.60	E	3.34	D	3.22	D	9581.15	E	4.00	E	4.00	E	n.a.
Sunflower seed oil	157482.81	E	3.34	D	3.23	D	4744.95	E	4.00	E	4.00	E	4.17
Rapeseed oil	360267.53	E	3.37	D	3.26	D	5292.45	E	4.00	E	4.00	E	8.72
Palm kernel oil	366075.28	E	3.35	D	3.23	D	16424.84	E	4.00	E	4.00	E	n.a.
Palm oil	86519.26	E	3.35	D	3.23	D	2737.47	E	4.00	E	4.00	E	n.a.
Coconut oil	348197.29	E	3.22	D	3.10	D	9581.15	E	4.00	E	4.00	E	n.a.
Olive oil	248746.95	E	3.36	D	3.24	D	2737.47	E	4.00	E	4.00	E	26.21
Tomato (HGH and UHG)	1826.44	E	1.55	C	1.73	C	0.79	B	0.79	B	0.76	B	1.13
Onion (OF)	1826.07	E	1.43	C	1.54	C	0.72	B	0.72	B	0.64	B	2.87
Cabbage (OF)	1826.92	E	1.52	C	1.63	C	0.81	B	0.81	B	0.61	B	0.86
Carrot (OF)	1825.95	E	1.26	C	1.25	C	0.53	B	0.53	B	0.51	B	2.81
Cucumber (HGH)	1825.50	E	0.96	B	1.01	C	0.29	A	0.29	A	0.33	A	0.86
Pumpkin (OF)	1826.10	E	1.36	C	1.52	C	0.42	A	0.42	A	0.34	A	0.82
Lettuce (OF)	1826.10	E	1.38	C	1.47	C	0.57	B	0.57	B	0.48	A	0.62
Spinach (OF)	1826.27	E	1.09	C	1.12	C	0.31	A	0.31	A	0.29	A	0.27
Orange	1831.27	E	2.25	D	2.45	D	2.13	D	2.13	D	1.87	C	1.99
Lemon	1826.06	E	1.27	C	1.42	C	0.83	B	0.83	B	0.70	B	0.48
Peach	1829.49	E	1.71	C	1.79	C	1.21	C	1.21	C	1.49	C	2.47
Banana	1828.03	E	1.69	C	1.84	C	1.13	C	1.13	C	1.12	C	6.63
Apple	1825.80	E	1.14	C	1.28	C	0.64	B	0.64	B	0.51	B	1.71
Pineapple	42381.90	E	1.72	C	1.96	C	0.88	B	0.88	B	0.91	B	1.87
Dates	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.00
Grapes	1826.06	E	1.25	C	1.42	C	0.49	A	0.49	A	0.94	B	n.a.
Coffee	24188.13	E	3.10	D	3.04	D	6.31	E	3.75	D	0.23	A	4.20
Cocoa	23321.86	E	1.64	C	1.80	C	1.10	C	1.10	C	1.40	C	1.45
Tea	24132.34	E	1.96	C	1.99	C	1.73	C	1.73	C	1.80	C	1.03
Wine	46379.15	E	2.56	D	2.53	D	6.54	E	4.00	E	4.00	E	4.32
Beer	46136.02	E	2.53	D	2.48	D	2.89	D	2.85	D	0.00	A	4.20
Meat, cattle	24273.62	E	3.47	D	3.38	D	8.74	E	4.00	E	0.18	A	29.46
Meat, dairy cow	29442.70	E	3.38	D	3.30	D	7.74	E	4.00	E	0.05	A	26.07
Meat, sheep	400.43	E	1.56	C	1.69	C	0.64	B	0.64	B	0.16	A	7.81
Meat, pig	2890.92	E	2.84	D	2.87	D	3.99	D	3.49	D	0.03	A	31.81
Meat, chicken	239.45	E	2.41	D	2.45	D	2.69	D	2.69	D	0.11	A	8.03
Butter	176.59	E	3.08	D	2.89	D	7.01	E	4.00	E	0.64	B	n.a.
Cream	43.77	E	1.24	C	1.22	C	0.93	B	0.93	B	0.05	A	n.a.
Eggs	855.90	E	1.50	C	1.44	C	0.89	B	0.89	B	0.03	A	4.38
Cow milk	11.78	E	0.56	B	0.55	B	0.22	A	0.22	A	0.02	A	3.49

Table S11. PHC Indices for P-min application with corresponding PHC Labels.

Food Product	Arithmetic mean, average (uncapped)		Arithmetic mean (capped at PB conformity fac-		Arithmetic mean (capped at PB conformity fac-		Median (uncapped)		Median (capped at PB conformity factor 4 (D<F))		**Median (capped at PB conformity factor 4 (D<F))**		g P/NRF9.3
Wheat	271470.51	E	2.38	D	2.29	D	2.78	D	2.54	D	2.099	D	0.33
Rice	271467.92	E	1.93	C	1.89	C	1.41	C	1.41	C	1.303	C	0.20
Barley	271468.06	E	2.08	D	2.05	D	2.03	D	1.97	C	1.774	C	0.27
Maize	271474.36	E	2.75	D	2.63	D	2.84	D	2.84	D	2.531	D	0.74
Rye	271471.88	E	2.27	D	2.18	D	1.67	C	1.67	C	1.555	C	0.35
Oats	271469.82	E	2.21	D	2.14	D	1.86	C	1.86	C	1.730	C	0.36
Potato	20574.44	E	2.48	D	2.47	D	2.74	D	2.65	D	2.982	D	0.35
Sugar	1959212.94	E	4.00	E	4.00	E	184779.40	E	4.00	E	4.000	E	n.a.
Beans (OF)	21822.55	E	3.94	D	3.73	D	13.03	E	4.00	E	4.000	E	2.18
Peas (OF)	20544.12	E	2.91	D	2.82	D	8.16	E	3.66	D	3.534	D	0.83
Almond	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.000	A	0.00
Cashew nut	280054.34	E	4.00	E	4.00	E	24.81	E	4.00	E	4.000	E	7.48
Walnut	280021.07	E	1.32	C	1.30	C	0.34	A	0.34	A	0.336	A	0.15
Soybean	20959.96	E	2.41	D	2.31	D	1.96	C	1.96	C	1.930	C	0.63
Groundnut	271472.43	E	1.89	C	1.84	C	1.02	C	1.02	C	1.012	C	0.40
Sunflower seed	485333.88	E	1.95	C	1.89	C	1.50	C	1.50	C	1.338	C	0.42
Rapeseed	304095.62	E	2.40	D	2.30	D	2.35	D	2.35	D	1.905	C	0.36
Coconuts	20532.53	E	1.56	C	1.53	C	0.84	B	0.84	B	0.687	B	n.a.
Sesame seed	271478.34	E	2.33	D	2.20	D	1.94	C	1.94	C	1.909	C	0.51
Olives	271486.24	E	3.80	D	3.78	D	16.75	E	4.00	E	4.000	E	3.07
Soybean oil	4061455.89	E	3.48	D	3.47	D	107787.98	E	4.00	E	4.000	E	n.a.
Sunflower seed oil	1771592.40	E	3.38	D	3.38	D	53380.72	E	4.00	E	4.000	E	1.65
Rapeseed oil	4052821.54	E	3.43	D	3.43	D	59540.03	E	4.00	E	4.000	E	2.11
Palm kernel oil	4118346.83	E	3.43	D	3.42	D	184779.40	E	4.00	E	4.000	E	n.a.
Palm oil	973259.74	E	3.42	D	3.41	D	30796.57	E	4.00	E	4.000	E	n.a.
Coconut oil	3917216.17	E	3.44	D	3.43	D	107787.98	E	4.00	E	4.000	E	n.a.
Olive oil	2798403.19	E	3.61	D	3.60	D	30796.57	E	4.00	E	4.000	E	26.21
Tomato (HGH and UHG)	20545.50	E	3.31	D	3.11	D	7.84	E	4.00	E	4.000	E	0.99
Onion (OF)	20546.40	E	3.65	D	3.54	D	10.17	E	4.00	E	4.000	E	3.61
Cabbage (OF)	20536.37	E	2.35	D	2.23	D	2.23	D	2.23	D	1.671	C	0.21
Carrot (OF)	20534.50	E	2.25	D	2.23	D	1.90	C	1.90	C	1.813	C	0.90
Cucumber (HGH)	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.000	A	0.00
Pumpkin (OF)	20549.74	E	3.30	D	3.05	D	6.95	E	4.00	E	4.000	E	1.21
Lettuce (OF)	0.00	A	0.00	A	0.00	A	0.00	A	0.00	A	0.000	A	0.00
Spinach (OF)	20532.85	E	1.21	C	1.26	C	0.44	A	0.44	A	0.402	A	0.03
Orange	20546.36	E	2.94	D	2.75	D	5.20	E	3.95	D	3.713	D	0.43
Lemon	20539.04	E	3.17	D	3.00	D	6.18	E	4.00	E	3.885	D	0.31
Peach	20552.79	E	3.31	D	3.10	D	5.82	E	3.96	D	4.000	E	1.06
Banana	20541.33	E	2.78	D	2.63	D	3.82	D	3.74	D	3.533	D	1.99
Apple	20537.27	E	3.02	D	2.83	D	4.86	E	3.99	D	3.848	D	1.16
Pineapple	476786.75	E	2.96	D	2.79	D	5.12	E	4.00	E	3.919	D	0.97
Dates	20619.11	E	4.00	E	4.00	E	47.91	E	4.00	E	4.000	E	0.00
Grapes	20539.32	E	2.81	D	2.61	D	3.80	D	3.53	D	3.031	D	n.a.
Coffee	271783.76	E	3.70	D	3.68	D	34.68	E	4.00	E	4.000	E	2.05
Cocoa	262369.08	E	2.80	D	2.63	D	11.64	E	2.99	D	2.757	D	1.36
Tea	271471.49	E	2.56	D	2.47	D	4.64	E	3.24	D	3.095	D	0.25
Wine	521761.65	E	3.67	D	3.63	D	50.36	E	4.00	E	4.000	E	2.96
Beer	519019.05	E	3.05	D	3.04	D	6.99	E	3.91	D	3.989	D	0.90
Meat, cattle	266172.36	E	3.88	D	3.84	D	35.09	E	4.00	E	4.000	E	10.51
Meat, dairy cow	330848.16	E	3.64	D	3.65	D	13.51	E	4.00	E	4.000	E	4.05
Meat, sheep	1570.86	E	2.48	D	2.29	D	2.52	D	2.52	D	1.992	C	2.72
Meat, pig	9372.54	E	3.81	D	3.74	D	12.93	E	4.00	E	4.000	E	9.17
Meat, chicken	960.40	E	3.76	D	3.65	D	10.78	E	4.00	E	4.000	E	2.86
Butter	8.87	E	1.04	C	1.01	C	0.35	A	0.35	A	0.364	A	n.a.
Cream	2.20	D	0.30	A	0.29	A	0.05	A	0.05	A	0.038	A	n.a.
Eggs	1711.99	E	2.31	D	2.20	D	1.79	C	1.79	C	1.756	C	0.78
Cow milk	0.59	B	0.24	A	0.24	A	0.01	A	0.01	A	0.010	A	0.02

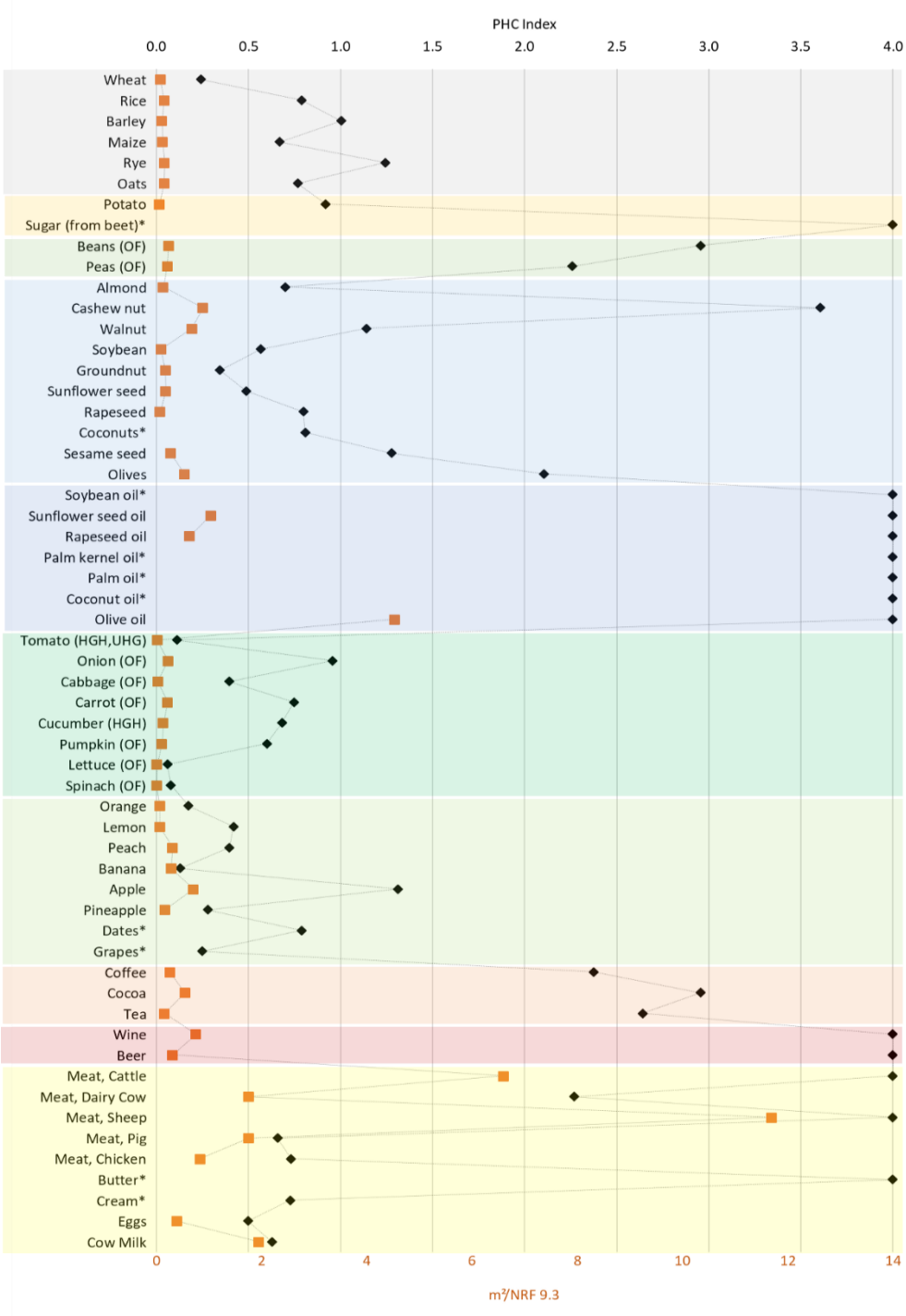


Figure S1. Weighted and capped median PHC (black dots) and m²/NRF9.3 (orange dots). * For these products, the environmentally adjusted NRF9.3 (orange dots) is not calculable.



Figure S2. Weighted and capped median PHC (black dots) and L/NRF9.3 (orange dots). * For these products, the environmentally adjusted NRF9.3 (orange dots) is not calculable.

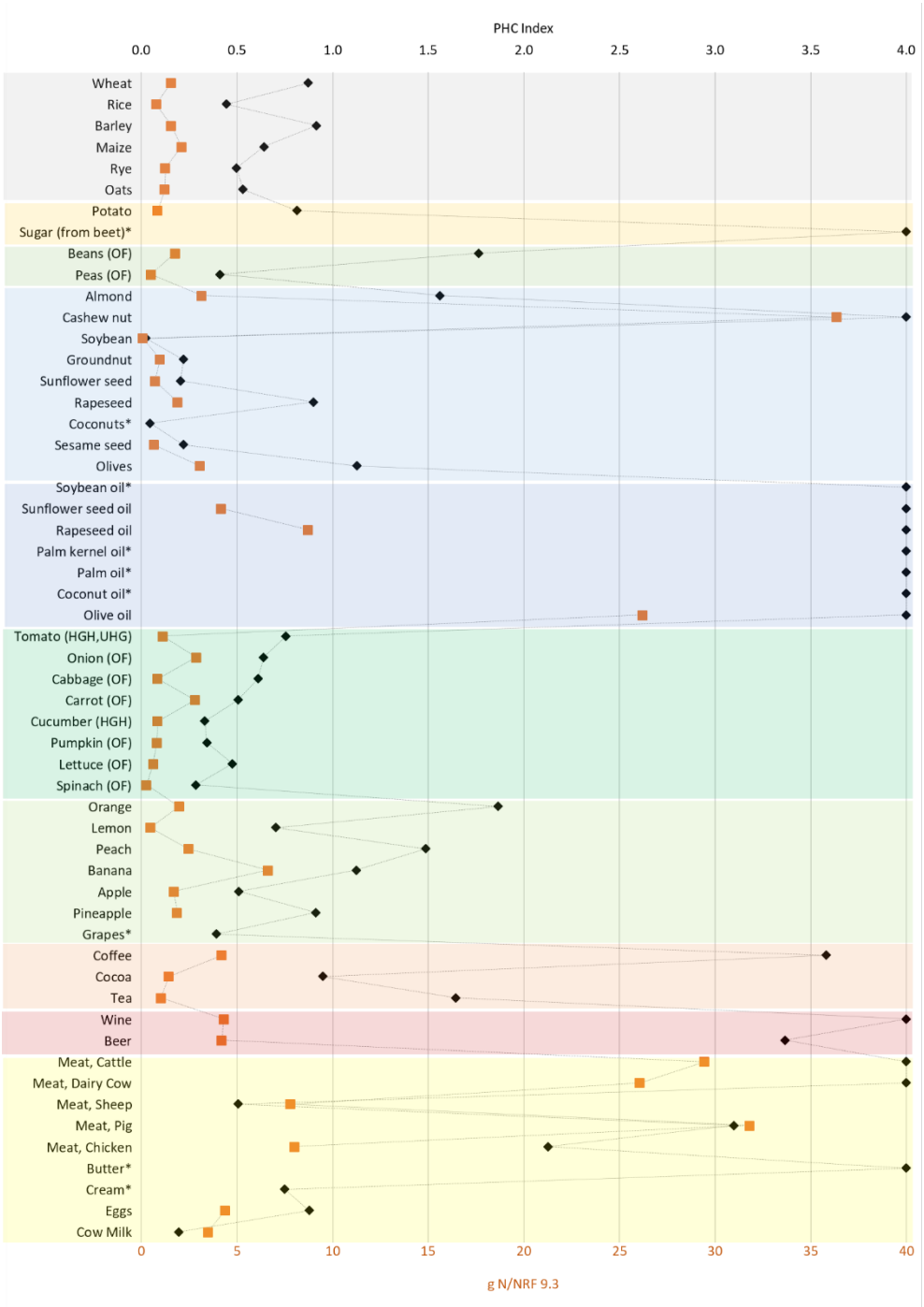


Figure S3. Weighted and capped median PHC (black dots) and g N-min/NRF9.3 (orange dots). * For these products, the environmentally adjusted NRF9.3 (orange dots) is not calculable.

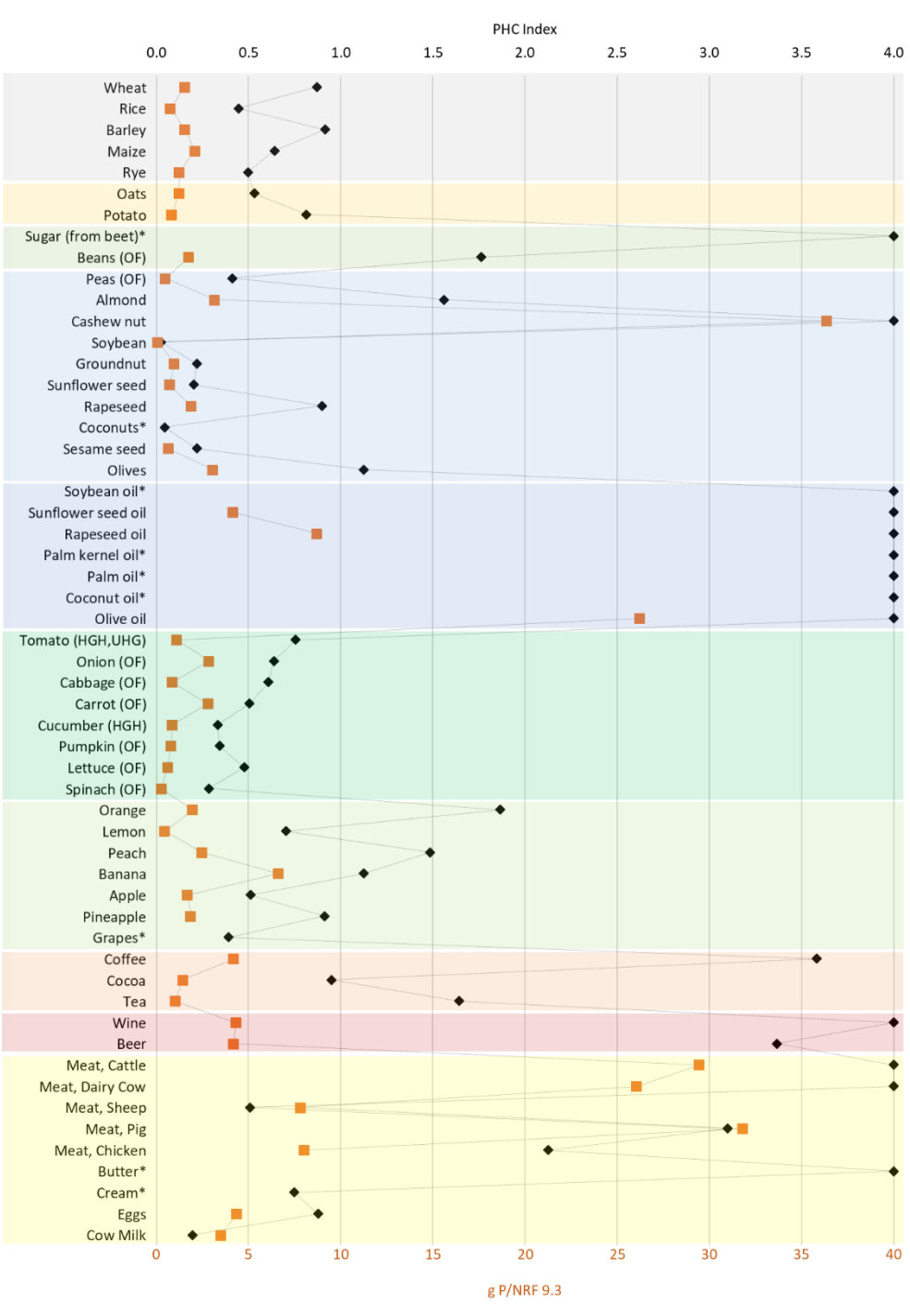


Figure S4. Weighted and capped median PHC (black dots) and g P-min/NRF9.3 (orange dots). * For these products, the environmentally adjusted NRF9.3 (orange dots) is not calculable.

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