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Supplementary Note 1

Derivation of Rebound Ratio and Key Properties

$RR =$ rebound ratio
$\Delta P =$ change in quantity of food produced for human consumption
$\Delta C =$ change in quantity of food consumption
$\Delta W =$ reduction in quantity wasted
$\Delta L =$ reduction in quantity lost
$\Delta T =$ change in quantity traded in the market

The rebound ratio is equal to (Fig. 1c),

$$RR = \frac{\Delta W + \Delta T}{\Delta W + \Delta L} \quad \text{(S1)}$$

Note that $\Delta C = \Delta T + \Delta W$, by definition. Rewriting (S1) in terms of ΔC yields:

$$RR = \frac{\Delta C}{\Delta W + \Delta L} \quad \text{(S2)}$$

Solving for (S2) ΔC yields:

$$\Delta C = RR(\Delta W + \Delta L) \quad \text{(S3)}$$

Since ΔW and ΔL are always positive (because we are imagining scenarios of avoided waste and loss), ΔC is always positive (i.e., food security improves). In other words, reducing loss and/or waste always increases food consumption, as long as the rebound ratio is positive (generally the case, with downward-sloping demand and upward-sloping supply).

Note that that $\Delta T = \Delta P + \Delta L$, also by definition. Rewriting (S1) in terms of ΔP,

$$RR = \frac{\Delta W + \Delta P + \Delta L}{\Delta W + \Delta L} \quad \text{(S4)}$$

Solving (S4) for ΔP,

$$\Delta P = (RR - 1)(\Delta W + \Delta L) \quad \text{(S5)}$$

Since ΔL and ΔW are positive, ΔP is negative (i.e., production, and environmental impact decrease) so long as RR < 1.

With no waste ($\Delta W = 0$), we can see from equation (S2) that RR becomes (as in Fig. 1a):

$$RR = \frac{\Delta C}{\Delta W} \tag{S6}$$

With no loss ($\Delta L = 0$), we can see from equation (S1) that RR becomes (as in Fig. 1b):

$$RR = \frac{\Delta W + \Delta T}{\Delta W} = \frac{\Delta W - |\Delta T|}{\Delta W} \tag{S2}$$

2. Supplementary Tables

Table 1 | Price elasticities of demand. Range of estimates for elasticities of demand for different income regions from Green et al (2013). While Green et al analyzed 10 food groups, our study included equivalents for Fruits and Vegetables, Meat, Dairy, Cereals, and Fats and Oils only.

	Low Income			**Middle Income**			**High Income**		
	n = 1412			**n = 827**			**n = 1124**		
Food Groups	*Low*	*Average*	*High*	*Low*	*Average*	*High*	*Low*	*Average*	*High*
Fruits & Vegetables	-0.77	-0.72	-0.66	-0.71	-0.65	-0.59	-0.59	-0.53	-0.48
Meat	-0.83	-0.78	-0.73	-0.78	-0.72	-0.66	-0.66	-0.60	-0.54
Dairy	-0.84	-0.78	-0.73	-0.78	-0.72	-0.66	-0.66	-0.60	-0.54
Cereals	-0.66	-0.61	-0.56	-0.61	-0.55	-0.49	-0.48	-0.43	-0.36
Fats and oils	-0.65	-0.60	-0.54	-0.60	-0.54	-0.47	-0.48	-0.42	-0.35

Table 2 | Food type key. This key translate correlates the FAO food types to the nearest equivalent of food types used by Green et al 2013.

Green et al 2013		**FAO Food Types**		**Green Equivalency**
1	Fruits & Vegetables	1	Cereals	6
2	Meat	2	Fruits and Vegetables	1
3	Fish	3	Meat	2
4	Dairy	4	Milk	4
5	Eggs	5	Oilcrops and Pulses	7
6	Cereals	6	Roots and Tubers	6
7	Fats & Oils			
8	Sweets, confectionary, & sweetened beverages			
9	Other			
10	All food groups combined			

Table 3 | Region-income-group key. This key determines SDG regions of interest as high, middle, or low income as determined by Green et al 2013 and the World Bank.

Green et al 2013		SDG Region		Green Equivalency	
1	Low	1	Australia and New Zealand	3	High
2	Middle	2	Central and Southern Asia	2	Middle
3	High	3	Eastern and South-Eastern Asia	2	Middle
		4	Latin America and the Caribbean	2	Middle
		5	Northern America and Europe	3	High
		6	Oceania (excluding Australia and New Zealand)	2	Middle
		7	Sub-Saharan Africa	1	Low
		8	Western Asia and Northern Africa	2	Middle

Table 4 | Price elasticities of supply . Price elasticities of supply as determined by the USDA Economic Research Service (ERS) SWOPSIM Model Appendix Table 7. We map the SDG regions and food types to the SWOPSIM model categories as follows: We assume meat and milk are livestock products while the remaining food types are crops. Northern America and Europe are assumed to have supply elasticities estimated for the "United States" region in the SWOPSIM model; Australia and New Zealand are assumed to have supply elasticities from "Other developed-market economies" region in the SWOPSIM model; the remaining regions are given the corresponding "Rest of the World" region supply elasticities from the SWOPSIM model.

Region/Food Type	*Australia and New Zealand*	*Central and Southern Asia*	*Eastern and South-Eastern Asia*	*Latin America and the Caribbean*	*Northern America and Europe*	*Oceania (excluding Australia and New Zealand)*	*Sub-Saharan Africa*	*Western Asia and Northern Africa*
Cereals	0.35	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Fruits and Vegetables	0.35	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Meat	0.60	0.49	0.49	0.49	0.63	0.49	0.49	0.49
Milk	0.60	0.49	0.49	0.49	0.63	0.49	0.49	0.49
Oilcrops and Pulses	0.35	0.29	0.29	0.29	0.31	0.29	0.29	0.29
Roots and Tubers	0.35	0.29	0.29	0.29	0.31	0.29	0.29	0.29

Tables 5 | Aggregated food supply for human consumption for all regions and food types. Food supply values calculated using Equation 3b for all region and food type combinations using FAOSTAT data from the year 2019. For a more detailed aggregation process, see Supplementary Data 1.

Food Supply (Mt)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	2.39E+07	7.22E+06	3.45E+06	4.68E+07	3.07E+06	1.90E+06
Central and Southern Asia	8.49E+08	3.36E+08	1.42E+07	2.62E+08	1.11E+08	9.14E+07
Eastern and South-Eastern Asia	1.43E+09	9.99E+08	1.24E+08	6.66E+07	6.13E+08	2.57E+08
Latin America and the Caribbean	3.49E+08	1.50E+08	4.30E+07	1.02E+08	1.60E+08	5.43E+07
Northern America and Europe	1.06E+09	2.86E+08	1.28E+08	5.68E+08	2.03E+08	1.39E+08
Oceania (excluding Australia and New Zealand)	1.37E+06	3.59E+06	7.24E+05	1.05E+05	4.96E+06	2.54E+06
Sub-Saharan Africa	3.11E+08	1.34E+08	1.09E+07	3.15E+07	7.54E+07	3.52E+08
Western Asia and Northern Africa	2.80E+08	1.48E+08	1.33E+07	7.39E+07	3.52E+07	2.46E+07

Tables 6 | Consumer food price indices by region. Consumer food price indices from 2019 provided by FAOSTAT.

Region	Consumer Price, Food Indices
Australia and New Zealand	103.79
Central and Southern Asia	128.24
Eastern and South-Eastern Asia	110.37
Latin America and the Caribbean	139.22
Northern America and Europe	104.65
Oceania (excluding Australia and New Zealand)	106.89
Sub-Saharan Africa	151.64
Western Asia and Northern Africa	145.98

Tables 7 | Food loss and waste percentages by region. Food loss is determined using officially reported data from FAOSTAT supply utilization accounts. For food waste, we sum food waste across all regions from the 2021 Food Waste Index (FWI) report. Note that because the UNEP report does not distinguish between differences in in food types, we assume the same fraction of food wasted for each food type. For a more detailed calculation and assumptions, see Supplementary Data 1.

Food Loss (tonnes)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	32578	318195	0	16575	6725	31873
Central and Southern Asia	7439096	26529304	32970	4101106	1406225	10163465
Eastern and South-Eastern Asia	9231692	70753491	523688	1437025	1376443	6279558
Latin America and the Caribbean	4066350	12653765	486422	2837753	416845	2515427
Northern America and Europe	3096841	12384451	250263	226253	292025	5691997
Oceania (excluding Australia and New Zealand)	1738	264635	580	1327	22655	161229
Sub-Saharan Africa	4780094	11427810	36779	1036772	1602835	12904918
Western Asia and Northern Africa	3178059	11719339	64343	1390285	284740	2522037

Food Waste (tonnes)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	428599	793381	532100	651574	32253	267017
Central and Southern Asia	57549974	56798905	2778599	37637199	7574131	12483126
Eastern and South-Eastern Asia	59714024	140328951	20163570	7772545	5668945	20769739
Latin America and the Caribbean	13217756	19702451	7718198	9731096	2048717	5353139
Northern America and Europe	17110314	31728966	13326441	20292089	1111377	11203361
Oceania (excluding Australia and New Zealand)	152570	649778	148228	15437	120362	407871
Sub-Saharan Africa	40416885	37871788	3734401	7373014	6415517	51013243
Western Asia and Northern Africa	19479217	26770831	3004221	8968743	1691539	3977919

Tables 8a-d | Aggregated results for all regions and food types. Median rebound percent (R) (a), the change in the market quantity traded (ΔT) (b), waste avoided (ΔW) (c), and loss avoided (ΔL) (d) for all region and food type combinations.

(a) Rebound Percent (%)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	0.58	0.64	0.53	0.53	0.58	0.58
Central and Southern Asia	0.64	0.69	0.57	0.58	0.64	0.65
Eastern and South-Eastern Asia	0.64	0.68	0.57	0.57	0.64	0.64
Latin America and the Caribbean	0.65	0.69	0.57	0.58	0.64	0.65
Northern America and Europe	0.58	0.64	0.53	0.53	0.58	0.58
Oceania (excluding Australia and New Zealand)	0.64	0.69	0.57	0.59	0.64	0.65
Sub-Saharan Africa	0.68	0.71	0.60	0.61	0.67	0.68
Western Asia and Northern Africa	0.65	0.69	0.58	0.58	0.64	0.65

(b) Change in the quantity traded (Mt)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	-8.02E-02	-4.14E-02	-1.26E-01	-1.49E-01	-4.84E-03	-4.65E-02
Central and Southern Asia	-7.84E+00	1.45E-01	-5.82E-01	-6.81E+00	-9.19E-01	1.14E+00
Eastern and South-Eastern Asia	-7.70E+00	1.95E+00	-4.16E+00	-1.24E+00	-5.85E-01	-1.67E+00
Latin America and the Caribbean	-1.03E+00	1.26E+00	-1.50E+00	-1.24E+00	-2.32E-01	-1.30E-01
Northern America and Europe	-2.69E+00	-1.82E+00	-3.09E+00	-4.75E+00	-1.51E-01	-6.73E-01
Oceania (excluding Australia and New Zealand)	-2.66E-02	-1.15E-02	-3.13E-02	-2.79E-03	-1.44E-02	-1.95E-02
Sub-Saharan Africa	-4.92E+00	-1.35E+00	-7.27E-01	-1.14E+00	-5.07E-01	-3.81E+00
Western Asia and Northern Africa	-2.41E+00	-1.54E-01	-6.11E-01	-1.49E+00	-2.12E-01	1.25E-01

(c) Waste Avoided (Mt)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	2.14E-01	3.97E-01	2.66E-01	3.26E-01	1.61E-02	1.34E-01
Central and Southern Asia	2.88E+01	2.84E+01	1.39E+00	1.88E+01	3.79E+00	6.24E+00
Eastern and South-Eastern Asia	2.99E+01	7.02E+01	1.01E+01	3.89E+00	2.83E+00	1.04E+01
Latin America and the Caribbean	6.61E+00	9.85E+00	3.86E+00	4.87E+00	1.02E+00	2.68E+00
Northern America and Europe	8.56E+00	1.59E+01	6.66E+00	1.01E+01	5.56E-01	5.60E+00
Oceania (excluding Australia and New Zealand)	7.63E-02	3.25E-01	7.41E-02	7.72E-03	6.02E-02	2.04E-01
Sub-Saharan Africa	2.02E+01	1.89E+01	1.87E+00	3.69E+00	3.21E+00	2.55E+01
Western Asia and Northern Africa	9.74E+00	1.34E+01	1.50E+00	4.48E+00	8.46E-01	1.99E+00

(d) Loss Avoided (Mt)						
Food Type / Region	*Cereals*	*Fruits and Vegetables*	*Meat*	*Milk*	*Oilcrops and Pulses*	*Roots and Tubers*
Australia and New Zealand	1.63E-02	1.59E-01	0.00E+00	8.29E-03	3.36E-03	1.59E-02
Central and Southern Asia	3.72E+00	1.33E+01	1.65E-02	2.05E+00	7.03E-01	5.08E+00
Eastern and South-Eastern Asia	4.62E+00	3.54E+01	2.62E-01	7.19E-01	6.88E-01	3.14E+00
Latin America and the Caribbean	2.03E+00	6.33E+00	2.43E-01	1.42E+00	2.08E-01	1.26E+00
Northern America and Europe	1.55E+00	6.19E+00	1.25E-01	1.13E-01	1.46E-01	2.85E+00
Oceania (excluding Australia and New Zealand)	8.69E-04	1.32E-01	2.90E-04	6.64E-04	1.13E-02	8.06E-02
Sub-Saharan Africa	2.39E+00	5.71E+00	1.84E-02	5.18E-01	8.01E-01	6.45E+00
Western Asia and Northern Africa	1.59E+00	5.86E+00	3.22E-02	6.95E-01	1.42E-01	1.26E+00

Table 9 | Environmental impact factor key. Equivalents for FAO food types analyzed and food groups for categories with impact factors in the 2019 FAO State of Food and Agriculture (SOFA) Report. Note that we create a 5th impact factor type by using a weighted food supply average of categories 1 and 4 from the 2019 FAO SOFA Report to more accurately reflect the impact of Oilcrops and Pulses (column 2).

2019 SOFA Report		**FAO Food Type**		**Key**
1	Cereals and Pulses	1	*Cereals*	*1*
2	Fruits and Vegetables	2	*Fruits and Vegetables*	*2*
3	Meat and Animal Products	3	*Meat*	*3*
4	Roots, Tubers, and Oilbearing Crops	4	*Milk*	*3*
		5	*Oilcrops and Pulses*	*5**
		6	*Roots and Tubers*	*4*
		7	*Fish and Seafood*	*3*

Table 10 | Environmental impact factors. 2019 State of Food and Agriculture impact factors for food loss and waste. We create a production-weighted average to represent Oilseeds and Pulses (column 5) for ease of analysis among food types (see Table 9 for equivalencies).

Carbon Impact Factor (Tonne of CO2 eqv/Tonne of food lost)					
Food Type / SDG Region	Cereals and Pulses	Fruits and Vegetables	Meat and Animal Products	Roots, Tubers, and Oilbearing Crops	Average Oil/Pulses
Australia and New Zealand	1.6	1.8	1.4	0.6	0.9
Central and Southern Asia	2.2	1.1	2.3	1.0	1.8
Eastern and South-Eastern Asia	2.6	1.0	5.6	1.0	1.2
Latin America and the Caribbean	1.7	1.1	4.4	1.3	1.5
Northern America and Europe	1.5	1.5	1.6	0.7	1.1
Oceania (excluding Australia and New Zealand)	2.3	1.1	3.6	2.3	2.3
Sub-Saharan Africa	1.9	0.5	2.3	0.5	1.4
Western Asia and Northern Africa	2.0	1.3	4.2	1.1	1.6

Water Impact Factor (m^3 /tonne of food lost)					
Food Type/ Region	Cereals and Pulses	Fruits and Vegetables	Meat and Animal Products	Roots, Tubers, and Oilbearing Crops	Average Oil/Pulses
Australia and New Zealand	57.3	212.9	82.0	96.7	85.0
Central and Southern Asia	609.1	266.7	564.6	741.8	656.2
Eastern and South-Eastern Asia	130.0	301.8	181.6	17.9	32.6
Latin America and the Caribbean	146.9	271.8	168.1	28.0	100.1
Northern America and Europe	64.3	242.3	65.2	39.7	50.7
Oceania (excluding Australia and New Zealand)	354.3	301.8	174.7	14.0	24.5
Sub-Saharan Africa	146.7	239.9	161.5	147.9	147.1
Western Asia and Northern Africa	538.0	226.8	977.3	624.1	581.0

Land Impact Factor (ha/tonne of food lost)					
Food Type/Region	Cereals and Pulses	Fruits and Vegetables	Meat and Animal Products	Roots, Tubers, and Oilbearing Crops	Average Oil/Pulses
Australia and New Zealand	0.8	0.1	2.5	0.0	0.2
Central and Southern Asia	0.4	0.1	12.6	0.2	0.3
Eastern and South-Eastern Asia	0.3	0.1	11.8	0.2	0.2
Latin America and the Caribbean	0.6	0.1	4.0	0.2	0.4
Northern America and Europe	0.3	0.1	1.2	0.1	0.2

Oceania (excluding Australia and New Zealand)	0.5	0.1	4.5	0.3	0.3
Sub-Saharan Africa	0.9	0.1	17.0	0.6	0.8
Western Asia and Northern Africa	0.9	0.1	29.1	0.2	0.6

Table 11 | Results for environmental impacts. Global quantities for possible impact avoided without rebound effects (column 1) and the actual impact avoided with rebound effects (column 2) in environmental impacts due to rebound effects of avoided food waste and loss. Column 3 represents the percent offset due to rebound effects.

Environmental Impact	**Possible impact avoided without rebound effects**	**Actual impact avoided with rebound effects**	**Offset (%)**
Emissions (Mt CO_2 eqv)	828.11	303.76	63
Water (m^3)	$1.45* 10^{11}$	$5.06* 10^{10}$	65
Land (ha)	$9.38 * 10^8$	$3.86 * 10^8$	59