The health and environmental aspects of dietary changes towards sustainable diets

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Background

Sustainable diets:

- Intended to address increasing health and environmental concerns related to food production and consumption;
- According to Food and Agriculture Organization of the United Nations (FAO): *"Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."*

Background

Health impacts of food consumption:

- Imbalanced diets are responsible for the greatest health burden globally and in most regions (GBD 2015);
- Food insecurity: 2 billion people are overweight and obese, and another 2 billion have nutritional deficiencies, whilst about 800 million are still suffering from hunger due to poverty and poorly developed food systems (FAO, IFAD, UNICED, WFP, WHO, 2018);
- Dietary health and obesity rates could worsen with dietary transition towards more processed and high-value products (Alexandratos and Bruinsma, 2012; Springmann et al, 2016).

Background

Environmental impacts of food production:

- Major driver of climate change (25% of GHG emissions, Vermeulen et al, 2012);
- Major driver of land-use change and biodiversity loss (40% of the Earth's surface, Ramankutty et al, 2008; Houghton et al, 2012);
- Major user of freshwater resources (70% of global freshwater withdrawals (WWAP, 2012);
- Major polluter of terrestrial and aquatic systems through fertilizer runoff (Vitousek et al, 1997) ($\rightarrow$ dead zones in coastal oceans, Diaz and Rosenberg, 2008)

Background

Current state of sustainable-diet research:

- Increasing number of systematic reviews (Aleksandrowicz et al, 2016; Nelson et al, 2016; Hallström et al, 2015; Joyce et al, 2014);
- Mostly national case studies with different reference diets, environmental footprints, and scenario designs $\rightarrow$ complicates comparisons between studies;
- Predominant focus on GHG emissions as environmental impact; few studies on land and water use;
- Health impacts often not explicitly analysed beyond adherence to national dietary guidelines or directional changes in nutrient levels (Payne et al, 2016).

Methods

This study:

- *Combined analysis of the health and environmental impacts of sustainable-diet strategies for 158 countries*

Coupled modelling framework:

- Nutritional analysis: nutritional content of food groups for 24 nutrients based on GENuS dataset (Smith et al, 2016) and USDA (B5, B12); comparison to WHO recommendations;
- Mortality analysis: comparative risk assessment with 9 dietary and weight-related risk factors and 5 disease endpoints based on Oxford Global Health model (Springmann et al, 2016a,b);
- Environmental analysis: country-specific footprints for GHG emissions, cropland use, freshwater use, nitrogen application, phosphorus application (Springmann et al, *forthcoming*).
- Economic analysis: food expenditure based on country-specific estimates of food prices (IMPACT; Robinson et al, 2015).

Methods

Scenarios for 2030: **Dietary-change strategies** based on

- Environmental objectives of reducing impacts of animal source foods:
  - Substitution of animal products with 2/3 legumes and 1/3 fruits&veg based on observational data of dietary patterns; range of ambition: 25-100%.

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- Food-security objectives of addressing energy imbalances, including underweight, overweight, and obesity:
  - Simultaneous reduction of underweight, overweight and obesity; range of ambition: 25-100%.

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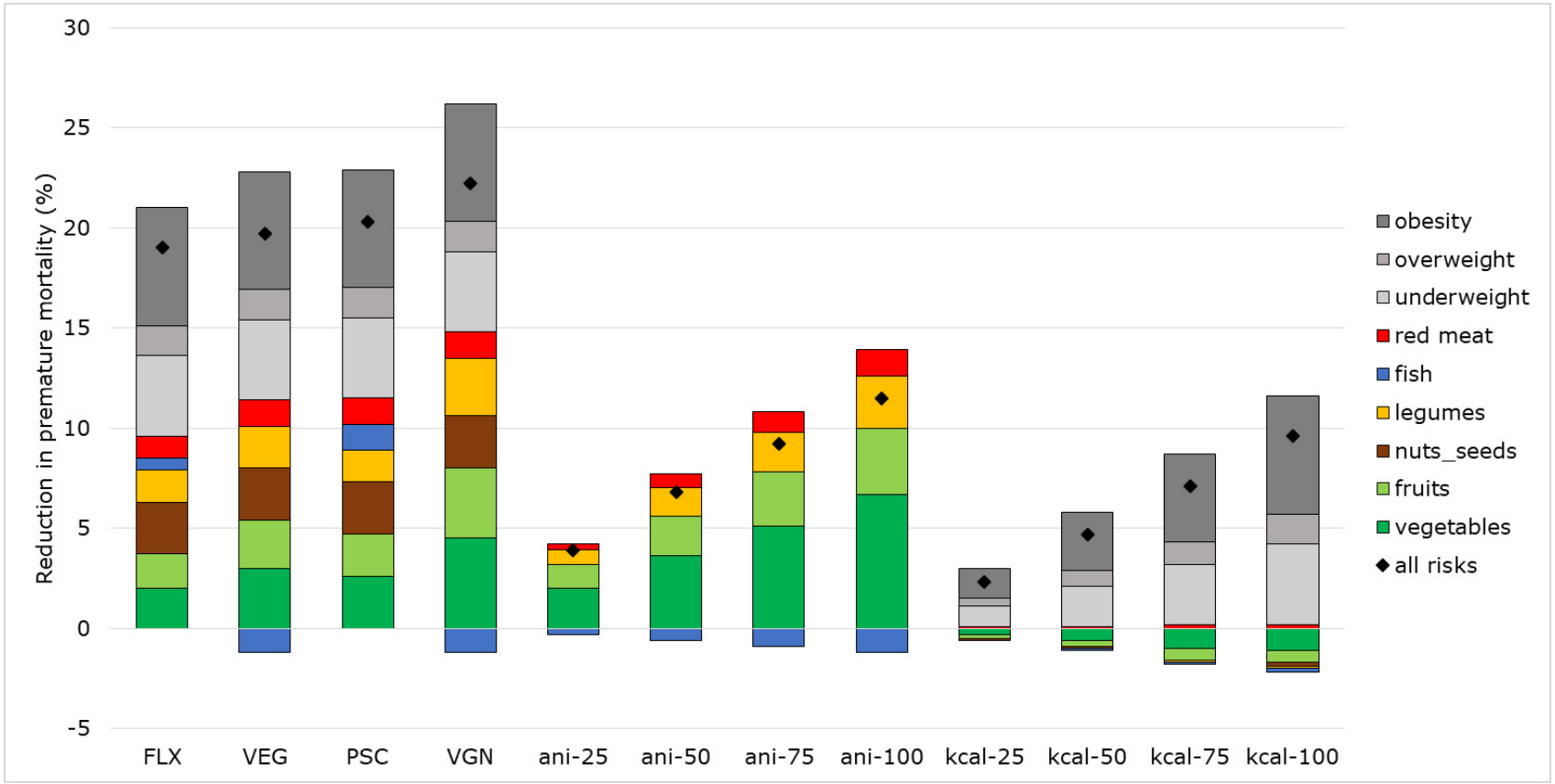
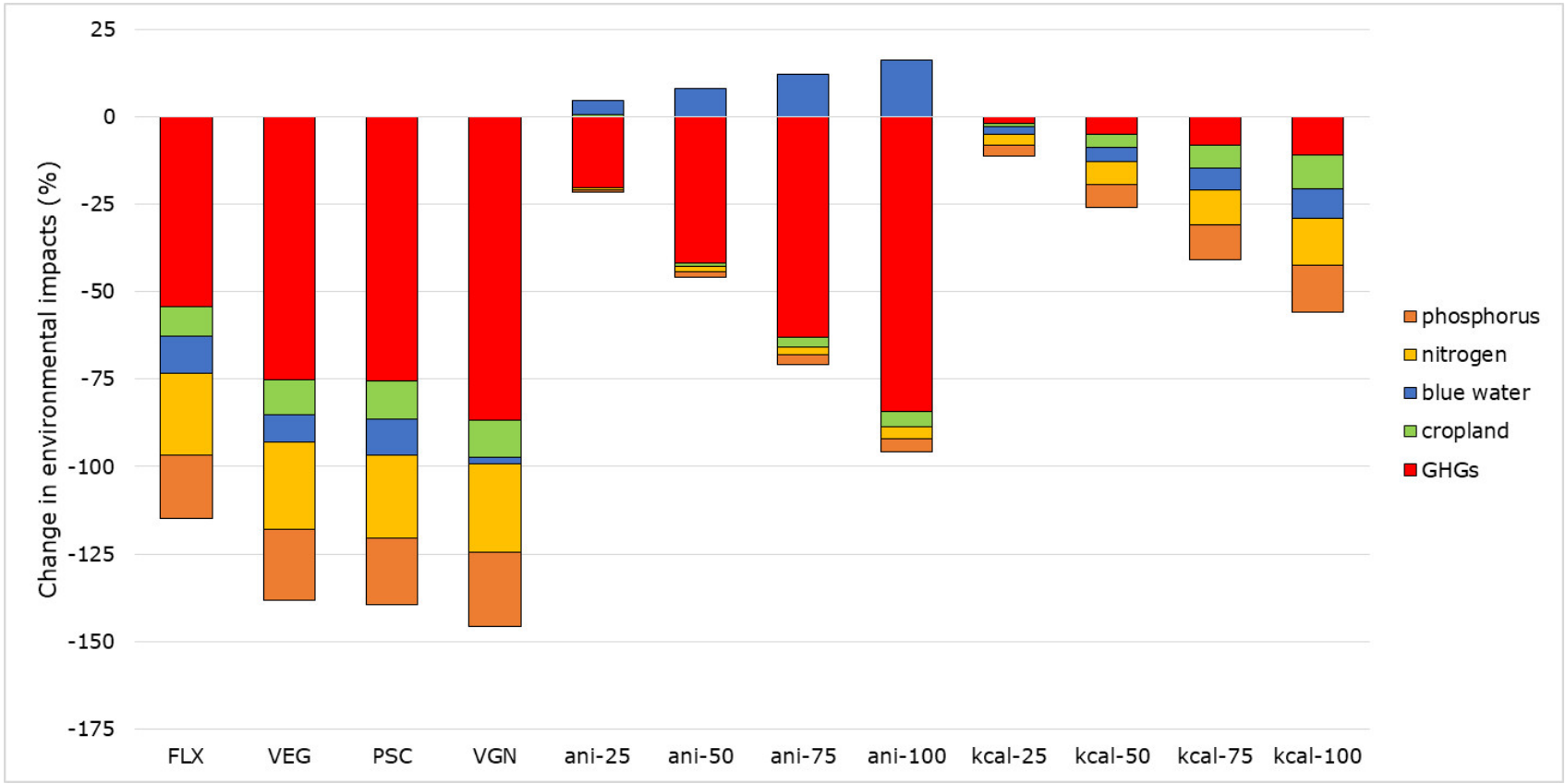
- Environmental objectives of reducing impacts of animal source foods:
  - Substitution of animal products with 2/3 legumes and 1/3 fruits&veg based on observational data of dietary patterns; range of ambition: 25-100%.
- Food-security objectives of addressing energy imbalances, including underweight, overweight, and obesity:
  - Simultaneous reduction of underweight, overweight and obesity; range of ambition: 25-100%.
- Public-health objectives of adopting nutritionally balanced dietary patterns based on the current evidence on healthy eating:
  - Use of energy-balanced varieties of healthy dietary patterns developed for the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems (flexitarian, pescatarian, vegetarian, vegan), regionalised by preserving national preferences for types of grains, fruits, and animal products

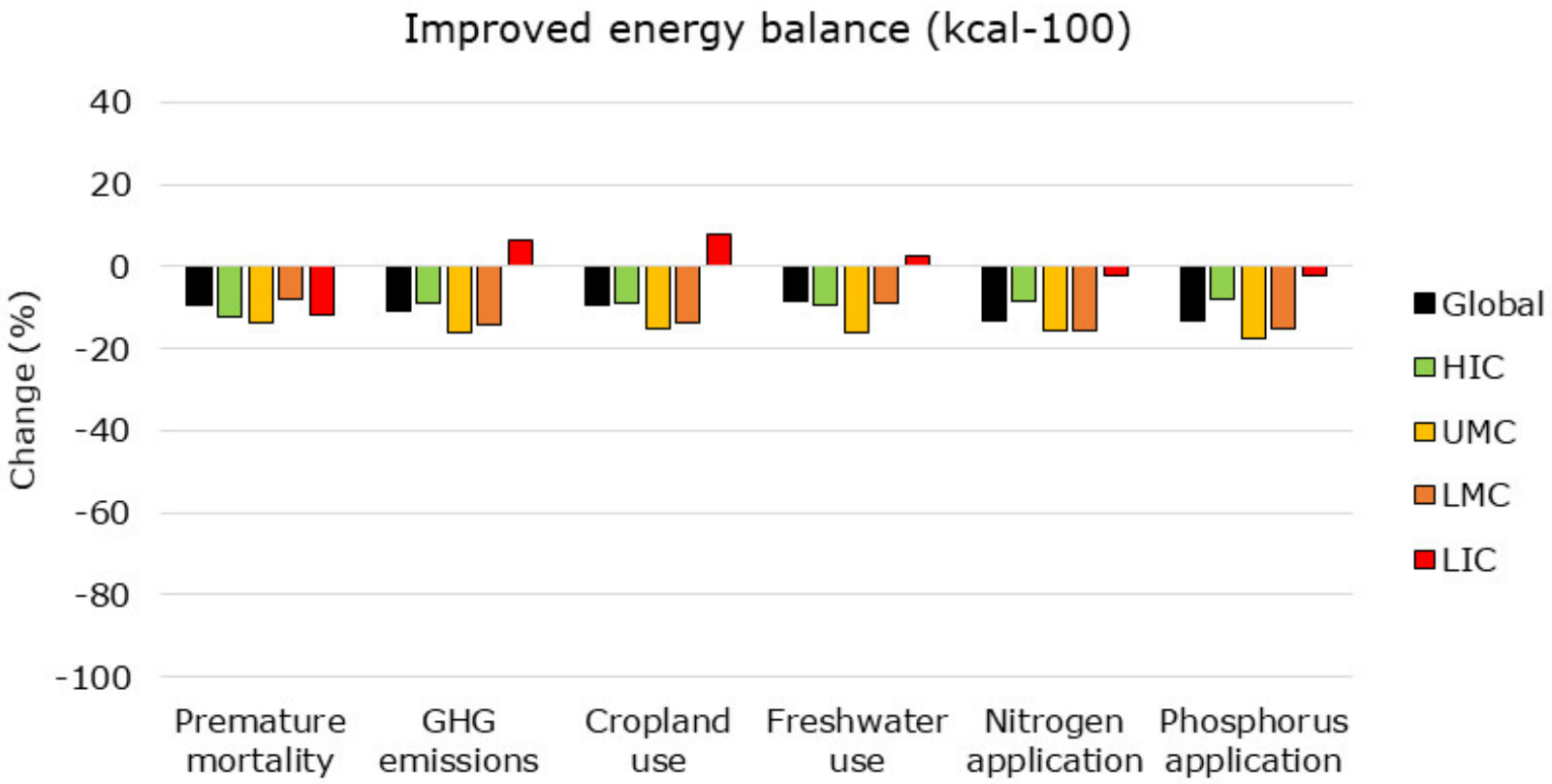
Results: mortality analysis



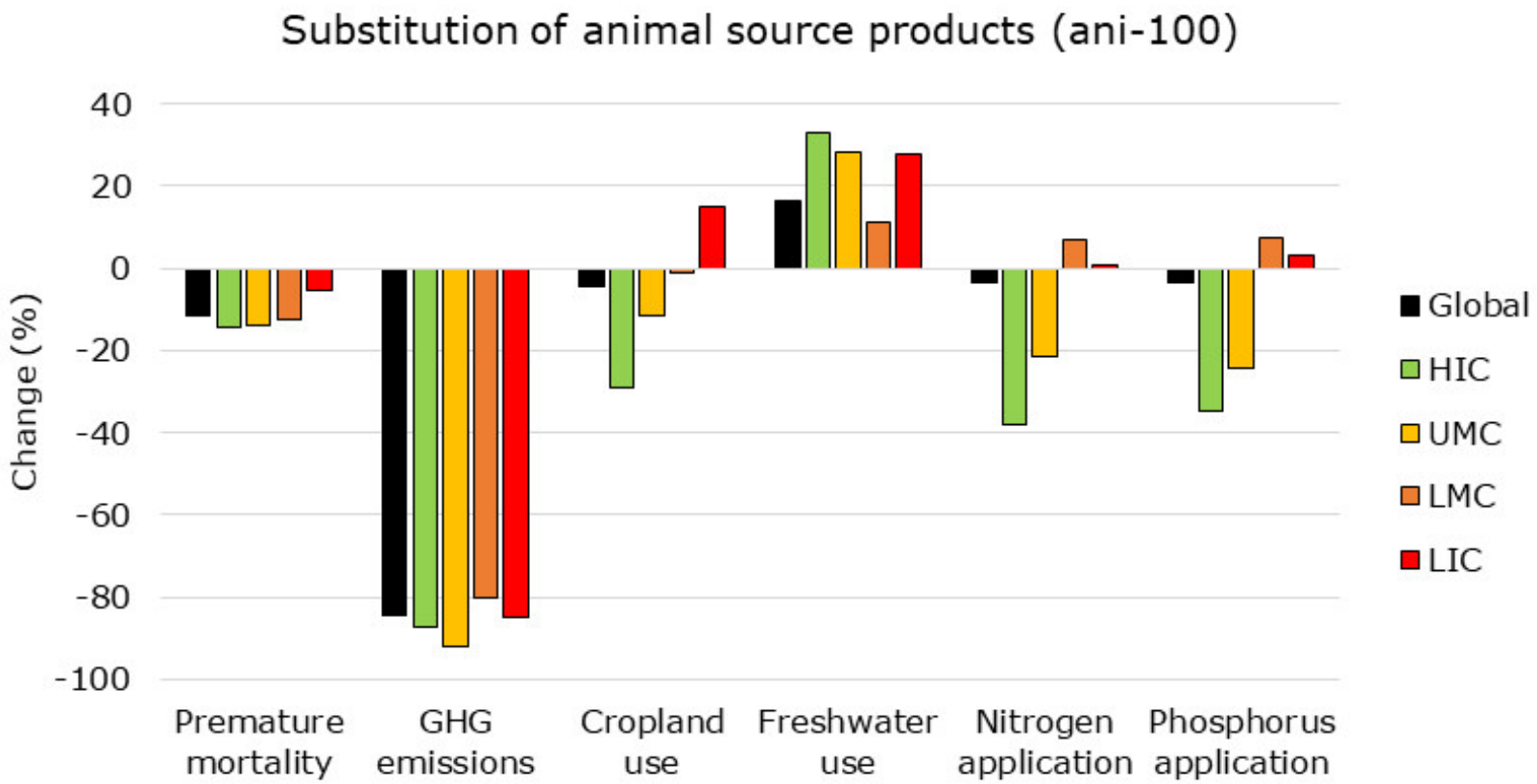
Results: environmental analysis



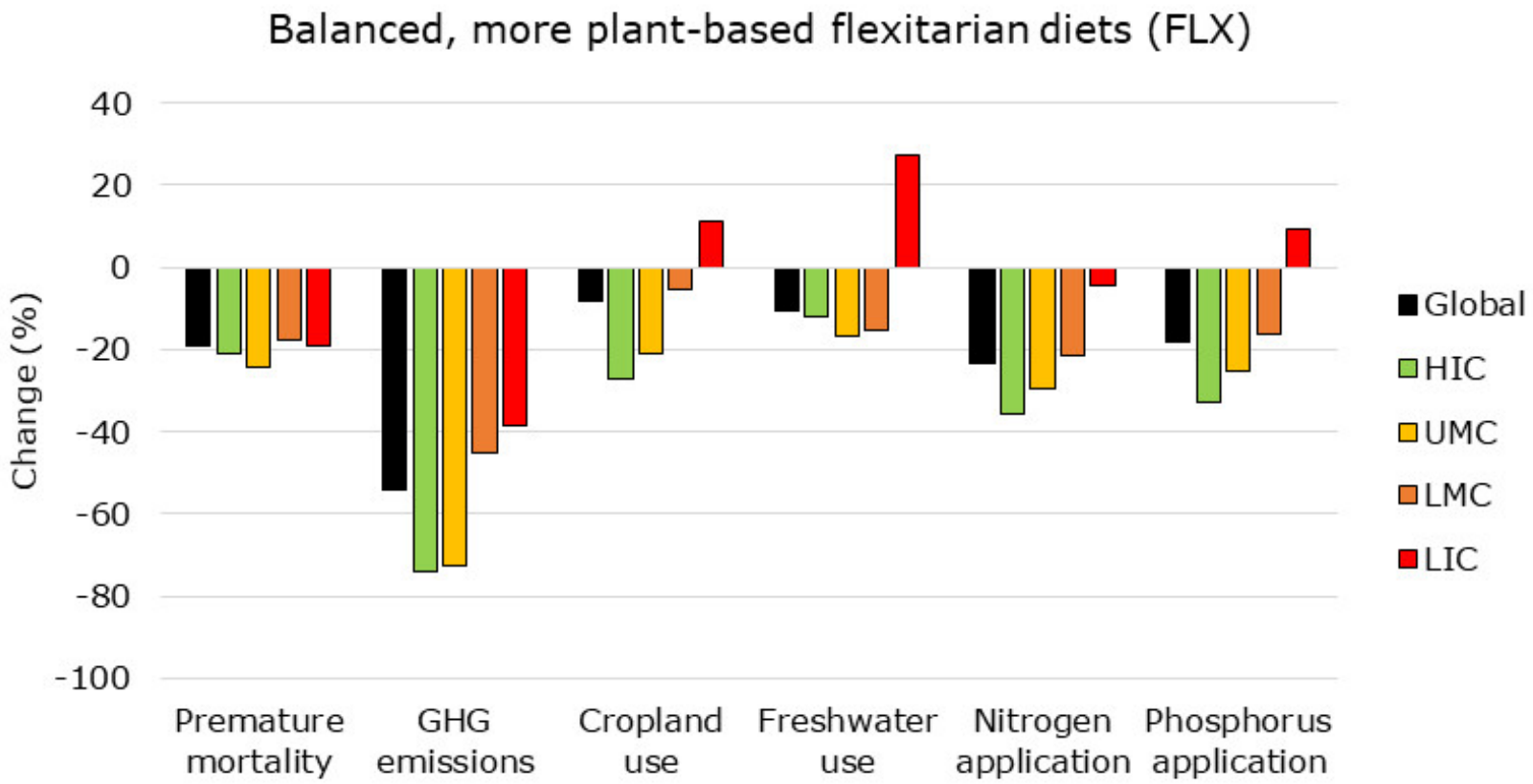
Results: regional analysis



Results: regional analysis



Results: regional analysis



Results: correlation analysis (Δenv per Δhealth)

Region	Domain	Diet scenario											
		FLX	PSC	VEG	VGN	ani-25	ani-50	ani-75	ani-100	kcal-25	kcal-50	kcal-75	kcal-100
Global	GHG emissions	2.85	3.71	3.82	3.91	5.19	6.15	6.83	7.31	0.89	1.08	1.13	1.14
	Cropland	0.45	0.55	0.49	0.48	-0.11	0.17	0.30	0.38	0.37	0.81	0.95	1.00
	Freshwater	0.57	0.50	0.40	0.08	-1.05	-1.20	-1.32	-1.40	0.85	0.88	0.88	0.87
	Nitrogen	1.22	1.18	1.27	1.14	0.15	0.22	0.26	0.29	1.33	1.40	1.41	1.40
	Phophorus	0.96	0.92	1.02	0.96	0.17	0.24	0.29	0.32	1.33	1.40	1.41	1.40
High-income countries	GHG emissions	3.51	3.69	3.84	3.84	4.18	5.13	5.83	6.06	0.78	0.76	0.77	0.74
	Cropland	1.30	1.45	1.45	1.57	1.40	1.72	1.95	2.03	0.76	0.75	0.76	0.72
	Freshwater	0.58	0.51	0.35	-0.01	-1.57	-1.93	-2.19	-2.28	0.83	0.82	0.83	0.79
	Nitrogen	1.70	1.85	1.93	1.97	1.82	2.23	2.54	2.64	0.75	0.73	0.74	0.71
	Phophorus	1.57	1.68	1.74	1.85	1.67	2.05	2.33	2.42	0.67	0.66	0.67	0.64
Upper middle-income countries	GHG emissions	3.01	3.31	3.44	3.46	4.66	5.46	6.22	6.70	1.25	1.15	1.21	1.21
	Cropland	0.87	1.01	0.95	0.91	0.59	0.69	0.79	0.85	1.17	1.07	1.13	1.13
	Freshwater	0.70	0.60	0.46	0.09	-1.43	-1.68	-1.91	-2.06	1.22	1.12	1.18	1.18
	Nitrogen	1.22	1.33	1.39	1.36	1.09	1.28	1.46	1.57	1.20	1.11	1.16	1.17
	Phophorus	1.04	1.13	1.20	1.27	1.24	1.45	1.65	1.78	1.34	1.24	1.30	1.30
Lower middle-income countries	GHG emissions	2.59	3.75	3.87	3.89	4.98	5.68	6.13	6.52	1.98	1.98	1.86	1.80
	Cropland	0.32	0.37	0.39	0.33	0.08	0.09	0.10	0.11	1.92	1.92	1.80	1.75
	Freshwater	0.87	0.78	0.72	0.38	-0.69	-0.78	-0.85	-0.90	1.24	1.24	1.16	1.13
	Nitrogen	1.23	1.08	1.21	0.97	-0.44	-0.50	-0.54	-0.57	2.19	2.19	2.06	2.00
	Phophorus	0.93	0.80	0.94	0.77	-0.46	-0.53	-0.57	-0.60	2.14	2.14	2.01	1.95
Low-income countries	GHG emissions	2.03	3.59	3.59	4.30	8.26	11.70	14.16	15.88	-1.98	-1.04	-0.72	-0.54
	Cropland	-0.58	-0.45	-0.69	-0.69	-6.63	-4.12	-3.30	-2.83	-3.46	-1.64	-1.00	-0.65
	Freshwater	-1.42	-1.49	-1.73	-2.18	-4.02	-4.33	-4.80	-5.16	-0.51	-0.32	-0.25	-0.21
	Nitrogen	0.24	0.31	0.30	0.37	-1.76	-0.78	-0.39	-0.16	-0.83	-0.17	0.07	0.19
	Phophorus	-0.49	-0.43	-0.41	-0.33	-2.12	-1.12	-0.76	-0.54	-0.91	-0.21	0.05	0.18

Results: correlation analysis in 2050 (Δenv per Δhealth)

Region	Domain	Diet scenario											
		FLX	PSC	VEG	VGN	ani-25	ani-50	ani-75	ani-100	kcal-25	kcal-50	kcal-75	kcal-100
Global	GHG emissions	3.00	3.85	3.93	4.01	5.18	6.20	6.97	7.49	1.10	1.46	1.58	1.62
	Cropland	0.74	0.80	0.86	0.79	-0.14	0.22	0.38	0.48	0.83	1.36	1.54	1.61
	Freshwater	0.94	0.77	0.88	0.50	-0.97	-1.06	-1.15	-1.22	1.44	1.49	1.51	1.50
	Nitrogen	1.37	1.46	1.35	1.36	0.23	0.38	0.46	0.51	1.68	1.81	1.85	1.85
	Phophorus	1.06	1.18	0.99	1.12	0.15	0.30	0.38	0.43	1.65	1.80	1.84	1.85
High-income countries	GHG emissions	3.95	4.09	4.20	4.04	5.63	6.46	7.16	7.64	1.24	1.22	1.21	1.19
	Cropland	1.54	1.62	1.71	1.74	1.90	2.18	2.42	2.58	1.23	1.21	1.20	1.18
	Freshwater	0.83	0.58	0.76	0.24	-1.80	-2.07	-2.29	-2.45	1.33	1.30	1.29	1.27
	Nitrogen	1.96	2.09	2.11	2.12	2.38	2.74	3.03	3.23	1.21	1.19	1.18	1.16
	Phophorus	1.81	1.89	1.91	1.98	2.19	2.51	2.78	2.97	1.14	1.12	1.11	1.09
Upper middle-income countries	GHG emissions	3.94	4.25	4.37	4.23	5.95	6.82	7.56	8.07	2.24	2.20	2.18	2.15
	Cropland	1.31	1.34	1.48	1.28	0.82	0.94	1.04	1.11	2.09	2.04	2.03	2.00
	Freshwater	1.14	0.83	1.03	0.42	-1.61	-1.85	-2.05	-2.19	2.15	2.11	2.09	2.06
	Nitrogen	1.77	1.90	1.91	1.85	1.54	1.76	1.95	2.08	2.13	2.08	2.07	2.04
	Phophorus	1.42	1.54	1.48	1.58	1.38	1.58	1.75	1.87	2.31	2.27	2.25	2.22
Lower middle-income countries	GHG emissions	2.46	3.65	3.71	3.90	5.29	6.07	6.73	7.18	2.06	2.01	2.00	1.97
	Cropland	0.62	0.73	0.71	0.70	0.32	0.36	0.40	0.43	2.10	2.06	2.04	2.01
	Freshwater	1.15	1.02	1.10	0.76	-0.54	-0.62	-0.68	-0.73	1.66	1.62	1.61	1.59
	Nitrogen	1.27	1.34	1.17	1.18	-0.21	-0.24	-0.27	-0.29	2.20	2.16	2.14	2.11
	Phophorus	1.00	1.11	0.84	0.99	-0.23	-0.26	-0.29	-0.30	2.20	2.15	2.14	2.11
Low-income countries	GHG emissions	2.81	3.80	3.90	4.07	3.70	5.73	6.90	7.65	-2.85	-0.65	0.07	0.42
	Cropland	0.05	0.01	0.20	-0.01	-3.69	-2.19	-1.68	-1.39	-4.03	-1.00	-0.01	0.47
	Freshwater	-0.41	-0.62	-0.47	-0.91	-2.56	-2.46	-2.55	-2.63	-0.32	0.38	0.60	0.71
	Nitrogen	0.73	0.88	0.81	0.90	-1.26	-0.41	-0.08	0.12	-1.25	0.27	0.76	1.00
	Phophorus	-0.18	0.02	-0.14	0.07	-2.12	-1.03	-0.62	-0.38	-2.31	-0.23	0.44	0.77

Results: nutrient analysis (global)

Nutrients	rec	BMK	FLX	PSC	VEG	VGN	ani-25	ani-50	ani-75	ani-100	kcal-25	kcal-50	kcal-75	kcal-100
calories	2084	2146	2084	2084	2084	2084	2157	2157	2157	2157	2138	2120	2102	2084
protein	>52	68.4	70.6	72.5	65.0	64.7	67.9	66.6	65.3	64.1	68.5	67.8	67.2	66.5
carbohydrates	<391	324.4	273.8	278.1	288.7	303.7	341.1	356.1	371.1	386.1	323.9	321.8	319.6	317.5
fat		68.9	81.8	78.1	77.3	71.3	62.7	56.4	50.1	43.8	68.1	67.2	66.4	65.5
saturatedFA	<23	22.5	19.7	17.5	17.2	13.4	19.3	16.0	12.7	9.5	22.3	22.0	21.7	21.4
monounsatFA		26.7	31.4	28.1	27.7	26.1	23.7	20.7	17.7	14.6	26.4	26.1	25.7	25.4
polyunsatFA	>14	16.7	27.7	27.2	27.4	27.6	16.7	16.8	16.8	16.8	16.5	16.3	16.1	15.9
vitaminC	>42	86.9	148.3	162.5	170.9	195.7	124.1	146.8	169.5	192.3	100.3	99.3	98.2	97.2
vitaminA	>544	482.1	626.6	679.3	694.2	702.8	627.4	680.3	733.2	786.2	568.1	561.7	555.4	549.0
folate	>364	280.3	553.2	576.6	643.5	733.1	410.1	504.1	598.1	692.2	313.2	310.3	307.4	304.4
calcium	>520	555.7	621.0	660.4	629.8	489.2	546.3	517.5	488.7	459.9	571.3	567.5	563.7	559.9
iron	>17	16.4	18.8	19.3	19.5	21.1	18.1	19.3	20.5	21.6	16.9	16.8	16.7	16.6
zinc	>6.1	10.8	10.4	10.4	10.2	10.3	10.8	10.6	10.5	10.4	10.8	10.7	10.6	10.5
potassium	>3247	2506.1	3383.0	3555.0	3633.9	3952.4	2951.4	3282.7	3614.1	3945.4	2595.4	2570.8	2546.3	2521.7
fiber	>29	26.0	35.5	36.6	39.9	44.6	31.5	36.1	40.7	45.4	26.6	26.3	26.0	25.8
copper	>0.8	1.6	2.3	2.3	2.5	2.7	1.8	2.1	2.3	2.5	1.6	1.6	1.6	1.6
phosphorus	>757	1311.7	1379.0	1428.8	1366.4	1337.1	1333.6	1347.1	1360.7	1374.2	1310.1	1300.2	1290.3	1280.4
thiamin	>1.1	1.3	1.5	1.5	1.5	1.6	1.4	1.5	1.6	1.6	1.3	1.3	1.3	1.3
riboflavin	>1.1	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
niacin	>14	18.7	17.5	17.4	16.0	16.8	18.6	18.4	18.1	17.9	18.7	18.5	18.3	18.1
vitaminB6	>1.2	6.1	6.1	6.2	6.1	2.3	5.2	4.3	3.3	2.4	6.2	6.2	6.3	6.4
magnesium	>205	436.3	527.1	543.3	561.1	596.1	489.3	528.3	567.3	606.3	447.8	445.3	442.9	440.4
pantothenate	>4.7	5.7	5.4	5.4	5.3	4.9	6.4	6.1	5.8	5.5	6.7	6.7	6.7	6.6
vitaminB12	>2.2	3.0	2.4	3.7	0.8	0.0	2.8	1.8	0.9	0.0	3.7	3.6	3.6	3.6

Results: nutrient analysis (regional)

Region	Nutrient	Diet scenarios											
		BMK	FLX	PSC	VEG	VGN	ani-25	ani-50	ani-75	ani-100	kcal-25	kcal-50	kcal-75	kcal-100
HIC	saturatedFA	65					36	7			62	59	56	52
	vitaminA	-3												
	folate	-30									-23	-24	-26	-27
	calcium					-13				-1				
	iron	-26					-12	-0			-25	-26	-27	-28
	potassium	-25					-4				-24	-26	-27	-28
	fiber	-14									-13	-15	-16	-18
	riboflavin					-2								
	pantothenate					-4				-1				
	vitaminB12				-52	-100			-38	-100				
UMC	saturatedFA	14									11	9	6	3
	folate	-16									-11	-13	-16	-18
	calcium					-7				-7				
	iron	-12					-1				-12	-14	-17	-19
	potassium	-7									-7	-9	-12	-14
	pantothenate					-7				-3				
	vitaminB12				-48	-100		-13	-57	-100				
LMC	polyunsatFA													-1
	vitaminA	-15												
	folate	-20									-11	-12	-13	-14
	calcium	-5				-3	-4	-6	-8	-10	-2	-2	-3	-3
	iron	-2										-1	-2	-3
	potassium	-23	-1				-11	-2			-21	-22	-23	-24
	fiber	-14									-13	-14	-15	-16
	riboflavin	-26	-26	-24	-26	-33	-26	-27	-28	-29	-26	-27	-27	-28
	vitaminB12				-69	-100	-10	-40	-70	-100				
LIC	protein	-2								-1				
	polyunsatFA	-30					-29	-29	-30	-30	-27	-26	-25	-24
	vitaminA	-38					-23	-19	-15	-12	-25	-23	-22	-20
	folate	-32					-7				-16	-14	-12	-10
	calcium	-33				-7	-29	-31	-32	-34	-25	-23	-21	-19
	potassium	-32					-19	-15	-11	-7	-21	-19	-18	-16
	fiber	-17					-3				-7	-5	-3	-0
	riboflavin	-41	-15	-14	-14	-19	-36	-37	-38	-39	-34	-33	-31	-30
	vitaminB12	-41	-32	-14	-82	-100			-36	-100				

Results: food expenditure

Food group	Diet scenarios											
	FLX	PSC	VEG	VGN	ani-25	ani-50	ani-75	ani-100	kcal-25	kcal-50	kcal-75	kcal-100
Change in weekly food expenditure (USD) per person by food group:												
total	-0.97	0.43	-1.43	-0.31	0.63	1.11	1.60	2.08	-0.42	-0.98	-1.55	-2.11
staples	-0.91	-0.91	-0.91	-0.91	0.01	0.01	0.01	0.01	-0.06	-0.14	-0.22	-0.29
legumes	0.36	0.36	0.52	0.73	0.18	0.35	0.52	0.69	0.01	0.00	-0.01	-0.01
nuts	0.11	0.11	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01
fruits&veg	2.16	3.16	3.84	5.98	1.96	3.82	5.68	7.54	-0.15	-0.41	-0.66	-0.91
veg oils	0.12	0.12	0.12	0.12	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.03
sugar	-0.17	-0.17	-0.17	-0.17	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02	-0.03
meat&dairy	-3.08	-4.03	-4.03	-5.26	-1.30	-2.62	-3.94	-5.26	-0.16	-0.34	-0.51	-0.69
fish	0.45	1.80	-0.90	-0.90	-0.22	-0.45	-0.67	-0.90	-0.04	-0.07	-0.11	-0.14
Percentage change (%) by region:												
Global	-5.94	2.64	-8.75	-1.91	3.86	6.83	9.81	12.78	-2.58	-6.04	-9.5	-12.96
HIC	-26.01	-16.7	-30.95	-26.89	0.75	1.49	2.24	2.99	-2.22	-4.45	-6.67	-8.89
UMC	-15.34	-8.07	-17.73	-10.38	2.34	4.67	7.01	9.34	-3.95	-7.9	-11.85	-15.8
LMC	-5.18	3.46	-6.85	1.18	4.11	8.22	12.34	16.45	-4.09	-8.18	-12.27	-16.37
LIC	33.64	41.98	27.57	32.22	9.61	10.65	11.69	12.73	7.37	6.17	4.97	3.77

Discussion

By region:

- Improving nutrient levels and reducing diet-related, premature mortality is possible in all regions.
- In HIC and MIC, healthy diets can lead to reductions in environmental impacts;
- In LIC, adoption of healthier diets can increase demand for environmental resources, in part due to inefficient production systems.

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$\Rightarrow$ Synergistic perspective on sustainable diets should include regional considerations, technological and dietary aspects, international support mechanisms.

Discussion

By environmental domain:

- Associations between health and environmental benefits strongest for GHG; moderate for cropland, nitrogen, and phosphorus; small for freshwater.
- Reducing GHG emissions important at global level for mitigating climate change, but changes in other domains relate predominantly to local environmental impacts.

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- Associations between health and environmental benefits strongest for GHG; moderate for cropland, nitrogen, and phosphorus; small for freshwater.
- Reducing GHG emissions important at global level for mitigating climate change, but changes in other domains relate predominantly to local environmental impacts.

$\Rightarrow$ Need for context-specific strategies that balance environmental impacts between global and regional scales.

Discussion

By scenario:

- Public-health strategy for adapting healthy diets performs better in reducing environmental pressures, potential nutrient deficiencies, and diet-related mortality as strategies motivated only by environmental and food-security concerns;
- Addresses shortcoming of other approaches (high regional variability; low nutritional and environmental effectiveness).

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By scenario:

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- Addresses shortcoming of other approaches (high regional variability; low nutritional and environmental effectiveness).

$\Rightarrow$ Addressing both dietary composition and energy intake as part of food-based dietary guidelines could be suitable strategy for achieving sustainable diets.

Discussion

Comparison to current context:

- Many national dietary guidelines do not reflect current evidence on healthy eating: no or too lax limits for animal source foods, in particular for dairy (not supported by evidence base).

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- Many national dietary guidelines do not reflect current evidence on healthy eating: no or too lax limits for animal source foods, in particular for dairy (not supported by evidence base).

$\Rightarrow$ Updating national dietary guidelines to reflect the latest evidence on healthy eating important for improving health and environmental sustainability, and complement broader and more explicit criteria of sustainability.

Caveats

Aspects not addressed in analysis:

- Biodiversity impacts (related to land-use change)
- Economic aspects (and feedbacks on environmental footprints)
- Policy options that support diet scenarios:
  - Behavioural-change literature suggests cross-cutting approaches that focus on the whole food environment, combine multiple incentives, including fiscal ones, and offer support and positive re-enforcement for individuals have been successful in specific contexts (Mozaffarian et al, 2012, 2016).

$\Rightarrow$ Finding effective combinations of policies and approaches that account for local characteristics essential for successfully upscaling current initiatives and achieving reductions in health and environmental burden at the population level and globally.

Thank you for your attention

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