Food System Economics Commission

WORKING PAPER

Addressing Synergies and Trade-offs in the Food System

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Addressing Synergies and Trade-Offs in the Food System

Results from global CGE Simulations of Policy Bundles with the MAGNET model

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MAGNET modeling results pages

Methodology: Model setup, scenarios and indicator definitions
Key findings: Summary of methodology and key findings of the study →

Goals: Changes in three uniform policy goals (fruit & vegetables, GHG emissions, living wages) →
Goals - [Rural/Informal/Emerging/Modernizing/Industrial]: Goals per food system and scenario →

GDP & Income: GDP and average household income →
Wages [region/worker/sector]: Wages on pages zooming in on region, workers or sectors →
Employment [sector/scenario]: Employment changes zooming in on sectors or scenarios →

Diet: Change in calories, consumption and price of different Eat-Lancet diets →
Environment: Land use, fertilizer use, emissions and emission intensities →
Inclusion: Labour share in GDP, low skilled wages and affordability of Eat-Lancet diets →

Consumption & production: Consumption, prices, production and self-sufficiency changes →

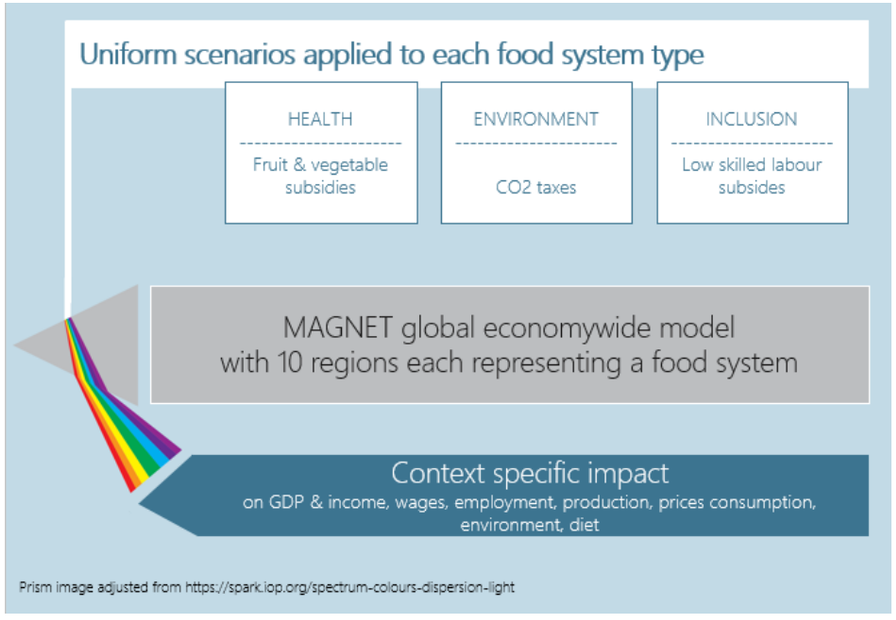
Background on scenarios, food system groups and indicator selection pages

Health scenario: Rationale & shocks when stimulating fruit & vegetable consumption →
Environment scenario: Rationale & shocks when reducing GHG emissions →
Inclusion scenario: Rationale & shocks when addressing living wages →

Food system descriptives: Methodology for grouping and characteristics of food system types →
Food system goals: Descriptives of food system goals used in selection by food system →
Selecting goals by food system: Food system specific goals to complement shared ones →

References: Reference list →

Methodology



Using MAGNET, a modular global general equilibrium model (www.magnet-model.eu) we simulate the impact of policy bundles aiming at health, environment, and inclusion goals.

We aggregated regions into a 10 food system types, adding environmental detail to the typology developed in Marshall et al. (2021). Uniform policies that are relevant across all 10 food systems allow an assessment of the context specific impact, highlighting what food system characteristics to watch for when translating these findings to specific country settings.

To add further context, we complement the three shared health, environment and inclusion goals with food system specific indicators derived from an empirical assessment of food system challenges in 2019.

In addition to the description of regions and scenarios on the respective pages in this report, the grouping, scenario quantification and indicator selection is presented in detail in Kuiper et al. (2022).

Scenario codes with short description

Reference scenario

2019	2019 reference

Health scenario - addresses fruit & vegetable intake being below recommended levels in all food systems

F&V_s	25% subsidy on fruit & vegetables
F&V_s+t	25% subsidy on fruit & vegetables + tax on non-perishables (rate endogenous)

Environment scenario - addresses the need for global and economywide steps towards reducing GHG emissions

GHG_t	50 $/ton CO2eq tax for all GHG emissions on MAC sectors (primary agriculture), 25 $/t for non-MAC sectors
GHG_t+s	50 $/ton CO2eq tax for all GHG emissions + levied tax applied as labour subsidy (rate endogenous)

Inclusion scenario - improve living wages defined as ability of lowest paid labour to afford average food expenditures

LAB_s	35% subsidy of low skilled labour
LAB_s+t	35% subsidy of low skilled labour financed by a tax on the use of capital (rate endogenous)

Combinations (all using the subsidy/tax versions of the scenarios above)

F&V+GHG	Combination F&V_s+t and GHG_t+s
F&V+LAB	Combination F&V_s+t and LAB_s+t
GHG+LAB	Combination GHG_t+s and LAB_s+t
F&V+GHG+LAB	Combination F&V_s+t ,GHG_t+s and LAB_s+t

Details on scenario set- up on the respective scenario pages and in Kuiper et al. (2022)

Indicators for impacts by food system (with desired direction of change)

HEALTH:	h_V&F_i	= Increase fruit & vegetable consumption (%)
	h_CAL_id	= Increase or decrease calories (%)
ENVIRONOMENT:	e_GHG_d	= Decrease emissions (%)
	e_LAND_d	= Decrease agriculture land (%)
	e_FERT_d	= Decrease fertilizer use (%) (Defined as fertilizer use (%) - Crop land (%))
INCLUSION:	i_W2F_i	= Increase low skilled agri. wage / food expenditures (% change)
	i_DIET_i	= Increase affordability of Eat Lancet vegan diet for agri. low skilled l(%)
	i_LAB_i	= Labour share in GDP (%)

GDP = Real GDP (%)

Details on indicator selection provided on the page "Food system goals" and in Kuiper et al. (2022).

Key findings

GHG taxes need to be redistributed to labour

GHG tax with no redistribution harms the poorest population most considerably reducing their living wage. Redistributing the tax revenues to labour (all types of workers) counteracts enough to improve living wages in all but the rich Industrial regions where the negative impact becomes negligible. The strongest improvement in living wages with redistribution of GHG tax revenues to labour is in the poorest land abundant Rural & Traditional region.

Designing fiscally neutral policies enhances effectiveness

Fiscally neutral policy bundles do not harm policy goals, and **well-targeted bundles support achievement of policy goals** while **facilitating policy implementation**. Emission reductions and improvement in living wages are not affected by making the policies fiscally neutral through labour subsidies and capital taxes, respectively. Targeted taxes on non-perishable foods to finance subsidies, however, provide a small additional increase in fruit and vegetable consumption.

Only living wages are consistently affected by other policies independent of food system context

Living wages are consistently affected in the same direction by other policy bundles across food systems. Effects are positive or negligible with the exception of negative effects of GHG taxation without redistributing revenues. **Impacts on fruit & vegetable consumption and GHG emissions depend on food system context.** In Rural and Informal food systems fruit & vegetable subsidies and GHG taxation have positive effects on each other's goals. Impacts are mixed qualitatively and quantitatively for Emerging, Modernizing and Industrial food systems.

Only for living wages there is synergy between policy bundles

Only for living wages there is synergy between the policy bundles - a combined implementation has a stronger positive impact than the sum of separate policies. There are no synergy effects between policy bundles for fruit and vegetable consumption and GHG emissions.

Economywide policies support food system workers without slowing structural transformation

Economywide policy bundles affect wages of the poorest food system workers most. Position of vulnerable food system works can thus be improved without food system specific policies which could risk a slowing of structural transformation of workers moving to better paid non-agricultural jobs. **Food service workers, comprising a fifth of foods system workers, benefit very little from any policy bundle.** As a non-agricultural sector, food service wages however are well above those in primary agriculture and at par with wages in non-food sectors.

Note: Background of the key findings with screenshots of dashboard settings and bullet point summary is provided in Kuiper at el. (2022b).

Scenario name

- Fruit & veg. subsidy (F&V_s)
- Fruit & veg. + non-perish. tax (F...
- GHG tax (GHG_t)
- GHG tax + labour subsidy (GHG_...
- Labour subsidy (LAB_s)
- Labour subsidy + capital tax (LA...
- Fruit & veg + GHG (F&V+GHG)
- Fruit & veg + labour (F&V+LAB)
- GHG + labour (GHG+LAB)
- Fruit & veg + GHG + labour (F&...

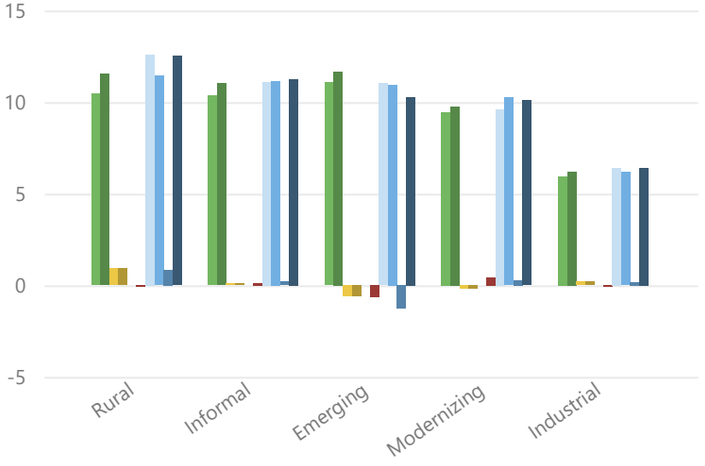
LandGroup

- Abundant
- Scarce

Health, environment and inequality policy goals by scenario

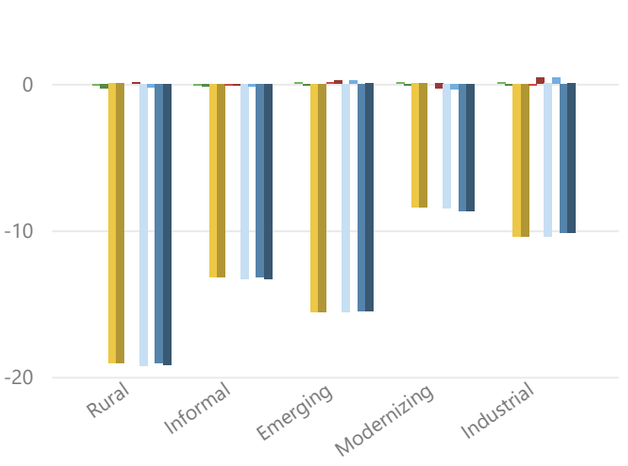
All values in % change compared to 2019 situation

Health: fruit and vegetable consumption (%)



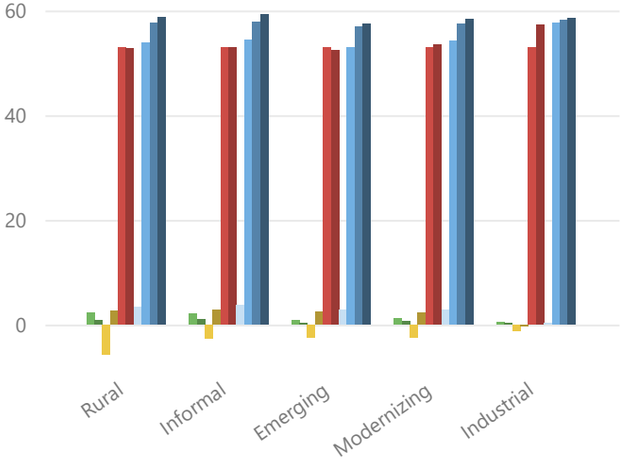
Scenario label F&V_s F&V_s+t GHG_t GHG_t+s LAB_s

Environment: GHG emissions (%)



Scenario label F&V_s F&V_s+t GHG_t GHG_t+s

Inequality: living wage (%)



Scenario label F&V_s F&V_s+t GHG_t GHG_t+s

Selection of goals (details on the respective scenario pages):

Fruit & vegetable consumption is below recommended levels according to WHO and national food based dietary guidelines (taken from FAO (2020)).
GHG emissions refers to agricultural and non-agricultural GHG emissions in CO_2 equivalents which need to decrease in all regions to combat climate change.
Living wage: the wage of the generally lowest paid workers relative to the average per capita household food expenditure and is used as a (conservative) indicator of living wages.

The living wage goal has consistent synergy effects with other policy bundles across food systems. Effects are positive or negligible with the exception of CO_2 taxation without redistributing revenues (CO2_t) which lowers living wages.

Synergy effects on fruit & vegetable consumption and GHG emissions goals depend on food system context. In Rural and Informal food systems fruit & vegetable subsidies and CO_2 taxation have positive synergy effects on each other. Synergy effects are mixed qualitatively and quantitatively for Emerging, Modernizing and Industrial food systems.

Substantial shifts in goals requires a policy per goal. Interaction effects are very limited in size compared to the impact of targeting policies. This qualifies the *Tinbergen Rule* that for each policy goal there must be at least one instrument (Tinbergen, 1950 cited in Knudson (2009)). Improvements in living wages, for example can be achieved through fruit & vegetable subsidies or CO_2 taxation with redistribution. Impacts, however, are much more limited than in the case of targeted policies. And positive impacts are not guaranteed as shown by the consistent negative impact of CO_2 taxation without redistribution on living wages.

Scenario name

- [ ] Fruit & veg. subsidy (F&V_s)
- [ ] Fruit & veg. + non-perish. tax (F...
- [ ] GHG tax (GHG_t)
- [ ] GHG tax + labour subsidy (GHG_...
- [ ] Labour subsidy (LAB_s)
- [ ] Labour subsidy + capital tax (LA...
- [ ] Fruit & veg + GHG (F&V+GHG)
- [ ] Fruit & veg + labour (F&V+LAB)
- [ ] GHG + labour (GHG+LAB)
- [ ] Fruit & veg + GHG + labour (F&...

Health, environment and inequality impacts by food system: Rural & Traditional

Goals selected as key for a food system are highlighted to signal a move towards (green) or away (red) from the goal. Goals selected for other food systems are included for comparison.

All values in % change compared to 2019 situation

Rural - A

	HEALTH		ENVIRONMENT			INCLUSION			
Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	12	0	0	1	5	3	14	1	-1
F&V_s+t	13	-1	0	0	3	1	14	0	0
GHG_t	2	-1	-26	-1	-22	-9	-2	-6	2
GHG_t+s	2	-1	-26	-1	-22	3	10	-6	2
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	0	53	53	0	1
F&V+GHG	15	-3	-26	-1	-19	4	25	-5	2
F&V+LAB	13	-1	0	0	4	55	74	0	1
GHG+LAB	2	-2	-26	-1	-22	58	70	-6	3
F&V+GHG+LAB	15	-3	-26	-1	-19	60	93	-5	3

Rural - S

Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	10	-1	0	0	3	2	12	1	-1
F&V_s+t	11	-3	0	0	-1	1	12	0	0
GHG_t	1	-2	-17	-1	-41	-5	-4	-3	0
GHG_t+s	1	-2	-17	-1	-41	3	4	-3	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	0	53	53	0	0
F&V+GHG	12	-5	-17	-1	-40	3	16	-3	0
F&V+LAB	11	-3	0	0	0	54	71	0	0
GHG+LAB	1	-2	-17	-1	-41	57	59	-3	0
F&V+GHG+LAB	12	-5	-17	-1	-40	58	77	-3	1

Indicators:

h_V&F_i = Increase fruit&veg. cons.(%)
h_CAL_id = Increase or decrease calories (%)

e_GHG_d = Decrease emissions (%)
e_LAND_d = Decrease agri.land (%)
e_FERT_d = Decrease fertilizer use (%)

i_W2F_i = Increase low skilled agri. wage / food expenditures (% change)
i_DIET_i = Increase affordability of EL vegan diet for agri.low skilled (%)
i_LAB_i = Labour share in GDP (%)

GDP = Real GDP (%)

Both Rural regions have substantial undernourishment (22% in Rural-A and 15% in Rural-S). **Average calorie consumption consistently decreases** across scenarios is apart from the **inclusion scenario which has no discernable impact on calories**. This decrease in calories is a cause of concern as in both the health and environment scenario average consumption of staples (cereals, roots & tubers) decrease. These are the source of cheap calories and compose the main part of the diet of the poor (Clements and Si 2015).

The sizeable positive impact on the real (agricultural) low skilled wages in **all scenarios with redistribution to labour** (CO2_t+s, LAB_s, LAB_s+t) indicates that the **purchasing power of the (agricultural) poor household improves (substantially)**. This may positively contribute to the nutrition status of the poor, as also signaled by the increased affordability of the cheapest global healthy diet, the Eat-Lancet vegan diet. Costs of the other diets also decrease. **Affordability of healthy diets thus improves due to both income (wage increases) and price effects (healthy foods becoming cheaper).**

Fruit and vegetable subsidies increase agricultural land area and fertilizer use in both regions, combined with a tax on processed food this shifts to a decrease in land are and fertilizer use only in the land scarce region. The increase in fertilizer use in Rural-A has a moderate effect on total fertilizer use as this is only 18 kg/ha in 2019. While LULUC accounts for 64% of its food system emissions the shifts in production pattern still reduce its agri-food GHG emissions. The increase in fertilizer use in Rural-S refers to an initial level of 144 kg/ha and thus implies a much stronger impact in absolute terms. Most substantial reductions in fertilizer use occur in the Rural-S region (around 41%) with high initial use in the CO2 taxation scenarios, accompanied by a decrease in agricultural land. The **CO2 taxes dominate reductions in land area and fertilizer use in all combined scenarios**.

Scenario name

- [ ] Fruit & veg. subsidy (F&V_s)
- [ ] Fruit & veg. + non-perish. tax (F...
- [ ] GHG tax (GHG_t)
- [ ] GHG tax + labour subsidy (GHG_...
- [ ] Labour subsidy (LAB_s)
- [ ] Labour subsidy + capital tax (LA...
- [ ] Fruit & veg + GHG (F&V+GHG)
- [ ] Fruit & veg + labour (F&V+LAB)
- [ ] GHG + labour (GHG+LAB)
- [ ] Fruit & veg + GHG + labour (F&...

Health, environment and inequality impacts by food system: Informal & Expanding

Goals selected as key for a food system are highlighted to signal a move towards (green) or away (red) from the goal. Goals selected for other food systems are included for comparison.

All values in % change compared to 2019 situation

#add analysis

Informal - A

	HEALTH		ENVIRONMENT			INCLUSION			
Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	11	0	0	1	3	2	14	0	0
F&V_s+t	11	-1	0	0	2	1	13	0	0
GHG_t	1	-3	-16	-3	-26	-3	0	-2	0
GHG_t+s	1	-3	-16	-3	-26	2	5	-2	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	1	53	52	0	0
F&V+GHG	12	-4	-16	-3	-24	3	19	-2	0
F&V+LAB	11	-1	0	0	3	54	73	0	0
GHG+LAB	1	-3	-16	-3	-26	56	61	-2	0
F&V+GHG+LAB	12	-4	-16	-3	-24	57	82	-2	0

Informal - S

Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	10	0	0	0	3	2	13	1	-1
F&V_s+t	11	-2	0	0	1	1	13	0	0
GHG_t	0	-3	-13	0	-29	-3	-2	-2	0
GHG_t+s	0	-3	-13	0	-29	3	4	-2	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	-1	53	55	0	2
F&V+GHG	11	-4	-13	0	-29	4	17	-2	0
F&V+LAB	11	-2	0	0	0	54	74	0	2
GHG+LAB	0	-3	-13	0	-30	58	61	-2	2
F&V+GHG+LAB	11	-4	-13	0	-29	59	81	-2	2

Indicators:

h_V&F_i = Increase fruit&veg. cons.(%)
h_CAL_id = Increase or decrease calories (%)

e_GHG_d = Decrease emissions (%)
e_LAND_d = Decrease agri.land (%)
e_FERT_d = Decrease fertilizer use (%)

i_W2F_i = Increase low skilled agri. wage / food expenditures (% change)
i_DIET_i = Increase affordability of EL vegan diet for agri.low skilled (%)
i_LAB_i = Labour share in GDP (%)

GDP = Real GDP (%)

Scenario name

- [ ] Fruit & veg. subsidy (F&V_s)
- [ ] Fruit & veg. + non-perish. tax (F...
- [ ] GHG tax (GHG_t)
- [ ] GHG tax + labour subsidy (GHG_...
- [ ] Labour subsidy (LAB_s)
- [ ] Labour subsidy + capital tax (LA...
- [ ] Fruit & veg + GHG (F&V+GHG)
- [ ] Fruit & veg + labour (F&V+LAB)
- [ ] GHG + labour (GHG+LAB)
- [ ] Fruit & veg + GHG + labour (F&...

Health, environment and inequality impacts by food system: Emerging & Diversifying

Goals selected as key for a food system are highlighted to signal a move towards (green) or away (red) from the goal. Goals selected for other food systems are included for comparison.

All values in % change compared to 2019 situation

#add analysis

Indicators:

h_V&F_i = Increase fruit&veg. cons.(%)

h_CAL_id = Increase or decrease calories (%)

e_GHG_d = Decrease emissions (%)

e_LAND_d = Decrease agri.land (%)

e_FERT_d = Decrease fertilizer use (%)

i_W2F_i = Increase low skilled agri. wage / food expenditures (% change)

i_DIET_i = Increase affordability of EL vegan diet for agri.low skilled (%)

i_LAB_i = Labour share in GDP (%)

GDP = Real GDP (%)

Emerging - A

	HEALTH		ENVIRONMENT			INCLUSION			
Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	9	0	0	0	5	1	15	0	0
F&V_s+t	9	0	0	0	4	0	15	0	0
GHG_t	0	-1	-9	0	-23	-3	-2	-2	-1
GHG_t+s	0	-1	-9	0	-23	4	5	-2	-1
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	1	52	53	0	2
F&V+GHG	9	-2	-9	0	-20	4	20	-2	-1
F&V+LAB	9	0	0	0	5	53	76	0	2
GHG+LAB	0	-1	-9	0	-22	59	61	-2	1
F&V+GHG+LAB	9	-1	-9	0	-19	60	85	-2	1

Emerging - S

Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	11	0	0	0	3	1	13	0	0
F&V_s+t	12	-1	0	0	2	0	13	0	0
GHG_t	-1	-2	-17	0	-13	-2	-3	-2	-1
GHG_t+s	-1	-2	-17	0	-13	2	2	-2	-1
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	-1	-1	0	0	1	53	50	0	-3
F&V+GHG	11	-3	-17	0	-11	3	15	-2	-1
F&V+LAB	11	-2	0	0	3	54	70	0	-3
GHG+LAB	-1	-3	-17	0	-13	58	53	-2	-4
F&V+GHG+LAB	10	-4	-17	0	-10	58	73	-2	-4

Scenario name

- [ ] Fruit & veg. subsidy (F&V_s)
- [ ] Fruit & veg. + non-perish. tax (F...
- [ ] GHG tax (GHG_t)
- [ ] GHG tax + labour subsidy (GHG_...
- [ ] Labour subsidy (LAB_s)
- [ ] Labour subsidy + capital tax (LA...
- [ ] Fruit & veg + GHG (F&V+GHG)
- [ ] Fruit & veg + labour (F&V+LAB)
- [ ] GHG + labour (GHG+LAB)
- [ ] Fruit & veg + GHG + labour (F&...

Health, environment and inequality impacts by food system: Modernizing & Formalizing

Goals selected as key for a food system are highlighted to signal a move towards (green) or away (red) from the goal. Goals selected for other food systems are included for comparison.

All values in % change compared to 2019 situation

#add analysis

Modernizing - A

	HEALTH		ENVIRONMENT			INCLUSION			
Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	10	0	0	1	2	1	15	0	0
F&V_s+t	10	-1	0	0	1	1	14	0	0
GHG_t	0	-2	-9	0	-12	-3	-2	-2	-1
GHG_t+s	0	-2	-9	0	-12	2	3	-2	-1
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	0	0	-2	54	58	0	4
F&V+GHG	10	-3	-9	0	-11	3	17	-2	-1
F&V+LAB	11	-1	0	0	-1	55	81	0	4
GHG+LAB	0	-1	-9	-1	-14	58	64	-1	3
F&V+GHG+LAB	10	-2	-9	0	-13	59	87	-1	3

Modernizing - S

Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	9	0	0	0	3	1	14	0	0
F&V_s+t	9	-1	0	0	2	0	14	0	0
GHG_t	0	-1	-7	0	-9	-1	-2	-1	0
GHG_t+s	0	-1	-7	0	-9	2	1	-1	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	1	1	0	0	0	52	58	0	5
F&V+GHG	9	-2	-8	0	-7	2	15	-1	0
F&V+LAB	10	0	0	0	2	53	79	0	5
GHG+LAB	0	0	-8	0	-9	56	61	-1	5
F&V+GHG+LAB	9	-1	-8	0	-7	57	83	-1	5

Indicators:

h_V&F_i = Increase fruit&veg. cons.(%)
h_CAL_id = Increase or decrease calories (%)

e_GHG_d = Decrease emissions (%)
e_LAND_d = Decrease agri.land (%)
e_FERT_d = Decrease fertilizer use (%)

i_W2F_i = Increase low skilled agri. wage / food expenditures (% change)
i_DIET_i = Increase affordability of EL vegan diet for agri.low skilled (%)
i_LAB_i = Labour share in GDP (%)

GDP = Real GDP (%)

Scenario name

- [ ] Fruit & veg. subsidy (F&V_s)
- [ ] Fruit & veg. + non-perish. tax (F...
- [ ] GHG tax (GHG_t)
- [ ] GHG tax + labour subsidy (GHG_...
- [ ] Labour subsidy (LAB_s)
- [ ] Labour subsidy + capital tax (LA...
- [ ] Fruit & veg + GHG (F&V+GHG)
- [ ] Fruit & veg + labour (F&V+LAB)
- [ ] GHG + labour (GHG+LAB)
- [ ] Fruit & veg + GHG + labour (F&...

Health, environment and inequality impacts by food system: Industrial & Consolidated

Goals selected as key for a food system are highlighted to signal a move towards (green) or away (red) from the goal. Goals selected for other food systems are included for comparison.

All values in % change compared to 2019 situation

#add analysis

Industrial - A

	HEALTH		ENVIRONMENT			INCLUSION			
Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	5	0	0	0	1	0	15	0	0
F&V_s+t	5	0	0	0	0	0	15	0	0
GHG_t	1	0	-13	0	-7	-1	-1	-1	0
GHG_t+s	1	0	-13	0	-7	0	0	-1	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	-1	-1	1	0	2	52	43	0	-7
F&V+GHG	6	0	-13	0	-6	0	15	-1	0
F&V+LAB	5	-1	1	0	2	52	64	0	-7
GHG+LAB	0	-1	-12	0	-5	52	43	-1	-7
F&V+GHG+LAB	5	-1	-12	0	-5	52	64	-1	-7

Industrial - S

Scenario label	h_V&F_i	h_CAL_id	e_GHG_d	e_LAND_d	e_FERT_d	i_W2F_i	i_DIET_i	i_LAB_i	GDP
F&V_s	6	0	0	0	2	1	15	0	0
F&V_s+t	7	0	0	0	1	0	15	0	0
GHG_t	0	0	-6	0	-5	-1	-2	-1	0
GHG_t+s	0	0	-6	0	-5	0	0	-1	0
LAB_s	0	0	0	0	0	53	53	0	0
LAB_s+t	0	0	-1	0	0	53	59	0	6
F&V+GHG	7	0	-6	0	-4	0	14	0	0
F&V+LAB	7	0	-1	0	1	53	83	0	6
GHG+LAB	0	0	-6	0	-5	53	59	-1	7
F&V+GHG+LAB	7	0	-6	0	-4	54	83	-1	7

Indicators:

h_V&F_i = Increase fruit&veg. cons.(%)
h_CAL_id = Increase or decrease calories (%)

e_GHG_d = Decrease emissions (%)
e_LAND_d = Decrease agri.land (%)
e_FERT_d = Decrease fertilizer use (%)

i_W2F_i = Increase low skilled agri. wage / food expenditures (% change)
i_DIET_i = Increase affordability of EL vegan diet for agri.low skilled (%)
i_LAB_i = Labour share in GDP (%)

GDP = Real GDP (%)

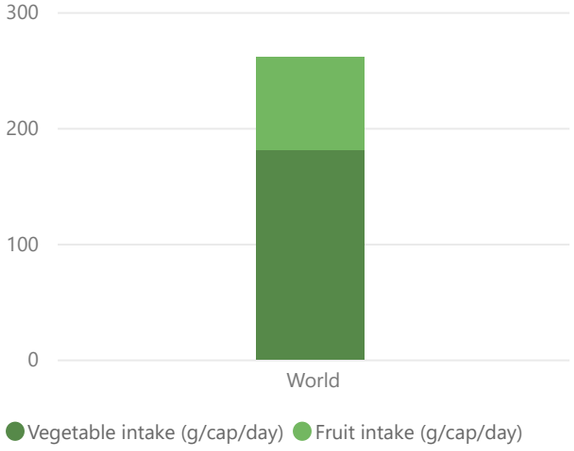
Diet scenario: stimulating fruit & vegetable consumption

Challenge: Fruit and vegetables are an important contributor to diet-based health benefits. Their consumption, however, is well below recommended intakes of around 400g/day (261 grams/capita/day globally). Poor dietary choices are in part due to prices, with health foods coming at a high or even unaffordable price (FAO et al. 2020).

Market failure being addressed: Pancrazi et al. (2022) find evidence in a rich US dataset that large fixed costs in the supply of fruit and vegetables distort their prices, estimating a relative price 40% higher than if markets were efficient. Fruit and vegetable consumption is thus below preferred levels.

Scenario: Following Pancrazi et al. (2022) we introduce a 25% on private consumption of fresh fruit and vegetables in all regions. The subsidy budget is provided by a (endogenous) tax on non-perishable food items not subject to the fixed costs required for fresh products to further narrow the price gap. The resulting taxes are up to 5.6%, keeping the total change in relative price well below the US estimate of 40%. As fixed costs of fresh food chains may be even higher in low income our scenario can be taken as a lower bound on correcting the price distortion from fixed costs in fresh fruit and vegetable supply chains.

Fruit & vegetable intake (g/cap/day) from GDD



Note: GDD is the global dietary database (Tufts University, 2022). More detail on the scenario motivation and quantification in the MAGNET model is provided in Kuiper et al. (2022).

Subsidy on fruit & vegetables (%)

LabelAS	F&V_s	F&V_s+t	F&V+GHG	F&V+LAB	F&V+GHG+LAB
Rural - A	-25,00	-25,00	-25,00	-25,00	-25,00
Rural - S	-25,00	-25,00	-25,00	-25,00	-25,00
Informal - A	-25,00	-25,00	-25,00	-25,00	-25,00
Informal - S	-25,00	-25,00	-25,00	-25,00	-25,00
Emerging - A	-25,00	-25,00	-25,00	-25,00	-25,00
Emerging - S	-25,00	-25,00	-25,00	-25,00	-25,00
Modernizing - A	-25,00	-25,00	-25,00	-25,00	-25,00
Modernizing - S	-25,00	-25,00	-25,00	-25,00	-25,00
Industrial - A	-25,00	-25,00	-25,00	-25,00	-25,00
Industrial - S	-25,00	-25,00	-25,00	-25,00	-25,00

Endogenous tax on non-perishables for budget neutrality (%)

LabelAS	F&V_s+t	F&V+GHG	F&V+LAB	F&V+GHG+LAB
Rural - A	5,78	5,72	5,78	5,72
Rural - S	9,33	9,18	9,33	9,18
Informal - A	5,29	5,24	5,30	5,24
Informal - S	7,37	7,31	7,37	7,30
Emerging - A	2,46	2,46	2,46	2,46
Emerging - S	5,52	5,52	5,53	5,53
Modernizing - A	5,56	5,55	5,55	5,54
Modernizing - S	4,82	4,82	4,81	4,81
Industrial - A	1,83	1,83	1,85	1,85
Industrial - S	2,89	2,89	2,88	2,88

As fruit & vegetables are small relative to non-perishables the endogenous tax rate for budget neutrality is much lower than the subsidy.

In poorer regions with lower non-perishable consumption the endogenous tax rate is higher.

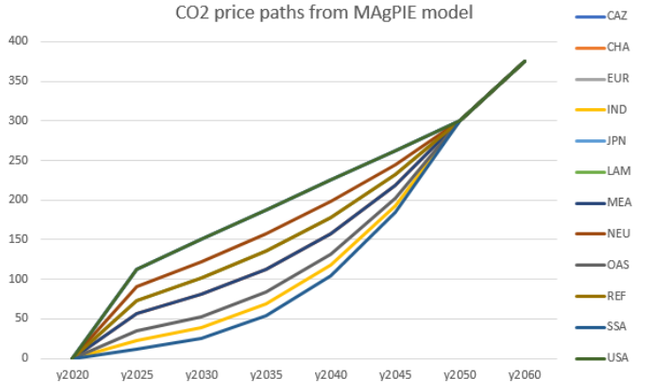
Environment scenario: GHG taxes combined with labour subsidy

Challenge: Greenhouse gas (GHG) emissions need to be reduced to avoid catastrophic climate change.

Market failure being addressed: Externalities of GHG emissions not incorporated in market prices.

Scenario: We have taken the CO_2eq price path from MAgPIE as a starting point, which converge by 2050. Since we are working in a comparative static way, we decided to focus on the price levels in the beginning periods which range in 2030 from 25 \$/ton CO_2eq in SSA to 50 \$/tonCO_2eq. However, since we aim at having universal scenarios for the different food systems, we decided on a uniform price point of 50 \$/tonCO_2eq. This price point was applied to the primary sectors with MAC data available only. All other sectors were applied only half the value of these prices points, as they are not able to respond endogenously as fully as the sectors with MAC curves implemented. The 50% value is a little arbitrary but was decided upon after some trial and error with various model setups.

In the second scenario (GHG_t+s) we have used the total revenues from the GHG taxes as input for labour subsidies (per region).



Emission intensities

LabelAS	Emissions agrifood	Emission intensity Agri-food
Rural - A	729,71	1,63
Rural - S	1.226,04	0,92
Informal - A	217,20	0,75
Informal - S	875,84	0,50
Emerging - A	355,27	0,47
Emerging - S	1.382,54	0,25
Modernizing - A	959,00	0,39
Modernizing - S	253,62	0,15
Industrial - A	1.187,90	0,13
Industrial - S	540,72	0,07

Labour subsidy from GHG tax

LabelAS	GHG_t+s
Rural - A	-11,48
Rural - S	-7,18
Informal - A	-5,19
Informal - S	-5,25
Emerging - A	-6,83
Emerging - S	-4,61
Modernizing - A	-5,08
Modernizing - S	-3,11
Industrial - A	-1,31
Industrial - S	-1,11

Note: More detail on the scenario motivation and quantification in the MAGNET model are provided in Kuiper et al. (2022).

Inclusion scenario: lowering income taxes for lowest paid workers

Challenge: About three quarters of the global population (71%) lives in countries where income inequality increased between 1990 and 2016. Apart from not delivering on the global SDG goal of leaving no one behind, income inequality slows sustained economic growth and may fuel political consolidation of vested interest preventing future redistributive polices (United Nations 2020).

Market failure being addressed: One driver of within-country inequality is wages not keeping pace with productivity increases. This leads to declining shares of labour in GDP while those of capital increase (United Nations 2020). Bengtsson and Waldenström (2018) find empirical support for Piketty's claim that GDP shares shifting from labour to capital are an important determinant of income inequality.

Scenario: To raise net wages of the lowest paid workers we subsidize the use of low skilled labour financed by a tax on the use of capital. We set the subsidy at 35%, the largest gap across regions between low skilled wage per worker and the average food expenditure on food (our inclusion measure).

Low skilled wage / average food expenditure (2019)

LabelAS	Agriculture	Industry	Services
Rural - A	0,97	1,54	2,94
Rural - S	0,82	6,48	4,32
Informal - A	2,04	1,43	2,94
Informal - S	1,06	2,97	2,16
Emerging - A	1,27	2,65	2,07
Emerging - S	0,74	6,86	11,60
Modernizing - A	0,85	2,54	2,92
Modernizing - S	0,67	3,27	1,87
Industrial - A	1,12	3,91	3,29
Industrial - S	1,18	2,30	1,48

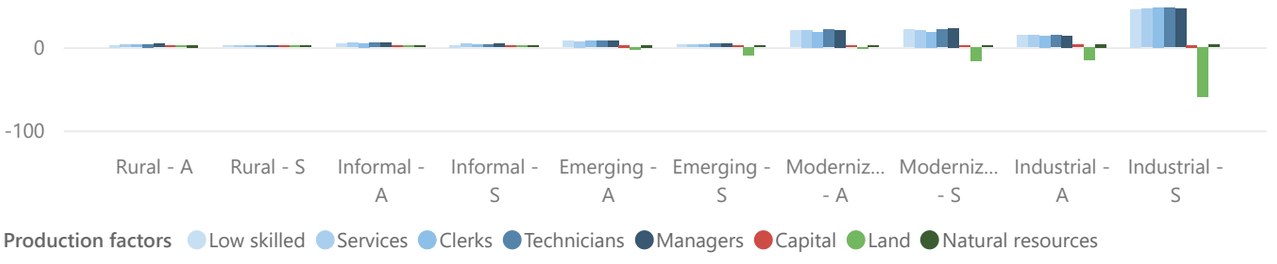
Subsidy low skilled labour (%)

LabelAS	LAB_s	LAB_s+t	F&V+LAB	GHG+LAB	F&V+GHG+LAB
Rural - A	-35,00	-35,00	-35,00	-35,00	-35,00
Rural - S	-35,00	-35,00	-35,00	-35,00	-35,00
Informal - A	-35,00	-35,00	-35,00	-35,00	-35,00
Informal - S	-35,00	-35,00	-35,00	-35,00	-35,00
Emerging - A	-35,00	-35,00	-35,00	-35,00	-35,00
Emerging - S	-35,00	-35,00	-35,00	-35,00	-35,00
Modernizing - A	-35,00	-35,00	-35,00	-35,00	-35,00
Modernizing - S	-35,00	-35,00	-35,00	-35,00	-35,00
Industrial - A	-35,00	-35,00	-35,00	-35,00	-35,00
Industrial - S	-35,00	-35,00	-35,00	-35,00	-35,00

Capital tax (%)

LabelAS	LAB_s+t	F&V+LAB	GHG+LAB	F&V+GHG+LAB
Rural - A	21,12	21,26	20,76	20,90
Rural - S	19,67	19,72	19,68	19,73
Informal - A	19,80	19,86	19,85	19,91
Informal - S	16,21	16,26	16,30	16,36
Emerging - A	9,21	9,22	9,26	9,27
Emerging - S	22,14	22,16	22,29	22,32
Modernizing - A	9,94	9,95	9,99	10,00
Modernizing - S	6,69	6,69	6,72	6,73
Industrial - A	20,78	20,78	20,95	20,95
Industrial - S	8,63	8,64	8,68	8,69

Factor tax rates (2019)



High labour taxes at world level are driven by the high income regions (these taxes include social security payments). At disaggregated level the pattern across regions is more diverse but labour taxes are always higher than taxes on capital.

Note: More detail on the scenario motivation and quantification in the MAGNET model are provided in Kuiper et al. (2022).

Descriptive

- [ ] Fruit & vegetable intake (g/capita/day)
- [ ] Red & processed meat intake (g/cap/day)
- [ ] Average energy supply (kcal/capita/day)
- [ ] Supply relative to average energy requir...
- [ ] Supply relative to minimum energy requ...
- [x] Undernourished (%)
- [ ] Adult obesity (%)
- [ ] Fertilizer use (kg/ha arable land)
- [ ] Food system GHG (ton CO2/capita, incl. ...
- [ ] LULUC (% food system emissions)
- [ ] Primary production (% food system GHG)
- [ ] Food processing & services (% food syst...
- [ ] Food consumption & waste (% food sys...
- [ ] People below 1.90$/day (%)
- [ ] GINI
- [ ] Palma ratio
- [ ] Energy sufficient diet (% food expenditu...
- [ ] Healthy diet (% food expenditure)

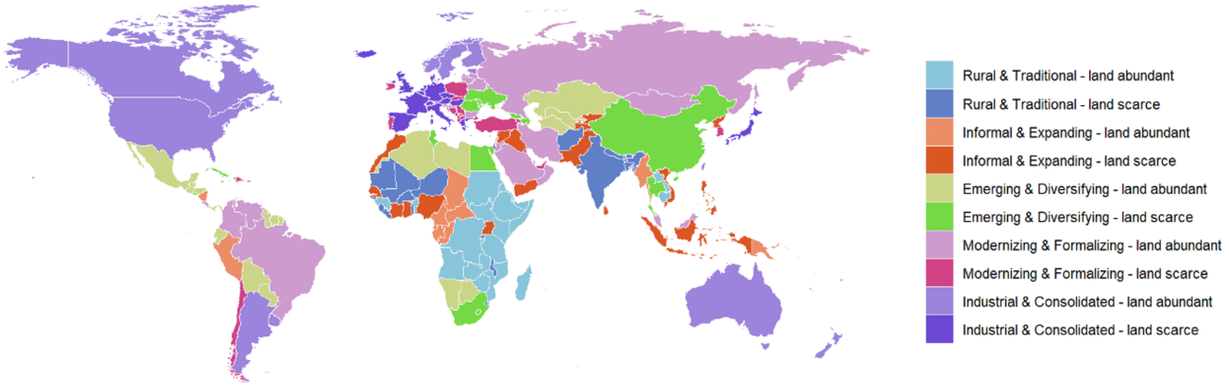
Descriptives of the food systems used in MAGNET & key indicators by food system

The 141 countries and aggregate regions in the MAGNET database have been aggregated into a 10 food system types, adding environmental detail to the typology developed in Marshall et al. (2021).

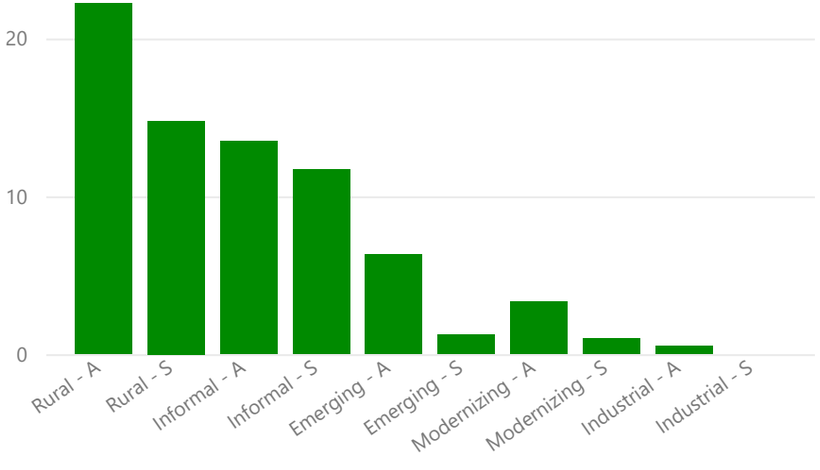
Similar to Marshall et al. (2021) we validate the grouping with empirical data for (or close to) the 2019 reference year to confirm that the MAGNET model regions properly reflect different challenges faced in each food system.

These descriptives are also used to identify a limited set of food system specific indicators to complement the generic policy goals for a broad assessment of the policy impacts.

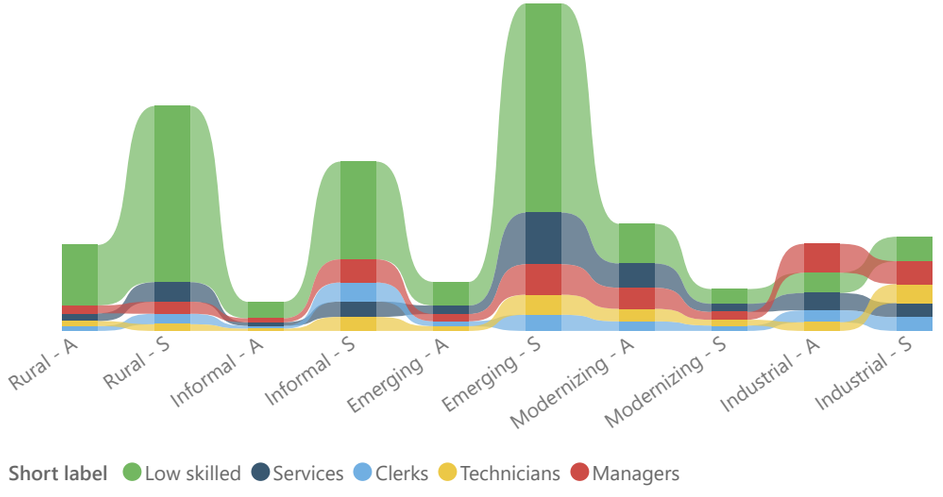
Food system typology resulting in 10 MAGNET model regions



Undernourished (%)



Labour force composition

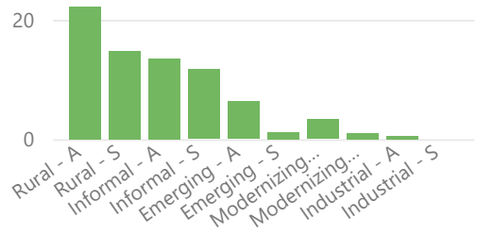


Note: **Data sources** (reference year 2019 unless indicated otherwise): **food intake** data from the Global Dietary database (Tufts University 2022), reference year 2018; **energy availabilities, undernourishment, obesity, and fertilizer use** from FAOSTAT (FAO, n.d., accessed April 2022); **GHG emissions** EDGAR-FOOD (Crippa et al. 2021); **poverty and inequality** from the World Development Indicators (World Bank, n.d., accessed April 2022); **diet affordability** from Herforth et al. (2020).More detail on the regional grouping and its validation are provided in Kuiper et al. (2022).

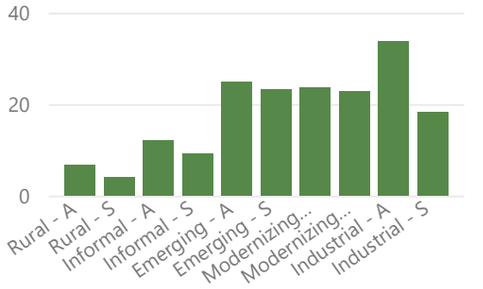
Food system goals derived from descriptives

Health

Undernourished (%)



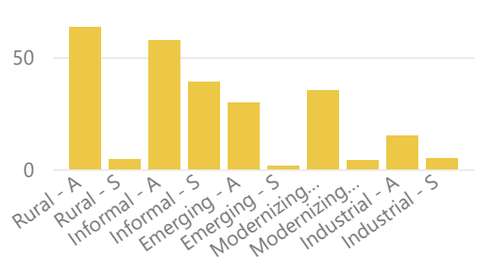
Adult obesity (%)



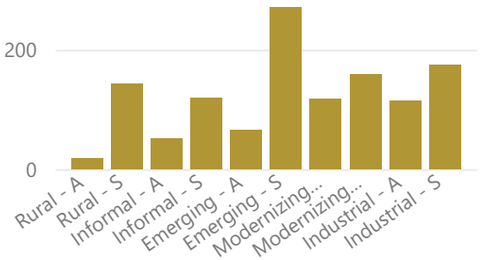
Undernourishment mostly occurs in Rural and Informal both in % of the population as in total number of people. Obesity rates are high (close to or well above 20% of population) in Emerging, Modernizing and Industrial. Aim for an **increase in calorie intake in Rural and Informal regions and decrease in the other regions.**

Environment

LULUC (% food system emissions))



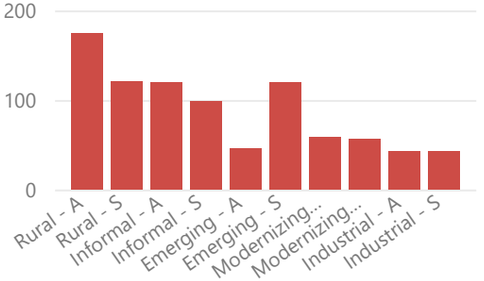
Fertilizer use (kg/ha)



Fertilizer use is higher in land scare regions signalling more intensive production systems. It is notably low in land abundant Rural (18 versus 137 global average). Food system emissions (FSE) are higher in Rural and Informal land abundant regions due to LULUC. Aim to **reduce fertilizer use in all land scarce regions and in the land abundant Modernizing and Industrial regions. Decrease agricultural land use in the other regions.**

Inclusion

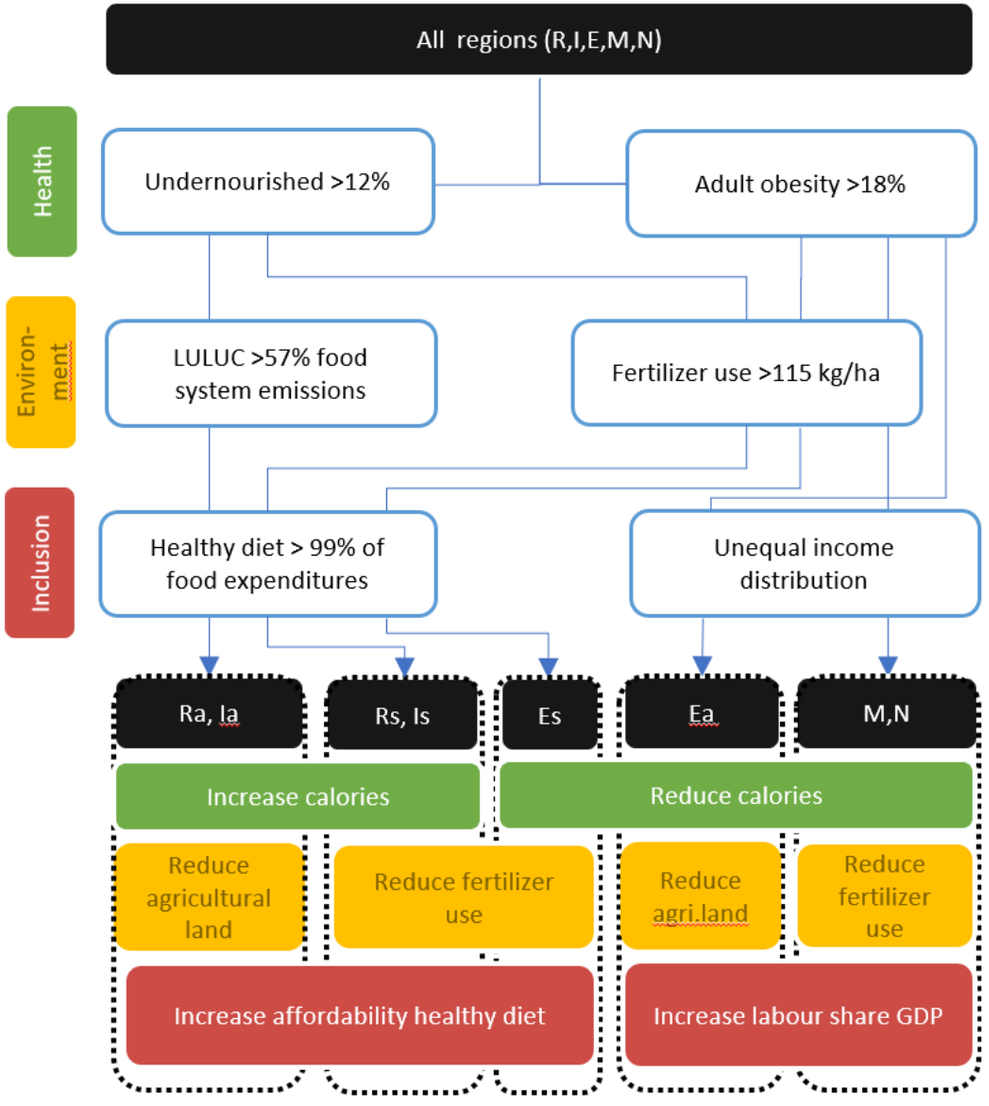
Healthy diet affordability (% food expendi...



Unaffordability of health diets is an issue in the poorest regions (Rural and Informal) as well as in the land scare Emerging region due to high income inequality. Aim to **increase the addordability of healthy diets in Rural, Informal and land scarce Emergin regions. Incrrease the labour share of GDP in other regions** (serving as an indication of income inequality)

Note: Data sources provided on the food system descriptives page. Futher details on the selection of indicators on the "Selecting goals by food system" page and in Kuiper et al. (2022)

Food system specific goals derived from descriptives



Region codes in the figure refer to : R = Rural; I = Informal; E = Emerging; M = Modernizing; N = Industrial; a = land abundant; s= land scarce

We follow the dashboard approach avoiding composite indicators with a very limited (7-10) set of context-specific indicators proposed in Stiglitz et al (2018) as our top-level measure of the impact of the policy bundles. Selecting 2 indicators for our 3 dimensions of diet-related health, environment, and inclusion we get 6 indicators. Including our 3 policy goals which are selected to be of relevance in all regions we identify one additional measure by region based on the regional descriptives which is endogenous in the MAGNET model. Grouping considerations are summarized on the "Food system goals" page and further detailed in Kuiper et al. (2022).

We avoid ex-post indicators computed from model variables using econometric estimates (see for example Campagnolo and Davide 2019) as the policy bundles result in counterfactual results which make the econometric estimates likely inaccurate.

We select indicators complementary to the 3 policy goals, i.e. not using food system emissions as these will decline with the economywide CO2 tax. The cut-off points by indicator are included in the figure.

The result is **a grouping of the food systems in 5 groups with shared additional goals next to the generic policy goals** of increasing fruit & vegetable consumption, reducing GHG emissions and increasing living wages.

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