Identifying Highly Nutritious Foods with Low Environmental Impacts

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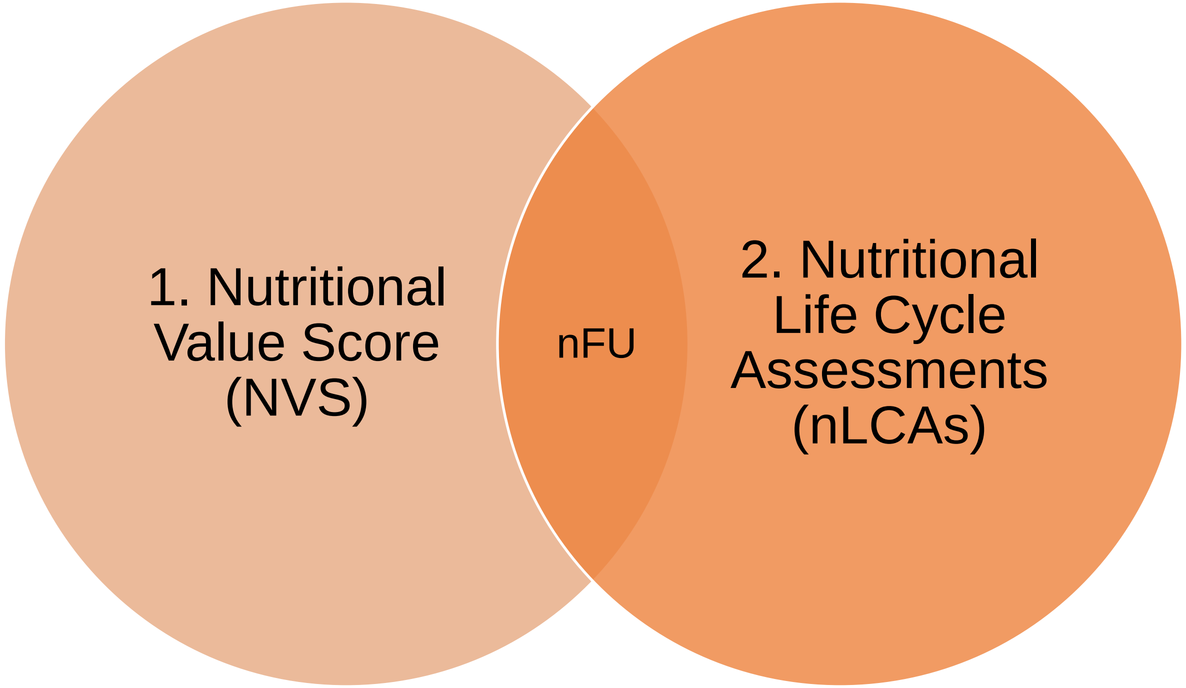
OUR STARTING POINT

- How can we ensure access to **healthy diets for all** while **limiting the environmental impact** of food production and consumption globally?
- Which dietary patterns should we be promoting? And **which foods** should we be **prioritizing** in policies and programs?
- How can we identify **locally available foods** that offer **high nutritional value** with relatively **low environmental impacts**?

OVERVIEW OF OUR APPROACH

RESEARCH OBJECTIVE: To develop an innovative method for holistically assessing the **combined nutritional value and environmental footprint of foods** commonly consumed in a given country.

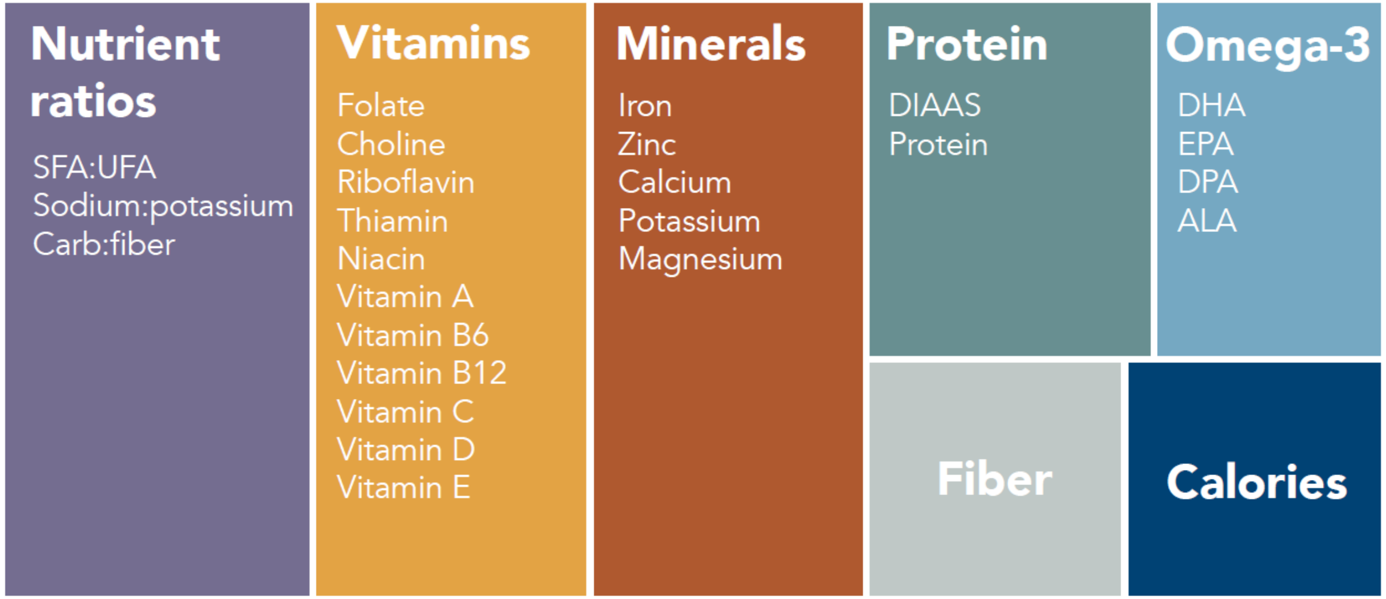
COUNTRY FOCUS: Indonesia and Bangladesh as proof-of-concept.



nFU: nutritional Functional Unit

COMPONENT 1: NUTRITIONAL VALUE SCORE (NVS)

- **What is it?** A new **Nutrient Profiling System (NPS)** to holistically assess the relative nutritional value of individual foods, food groups, and whole diets.
- **What can it be used for?**
  - To inform **policy and programmatic decisions** on which foods to prioritize for the greatest nutritional and health impacts.
  - As the denominator (i.e., nutritional Functional Unit, nFU) in **environmental impact and affordability assessments** of foods.

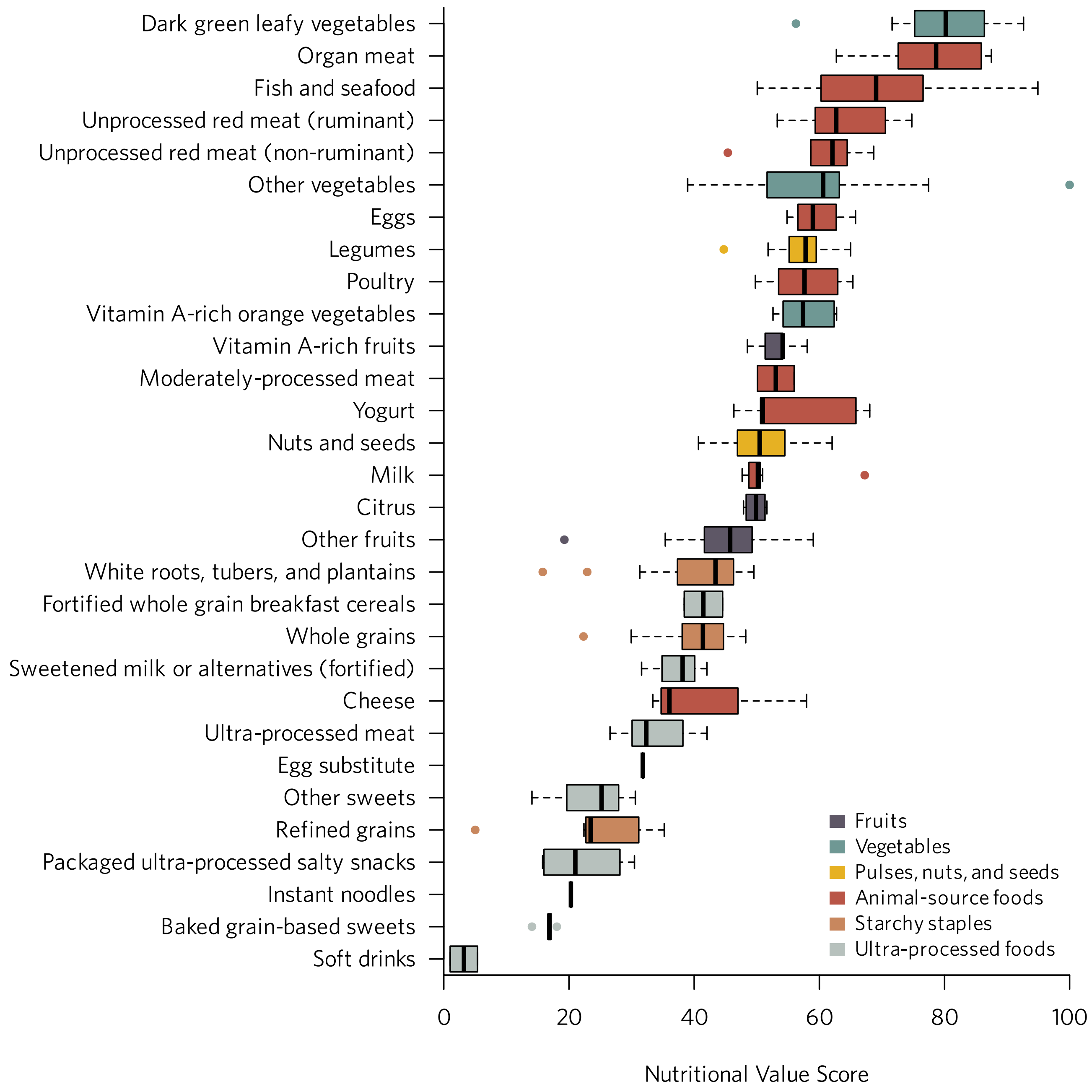


WHAT MAKES THE NVS UNIQUE FROM OTHER NPS?

1. Aligned with the **latest scientific guidance** on developing NPS for global application and for use in food sustainability & affordability assessments
2. Includes nutrients of **global health priority** exclusively
3. Adjusts for **bioavailability** of iron and zinc
4. Considers the **quantity and quality** of protein and omega-3 fats
5. Quantifies nutrient density per **unit mass *and* energy**
6. Includes **sub-scores** for vitamins, minerals, protein, omega-3 fats, fiber, calories, and nutrient ratios
7. Developed using foods commonly consumed in **low- and middle-income countries**
8. High **flexibility**: easy to adapt and apply to other countries and/or demographic groups

Nutritional Value Scores for 289 unique foods in Indonesia, Bangladesh, Kenya, Nigeria, and the US, categorized into common food groups

Scaled from 1 (lowest) to 100 (highest)



Beal and Ortenzi (under review). Nutritional Value Score rates foods based on global health priorities. *Nature Food*.

COMPONENT 2: NUTRITIONAL LIFE CYCLE ASSESSMENTS (nLCAs)

- **What is it?** A methodology to quantify **foods' environmental footprints** throughout the life cycle **per unit nutritional value** (i.e., the nutritional Functional Unit, nFU), in lieu of per unit energy or mass.

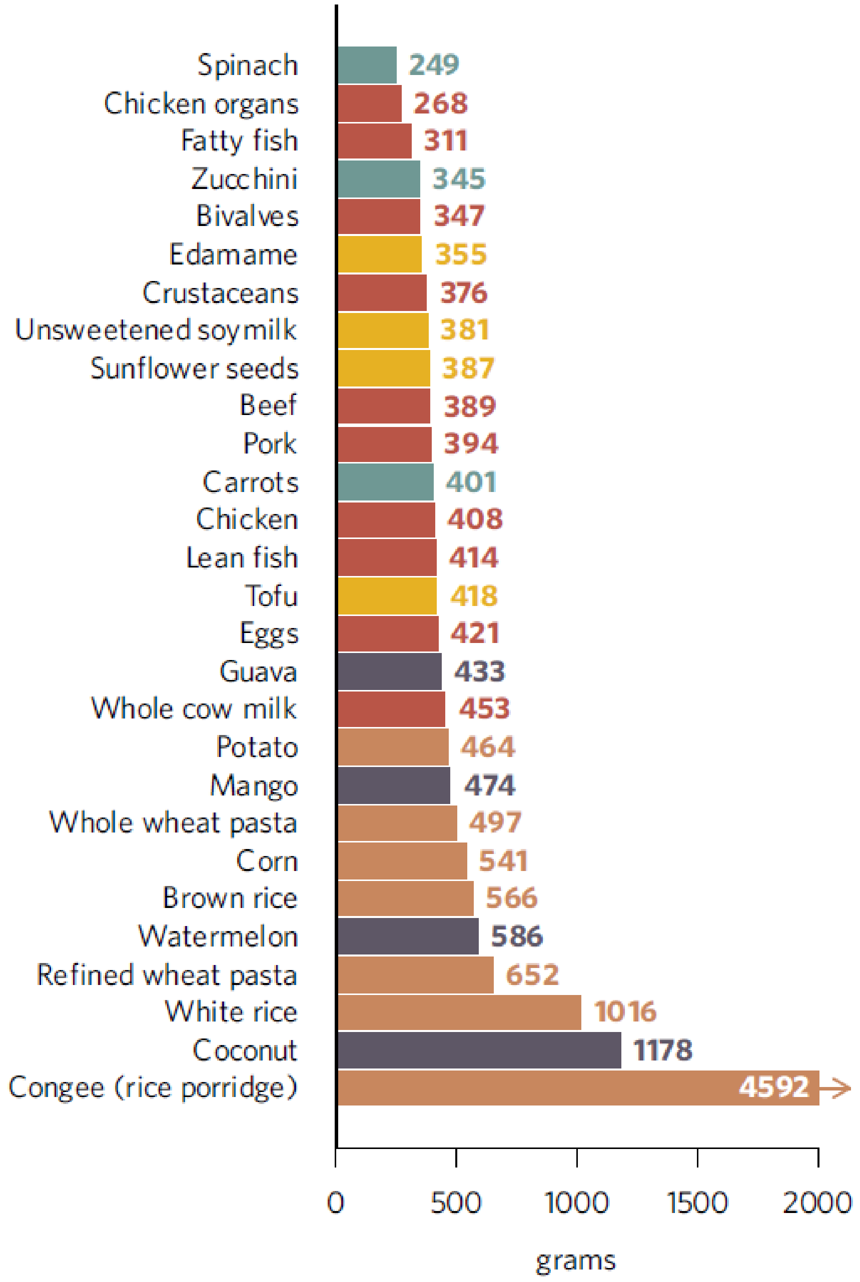
- **What can it be used for?**
  - To inform **policy and programmatic decisions** on which foods to prioritize for the greatest nutritional impacts with relatively low environmental impacts.
  - To incentivize public and private sector **innovations** in food supply chains.

WHAT MAKES OUR nLCA APPROACH UNIQUE FROM OTHERS?

1. Uses **Nutritional Value Scores** as the nutritional Functional Unit
2. Overall environmental footprints of foods summarized in a **single score** for ease of interpretation
3. Uses **local environmental impact data** to the extent possible, accounting for locally produced vs imported foods
4. Applied to foods commonly consumed in **low- and middle-income countries**
5. Assesses **7 environmental impact categories**, providing sub-scores for each
6. Adopts a **full life cycle perspective**, including home food preparation
7. High **flexibility**: easy to adapt and apply to other countries

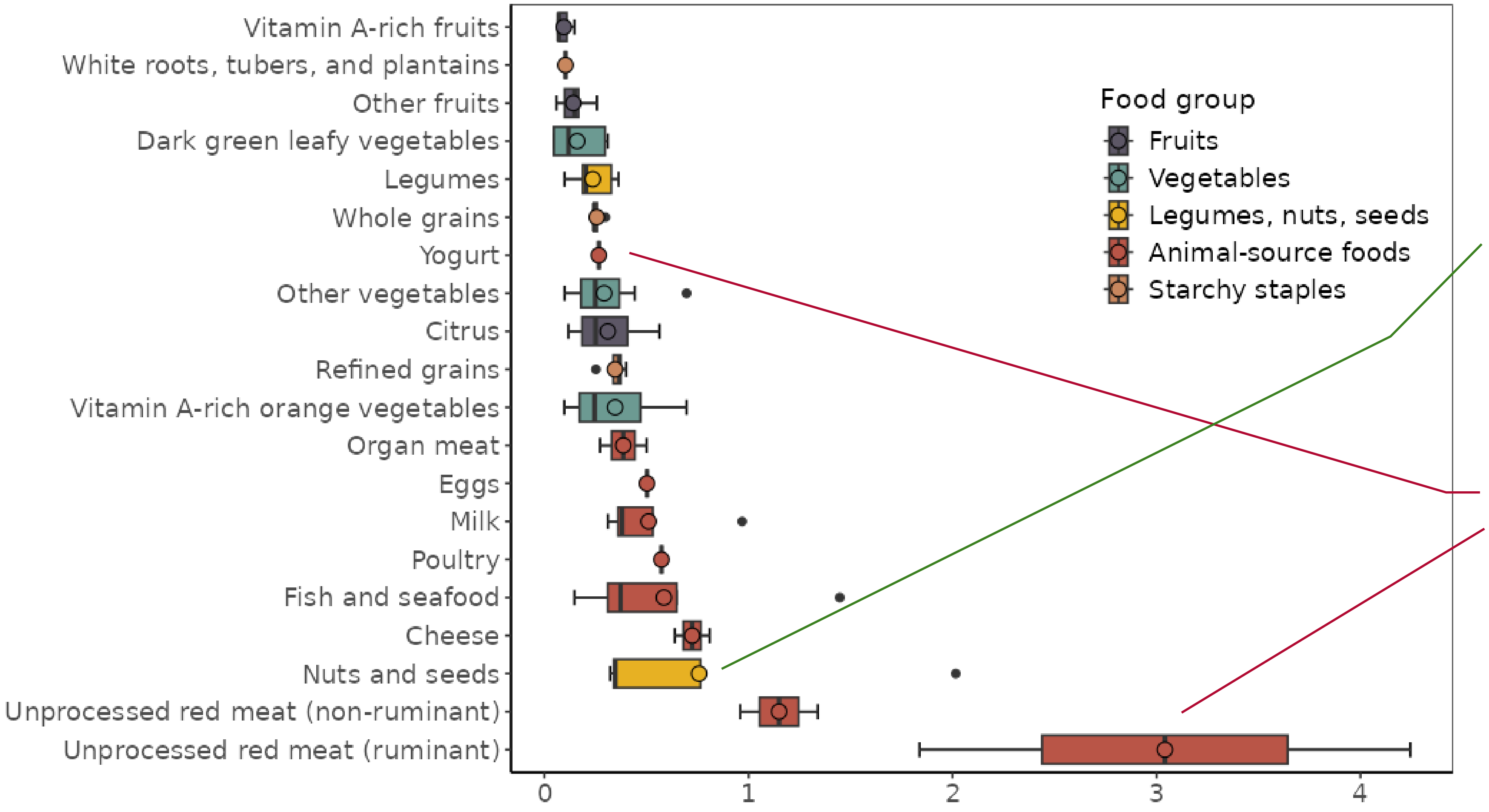
WHY DOES THE FUNCTIONAL UNIT MATTER?

- Assessing the environmental impacts of foods per unit mass or energy fails to account for differences in nutritional value.
- Using Nutritional Value Scores as the nFU allows to **standardize foods by nutritional value** when comparing their environmental footprints, making the results more nutritionally-relevant.



Grams of common foods in Indonesia needed for an NVS of 100

ENVIRONMENTAL IMPACTS PER UNIT MASS (kg) vs…

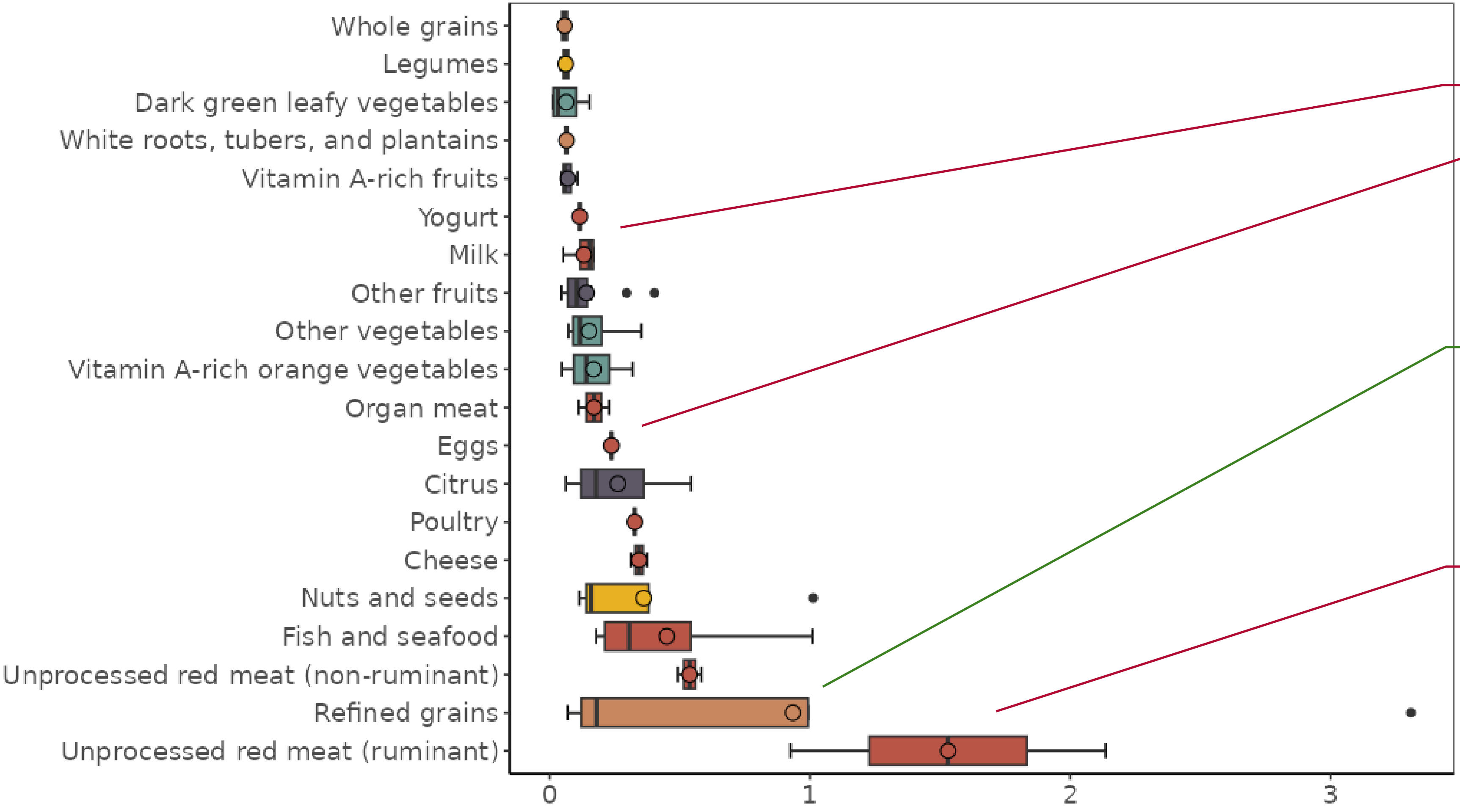


Overall environmental impacts of common foods in Indonesia per unit mass (milliPoints/kg), organized by common food groups

Except for nuts & seeds, plant-source foods have the lowest impacts.

Ruminant meat has disproportionally high impact. Yogurt is the only animal-source food scoring relatively low.

…PER UNIT NUTRITIONAL VALUE (NVS)



Plant-source foods are now interspaced with nutrient-dense animal-source foods

Refined grains are second only to ruminant meat

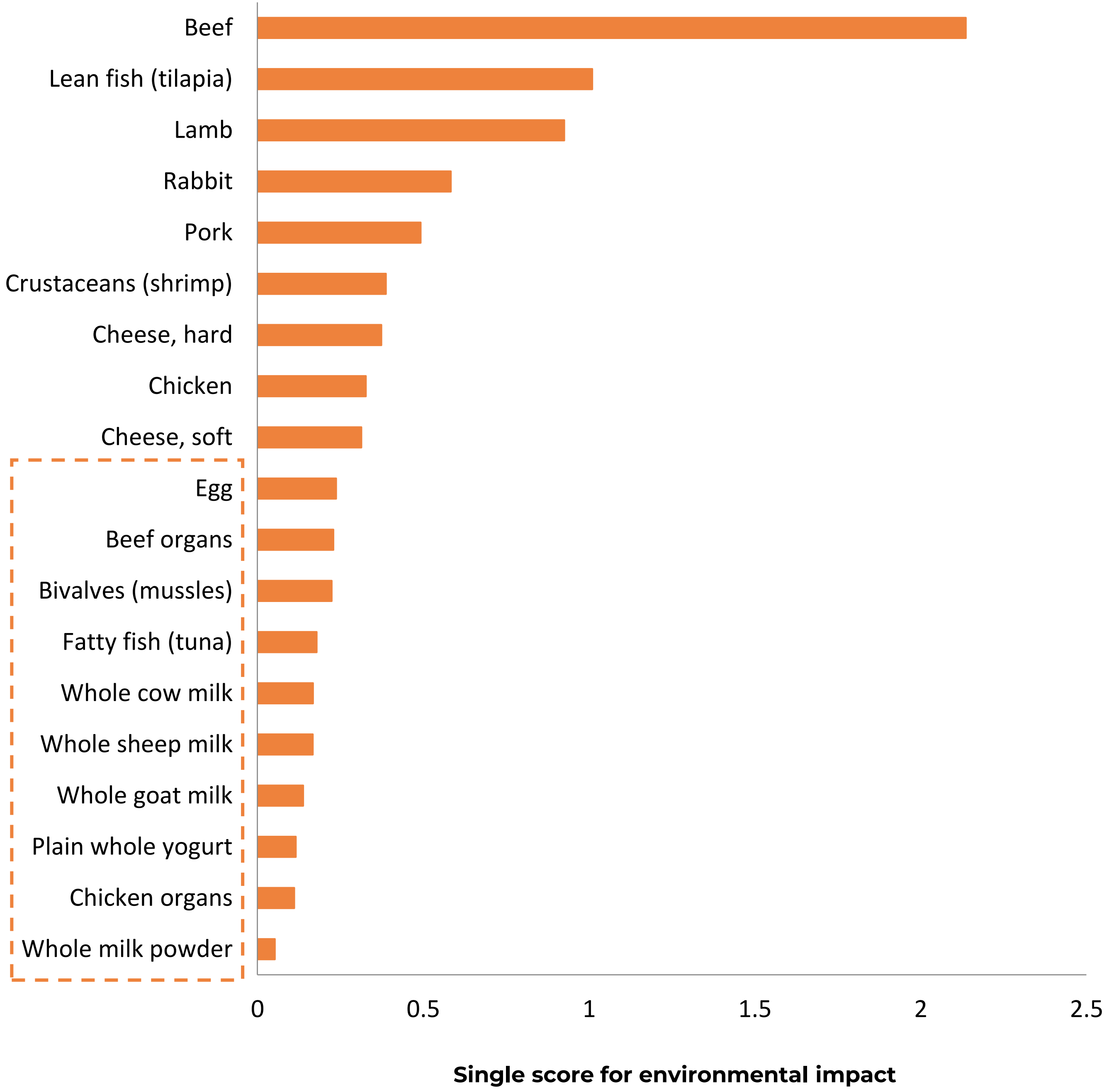
Ruminant meat still has the highest impact, but the scale has changed

Overall environmental impacts of common foods in Indonesia per unit nutritional value (milliPoints/100 NVS), organized by common food groups

Overall environmental impacts of common Indonesian animal-source foods per unit nutritional value

Expressed in milliPoints/100 NVS

- Environmental impacts show great variation not just across, but also ***within* food groups.**
- In Indonesia, minimally processed dairy (**milk and yogurt**), **organ meats, fatty fish, bivalves, and eggs** provide high nutritional value for relatively low environmental impacts.



Nutritional Value Scores and Environmental Impact Sub-Scores for common animal-source foods in Indonesia per unit nutritional value

CC: climate change (kg CO_2eq)

PM: particulate matter (g PM2.5eq)

TA: terrestrial acidification (g SO_2eq)

FE: freshwater eutrophication (g Peq)

ME: marine eutrophication (g Neq)

WU: water use (m^3 deprivation eq)

LU: land use (m^2-year crop eq)

Animal-sourced foods	Origin	NVS	CC	PM	TA	FE	ME	WU	LU
Whole milk powder	New Zealand	52	0.70	0.90	3.3	0.11	0.25	0.06	0.63
Plain whole yogurt	France	53	1.07	3.16	6.9	0.43	0.60	0.42	0.70
Whole goat milk	DOMESTIC	52	0.97	4.43	12.2	0.43	0.76	0.55	0.93
Chicken organs	DOMESTIC	91	0.95	2.09	2.6	0.46	0.68	0.22	1.24
Whole sheep milk	DOMESTIC	52	1.30	4.72	15.2	0.42	1.22	0.14	1.95
Whole cow milk	DOMESTIC	53	1.84	4.72	10.5	0.50	1.07	0.22	1.61
Plain whole yogurt	DOMESTIC	53	1.73	3.67	9.8	0.49	1.00	0.45	1.46
Fatty fish (tuna)	DOMESTIC	83	1.27	7.06	17.4	0.31	0.09	0.12	0.01
Beef organs	Australia	84	2.56	4.69	14.8	0.66	2.71	0.88	2.44
Bivalves (mussles)	DOMESTIC	76	2.19	9.03	8.3	1.27	-5.15	0.45	1.46
Egg	DOMESTIC	59	1.64	5.09	20.3	0.75	1.24	1.15	2.46
Cheese, soft	New Zealand	47	4.00	5.92	19.3	0.82	1.48	0.83	3.65
Cheese, hard	New Zealand	50	4.87	6.67	23.4	0.84	1.84	0.92	4.60
Beef organs	DOMESTIC	84	4.27	8.09	32.1	0.69	1.60	1.35	2.35
Crustaceans (shrimps)	DOMESTIC	71	3.87	10.28	22.2	1.40	2.81	1.02	2.56
Chicken	DOMESTIC	57	2.66	3.95	7.1	1.12	2.24	0.60	4.32
Pork	Europe	60	4.03	10.1	38.5	1.49	3.77	1.79	5.07
Rabbit	DOMESTIC	68	6.78	45.5	24.3	4.26	4.36	2.43	5.72
Pork	USA	60	3.32	9.75	43.7	1.40	2.44	3.70	2.94
Lamb	DOMESTIC	62	10.4	13.4	56.9	2.74	8.64	4.27	15.2
Lean fish (tilapia)	DOMESTIC	60	3.64	33.3	11.3	10.3	1.90	79.4	1.32
Beef	Australia	62	23.9	31.5	147.2	4.55	29.3	8.75	26.8
Beef	India	62	43.2	71.1	343.5	4.87	17.1	14.0	25.9

POTENTIAL USE CASES / APPLICATIONS

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Research

- Can be adapted to **any countries or regions globally**
- Can be expanded to a **larger number of foods**, as well as whole diets
- Can be combined with **other assessments** (e.g., affordability, acceptability)

Policy

- Can be used to inform policies on **healthy & sustainable foods/diets**
- Can help identify (i) **priority foods** for increasing access and (ii) **priority value chains** for reducing environmental impacts.

Programs

- Can be used to inform programs on **healthy & sustainable foods/diets**
- Can drive **technological innovations** in food supply chains to improve access or reduce environmental impacts.

Thank you!

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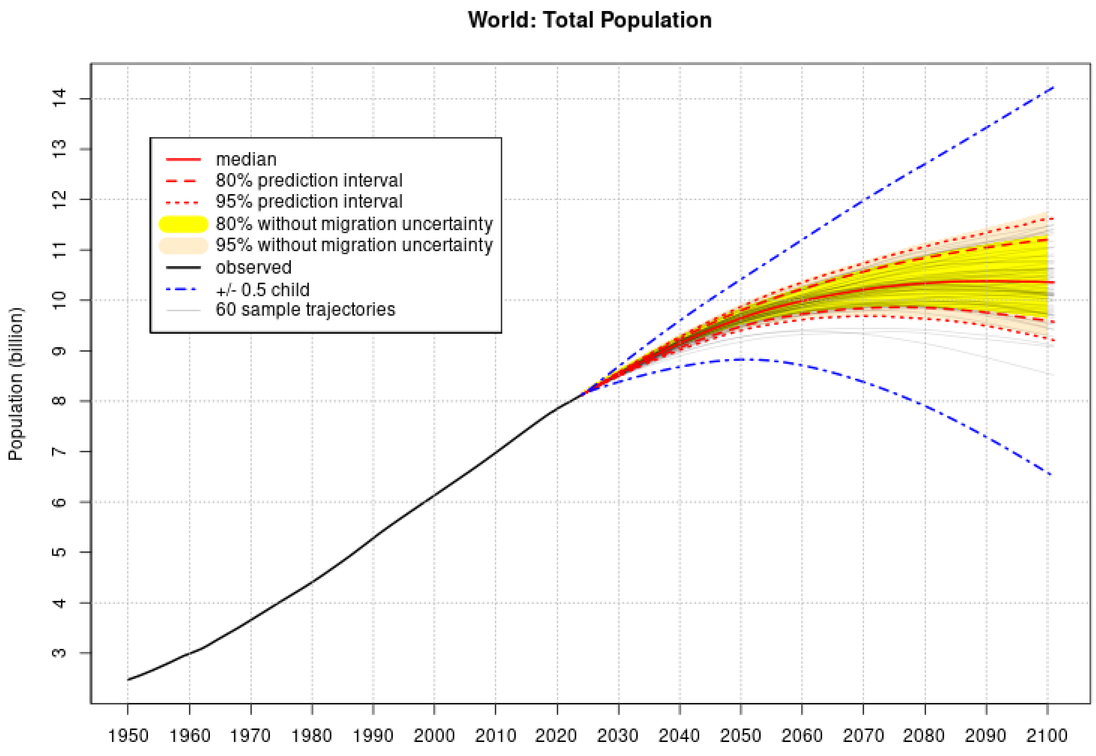
Annex slides

A DUAL GLOBAL CHALLENGE

1

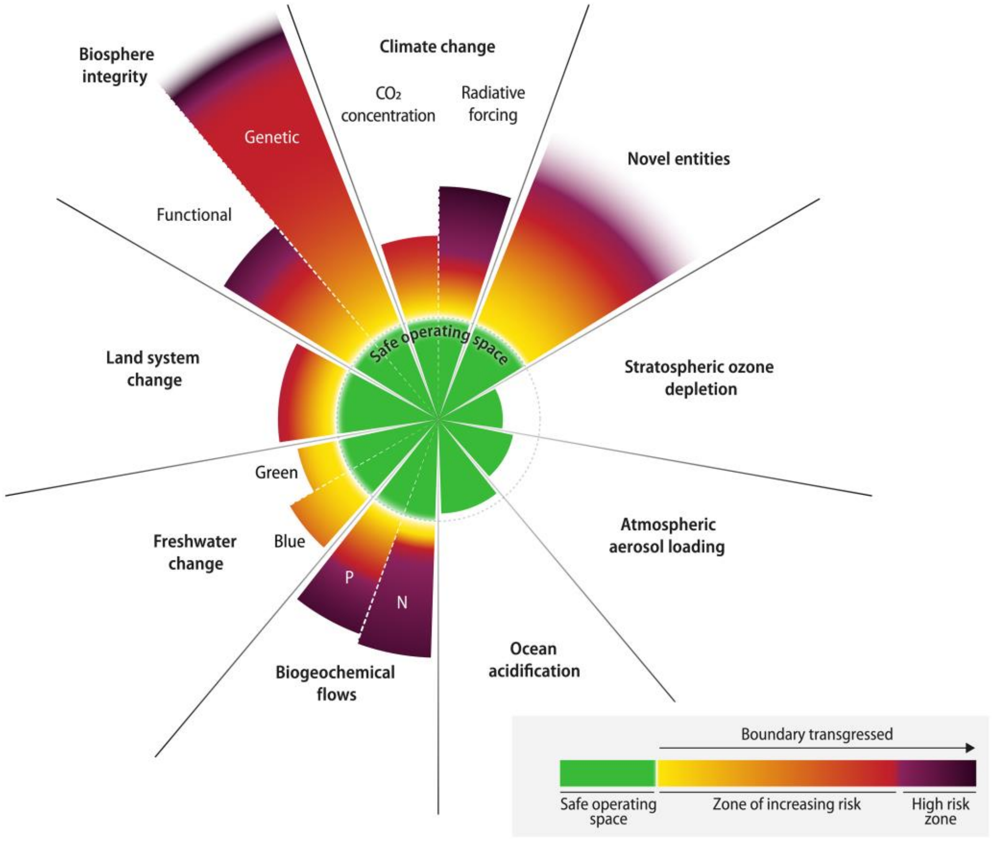
Global food systems need to provide **healthy diets** for over 8 billion people currently, and an expected **9.6 billion by 2050**.



Source: UN DESA Population Division, 2024

2

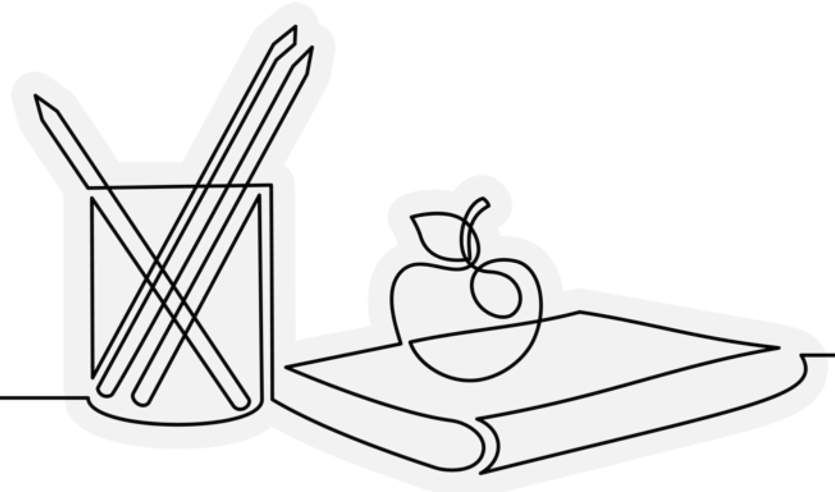
At the same time, global food systems must operate within **planetary boundaries**. As of 2023, six of the nine boundaries were transgressed, indicating unprecedented human disruption of Earth system.



Source: Richardson et al., 2023

OUTLINE

- A dual global challenge
- Our starting point
- Overview of our approach
- Component 1: Nutritional Value Score (NVS)
- Component 2: nutritional Life Cycle Assessments (nLCAs)
- Potential use cases / applications



THE TRIPLE BURDEN OF MALNUTRITION (1)

Overweight & obesity	• **>40%** of adults, **~20%** of children and adolescents (5–19 y), and **~6%** of young children (0-59 m) are **overweight or obese** • **>20%** of adults have **raised blood pressure** & **~10%** have **diabetes**
Micronutrient deficiencies	• **30%** of women of reproductive age (15-49 y) and **37%** of pregnant women suffer from **anaemia** • **1.6 billion** children under-5 and women of reproductive age are **deficient in one or more essential micronutrients**
Undernutrition	• **~9.1%** of the global population (733 million people) are facing **hunger** • **22%** of children under-5 are **stunted** and **~7%** are **wasted**

Source: 2022 Global Nutrition Report; Stevens et al., 2022; SOFI 2024

THE TRIPLE BURDEN OF MALNUTRITION ①

- According to the 2021 Global Burden of Disease study, **poor diets** represent the **fourth largest contributor** to disease burden worldwide, following high blood pressure, air pollution, and tobacco use (GBD, 2021).
- The world is largely **off course** to meet global nutrition targets:

Progress towards the global nutrition targets

Childhood stunting
53 On course
74 Some progress
28 No progress or worsening
39 No data

Anaemia
1 On course
29 Some progress
161 No progress or worsening
3 No data

Low birth weight
15 On course
49 Some progress
82 No progress or worsening
48 No data

Childhood overweight
105 On course
50 Off course
39 No data

Exclusive breastfeeding
35 On course
28 Some progress
33 No progress or worsening
98 No data

Childhood wasting
57 On course
20 Some progress
23 No progress or worsening
94 No data

Sodium intake, women and men
184 Off course
10 No data

Raised blood pressure, women
45 On course
145 Off course
4 No data

Raised blood pressure, men
23 On course
167 Off course
4 No data

Obesity, women
190 Off course

Obesity, men
190 Off course

Diabetes, women
19 On course
171 Off course

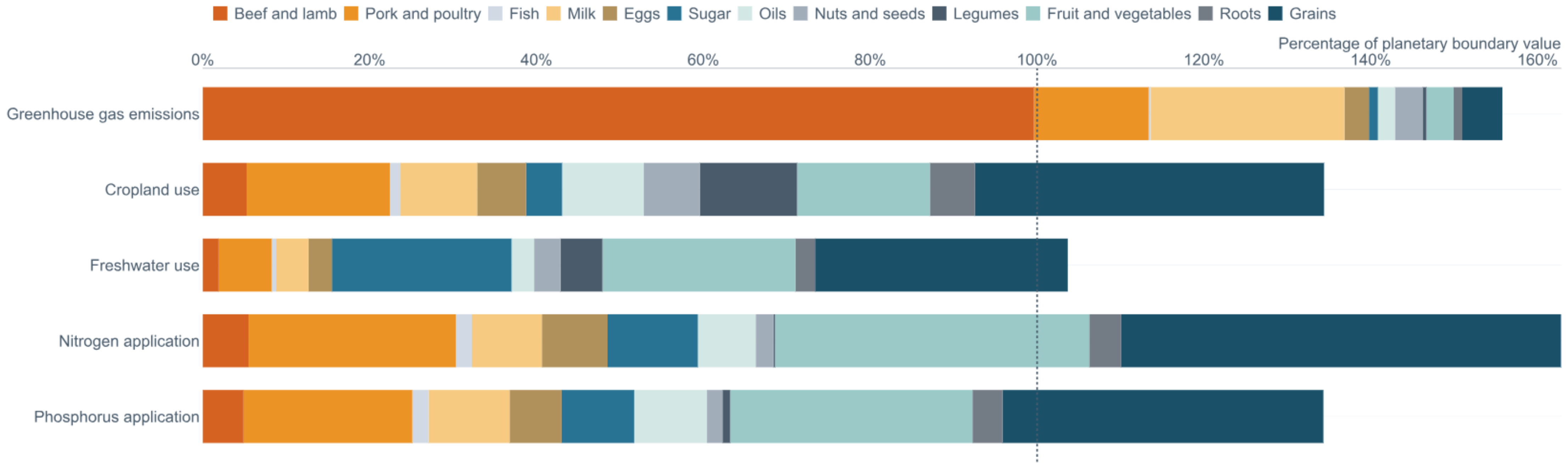
Diabetes, men
8 On course
182 Off course

Source: 2022 Global Nutrition Report

THE ENVIRONMENTAL IMPACT OF FOOD SYSTEMS 2

- Global food systems are responsible for:
  - **34%** of all anthropogenic **greenhouse gas emissions** (Crippa et al., 2022)
  - **70%** of all **freshwater withdrawals** (FAO, 2021)
  - The largest threat to **species extinction** due to land use change (Tilman et al., 2017)
- It is estimated that **between 2010 and 2050**, food systems' environmental footprint could **increase by 50–90%** without dedicated mitigation measures (Springmann et al., 2018).

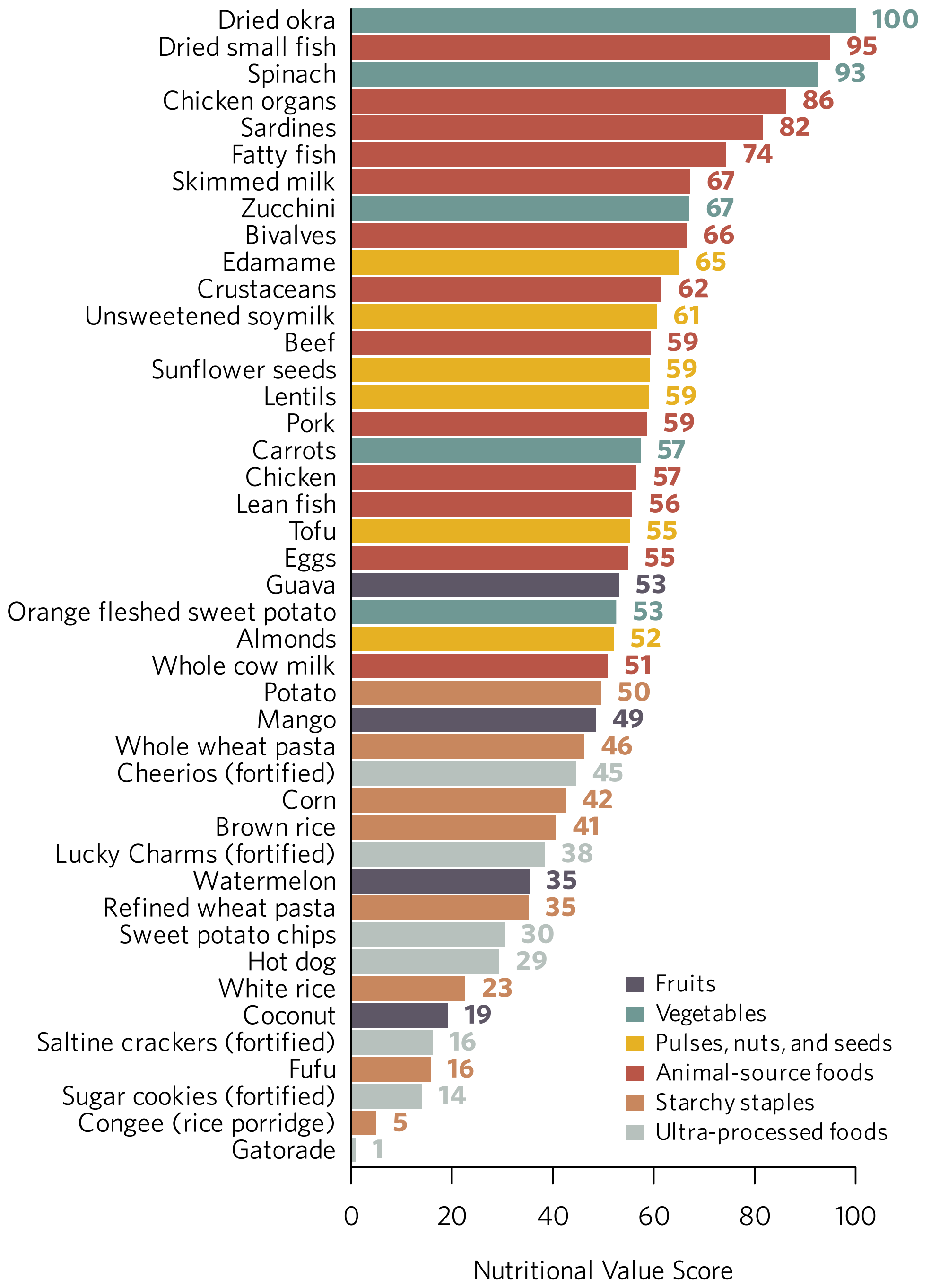
Food system impact on planetary boundaries



Source: 2022 Global Nutrition Report

Nutritional Value Scores for common foods in Indonesia, Bangladesh, Kenya, Nigeria, and the US

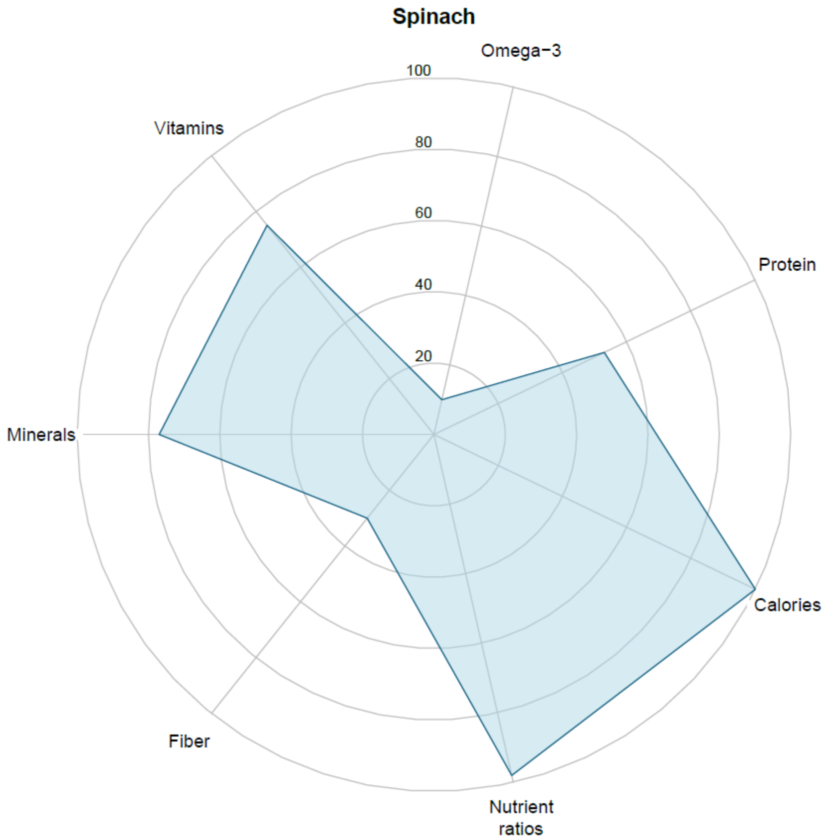
Scaled from 1 (lowest) to 100 (highest)

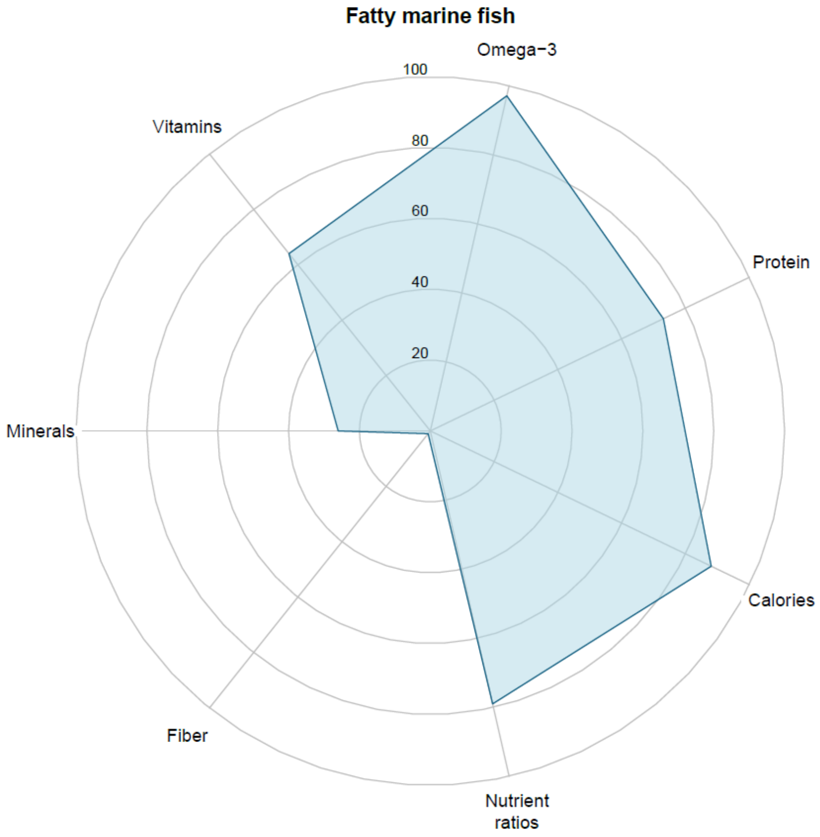


Beal and Ortenzi (under review). Nutritional Value Score rates foods based on global health priorities. *Nature Food*.

KEY FINDINGS

- No foods score high **across *all* dietary components** included. Plant- and animal-source foods have complementary nutritional profiles.
- **Nutritional value varies greatly** across and within food groups.
- In Indonesia, Bangladesh, Kenya, and Nigeria, the highest scoring food groups are **dark green leafy vegetables, organ meat, and fish and seafood**, followed by unprocessed red meat, other vegetables, eggs, legumes, poultry, and vitamin A-rich vegetables.





WHAT'S BEHIND THE SINGLE SCORE?

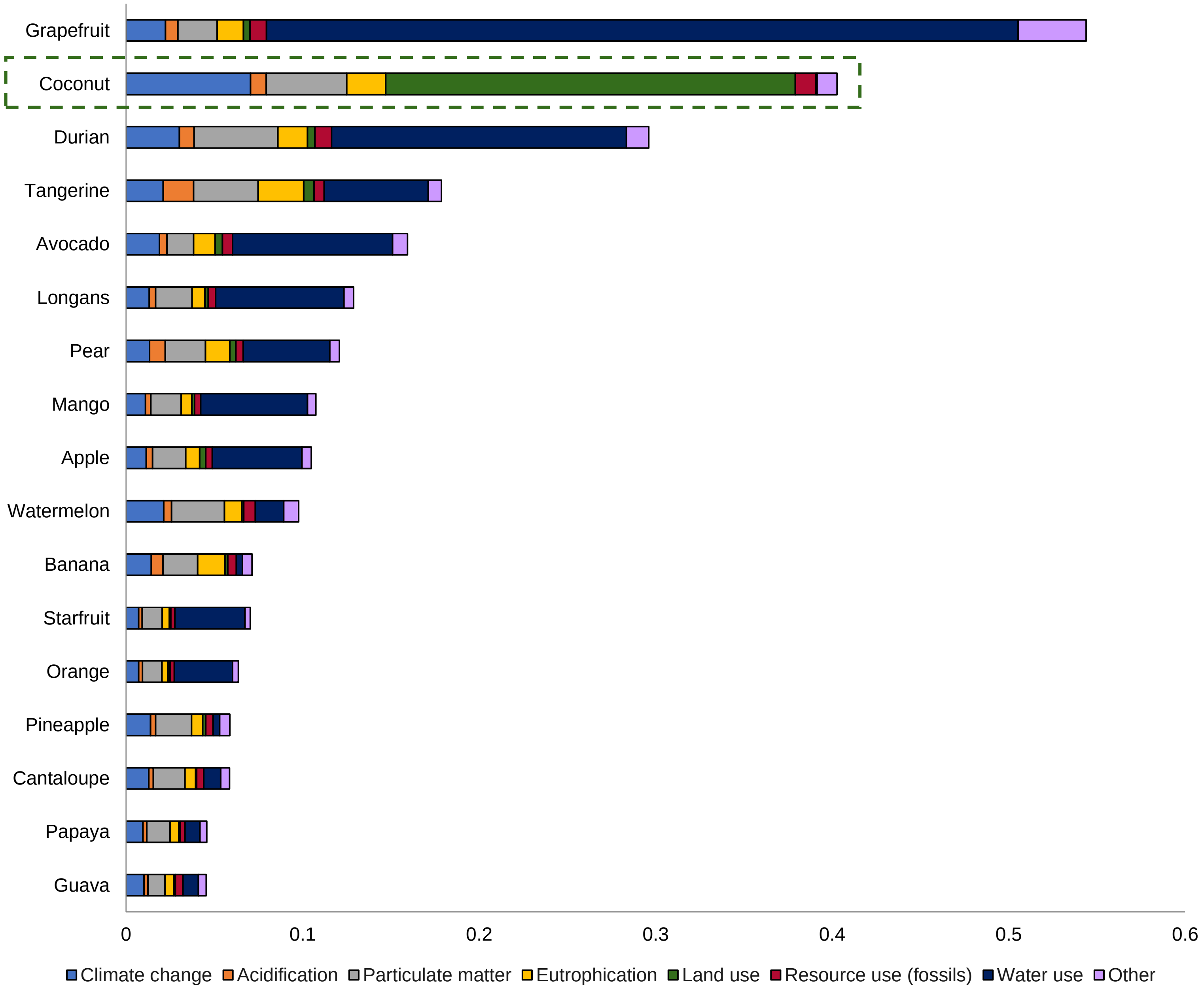
Midpoint	Normalization	Weighting
Climate change: kg CO2eq	person-year	21.1%
Particulate matter: kg PM2.5eq	person-year	9.0%
Eutrophication: kg N eq, kg P eq	person-year	10%
Acidification: mol H+ eq	person-year	6.2%
Land use: m2-year crop eq	person-year	8.0%
Fossil resource scarcity: MJ	person-year	8.3%
Water scarcity: m3 deprivation eq	person-year	8.5%
Other impact categories	person-year	28.9%

Source: European Commission, 2017

Environmental impacts by category of common Indonesian fruits per unit nutritional value

Expressed in milliPoints/100 NVS

- Contribution analysis allows to **identify hotspots** for targeted interventions.
- **Water use** represents the primary concern **for all fruits, except for coconut**, for which **land use** is the category contributing the most due to deforestation.

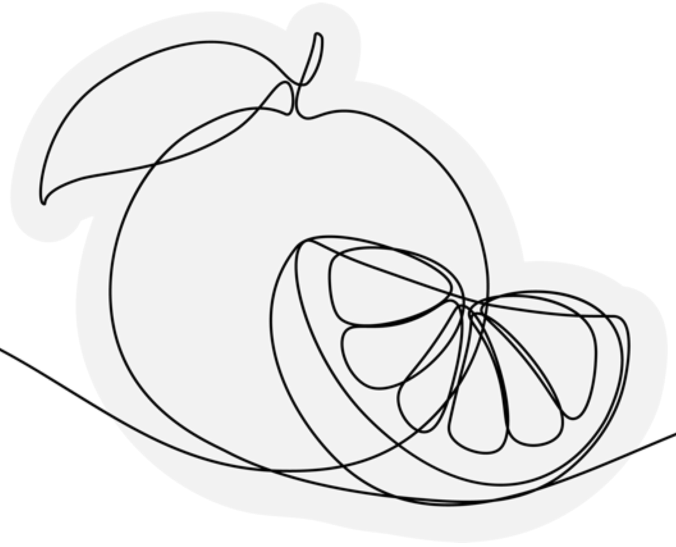


Category contributions to the single score for environmental impact

SUMMARY OF KEY FINDINGS

- Using Nutritional Value Scores as the nFU enables **more nutritionally-relevant comparisons** of foods' environmental footprints within food groups. For example:
  - Among animal-source foods in Indonesia, **organ meats, minimally processed dairy, fatty fish, bivalves, and eggs** have the lowest environmental impacts per unit nutritional value.
  - Among vegetables: **dark green leafy vegetables**, certain vitamin-A rich orange vegetables (e.g., carrots), and certain other vegetables (e.g., tomato).
  - Among pulses, nuts, and seeds: **soy-derived products**.

- The contribution and hotspot analyses are useful to identify **the most impactful processes** for each food, to design targeted mitigation policies and interventions, and incentivize technological innovation.



Nutritional Value Scores and Environmental Impact Sub-Scores for common pulses, nuts, and seeds in Indonesia per unit nutritional value

Pulses, nuts and seeds	Origin	NVS	CC	PM	TA	FE	ME	WU	LU
Unsweetened soymilk	USA/domestic	54	0.32	1.91	0.9	0.30	0.08	0.09	0.04
Tempeh	USA/domestic	59	0.77	4.21	2.3	0.55	0.27	0.47	0.62
Tofu	USA/domestic	55	0.79	4.52	2.4	0.59	0.29	0.50	0.66
Edamame	USA/domestic	68	0.67	3.35	1.8	0.55	0.44	0.84	1.22
Peanuts	DOMESTIC	54	1.17	4.03	1.8	0.72	1.87	0.12	7.19
Peanut butter	DOMESTIC	47	1.32	4.59	2.0	0.82	2.14	0.15	8.26
Red beans	Myanmar	66	0.35	1.56	2.0	0.38	0.38	0.04	0.58
Mung beans	Myanmar	62	0.39	1.70	2.2	0.42	0.42	0.04	0.63
Sunflower seeds	China	65	0.69	4.42	3.6	0.68	0.53	2.36	1.65
Cashews	Vietnam	46	4.62	22.5	126.7	1.42	16.2	4.88	5.63

CC: climate change (kg CO_2eq)

PM: particulate matter (g PM2.5eq)

TA: terrestrial acidification (g SO_2eq)

FE: freshwater eutrophication (g Peq)

ME: marine eutrophication (g Neq)

WU: water use (m^3 deprivation eq)

LU: land use (m^2-year crop eq)

Nutritional Value Scores and Environmental Impact Sub-Scores for common pulses, nuts, and seeds in Indonesia per unit nutritional value

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ME: marine eutrophication (g Neq)

WU: water use (m^3 deprivation eq)

LU: land use (m^2-year crop eq)

Vegetables	Origin	NVS	CC	PM	TA	FE	ME	WU	LU
Pumpkin leaves	DOMESTIC	90	0.13	0.22	0.3	0.12	0.05	0.00	0.00
Drumstick leaves	DOMESTIC	81	0.15	0.24	0.3	0.13	0.05	0.00	0.00
Sweet potato leaves	DOMESTIC	78	0.15	0.25	0.3	0.13	0.05	0.00	0.00
Tree fern	DOMESTIC	61	0.25	0.35	0.5	0.18	0.07	0.01	0.00
Water spinach	DOMESTIC	87	0.20	0.50	2.4	0.14	1.14	0.15	0.01
Green pepper	DOMESTIC	48	0.35	0.60	1.1	0.25	0.39	1.48	0.23
Carrots	DOMESTIC	60	0.31	0.66	2.1	0.24	0.33	1.48	0.19
Radish	DOMESTIC	62	0.35	1.19	6.3	0.32	2.09	0.79	0.07
Tomatoes	DOMESTIC	61	0.36	1.18	6.4	0.37	2.97	0.60	0.05
Cucumber	DOMESTIC	44	0.51	1.17	4.6	0.41	2.06	0.82	0.08
Cabbage	DOMESTIC	69	0.39	1.22	6.5	0.40	2.99	0.81	0.07
Spinach	DOMESTIC	99	0.36	1.28	7.6	0.49	3.45	1.43	0.13
Long bean	DOMESTIC	59	0.52	1.40	7.4	0.44	3.44	1.23	0.11
Chinese cabbage	DOMESTIC	84	0.47	1.40	7.6	0.40	4.10	1.47	0.13
Cauliflower	DOMESTIC	45	0.50	1.61	8.7	0.50	3.48	1.27	0.11
Zucchini	DOMESTIC	69	0.43	1.36	6.7	0.49	2.53	4.58	0.40
Chinese broccoli	DOMESTIC	82	0.48	1.93	11.8	0.56	5.39	1.83	0.16
Eggplant	DOMESTIC	41	0.65	2.09	11.5	0.59	4.81	1.15	0.10
Pumpkin	DOMESTIC	60	0.56	1.80	9.3	0.52	3.71	4.31	0.38
Broccoli	DOMESTIC	73	0.54	2.17	13.3	0.63	6.05	2.06	0.18
Bitter melon	DOMESTIC	69	0.82	2.37	13.2	0.45	6.93	5.28	0.46
Mushrooms (shiitake)	DOMESTIC	54	2.16	3.68	7.8	0.83	0.67	1.94	0.61
Green beans	DOMESTIC	61	0.69	3.02	19.7	0.63	9.22	2.53	0.22
Winged beans	DOMESTIC	54	0.78	3.41	22.3	0.71	10.42	2.86	0.25
Luffa gourd	DOMESTIC	51	0.94	2.94	16.6	0.56	8.77	6.69	0.58
Red pepper	DOMESTIC	53	1.38	5.65	36.1	1.03	4.88	2.87	1.27
Green pepper	DOMESTIC	48	1.52	6.23	39.9	1.14	5.39	3.17	1.41
Mung bean sprouts	DOMESTIC	60	0.98	5.33	6.6	1.35	1.36	0.07	2.07

LIMITATIONS OF THE nLCA APPROACH

- **Uncertainty** in most LCAs/nLCAs is **high**: small differences in environmental impacts among foods may not be meaningful.
- Inability of LCA/nLCAs to account for farm-specific production systems, including **on-farm/grassland biodiversity and circularity**, resulting in excessive penalization of foods facilitating circularity (e.g., ruminant meat).
- The chosen **weighting system** significantly affects the food rankings. Weights assigned to each impact category would ideally be **context-specific**.
- Existing LCA inventories primarily include data for foods commonly consumed globally, making it difficult to find data on **less common foods** that are important for **local communities**.
- Limited **data on foods' environmental footprints from LMICs**, forcing us to resort to proxies of variable quality when needed.