



An introduction of GTEM-Food: A baseline calibration with a focus on food

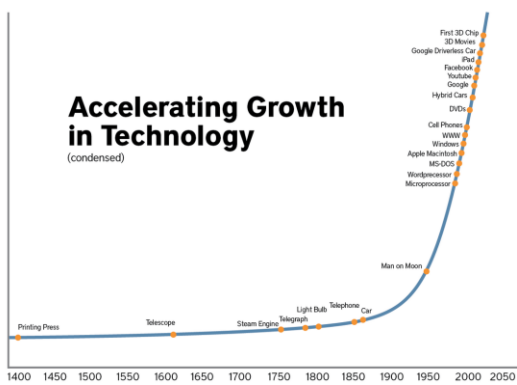
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Outline

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1. Introduction



- Future technology development, environmental and socio-economic changes
 - ➔ Complex impacts on agriculture and food systems
 - ➔ In need of comprehensive foresight modelling tools

Objectives

CSIRO-ABARES Collaboration Project

- Develop an integrated modelling approach (core model: GTEM-Food)
- Facilitate detailed and insightful analyses of global and regional agricultural and food systems

1. Update the GTEM database

GTAP V8 (2007) => GTAP V10 (2014)

2. Have more detailed and key animal-sourced and seafood sectors

=> More live animal, meat and fishery sectors

=> New production and consumption structures

3. Re-organise the sectoral and regional aggregation levels

2. Development of GTEM-Food

GTAP V10a Overview

#	Code	Description
1	pdr	Rice: seed, paddy (not husked)
2	wht	Wheat: seed, others
3	gro	Other Grains: maize (corn), sorghum, barley, rye, oats, millets, other cereals
4	v_f	Veg & Fruit: vegetables, fruit and nuts, edible roots and tubers, pulses
5	osd	Oil Seeds: oil seeds and oleaginous fruit
6	c_b	Cane & Beet: sugar crops
7	pfb	Fibres crops
8	ocr	Other Crops: stimulant; spice and aromatic crops; forage products; others
9	ctl	Live bovine animals (cow, buffalo sheep, goat)
10	oap	Live swine; poultry; others
11	cmt	Bovine meats (beef, lamb, goat)
12	omt	Pork, poultry, others
13	fsh	Fishery
14	rmk	Raw milk
15	vol	Vegetable oils
16	mil	Milk: dairy products
17	pcr	Processed Rice: semi- or wholly milled, or husked
18	sgr	Sugar and molasses
19	ofd	Other Food: prepared and preserved fish; prepared and preserved vegetables

Data source Overview

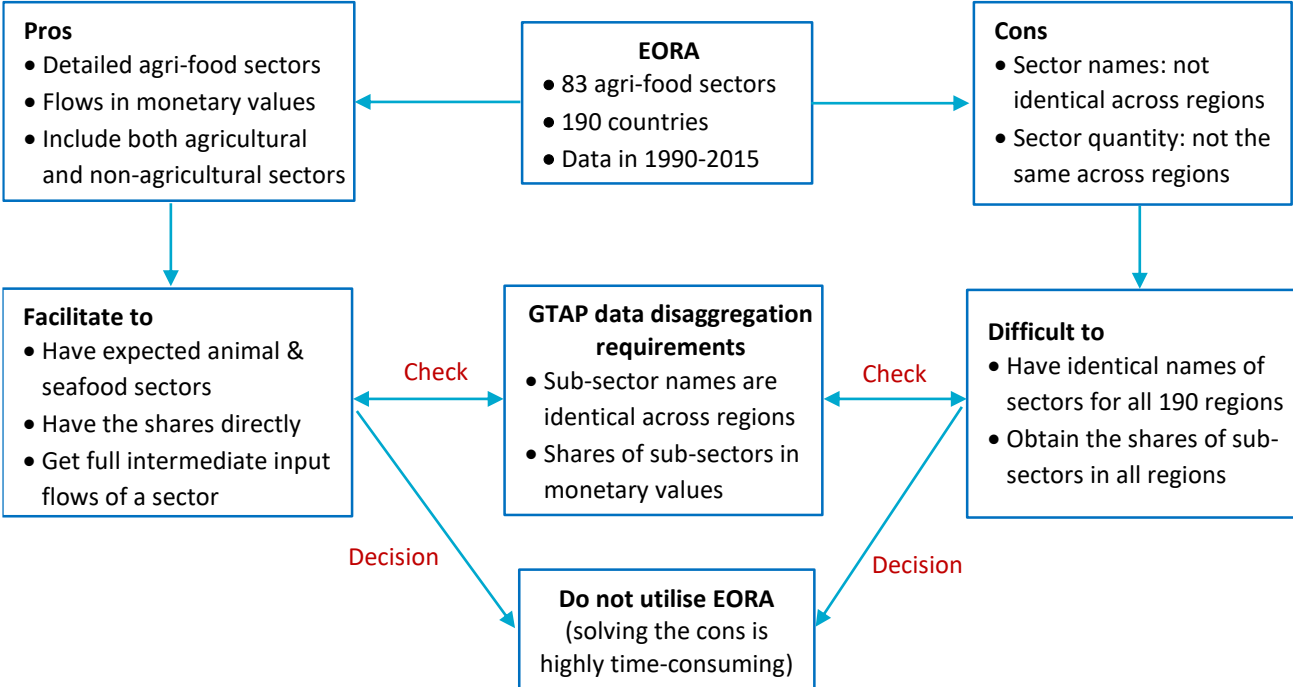


Figure 2: The main features of the EORA data set



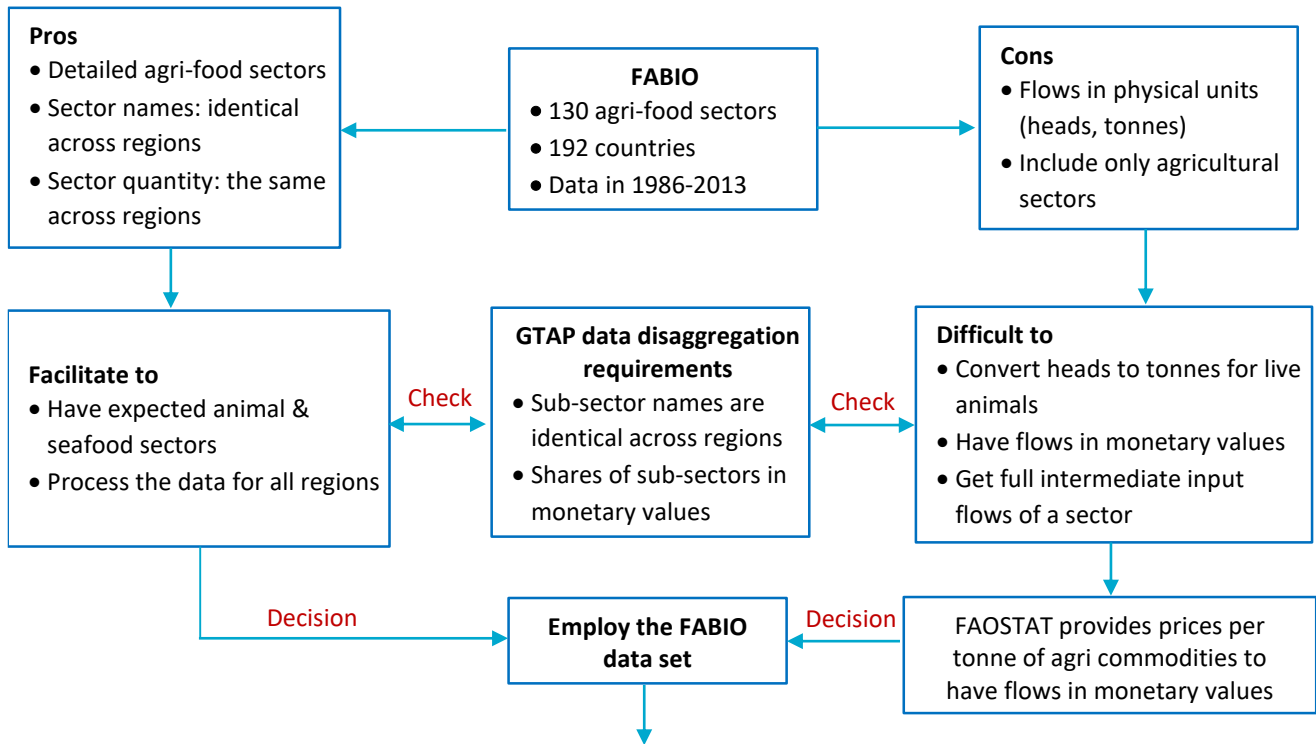


Figure 3: The main features of the FABIO data set and its application for GTEM food data

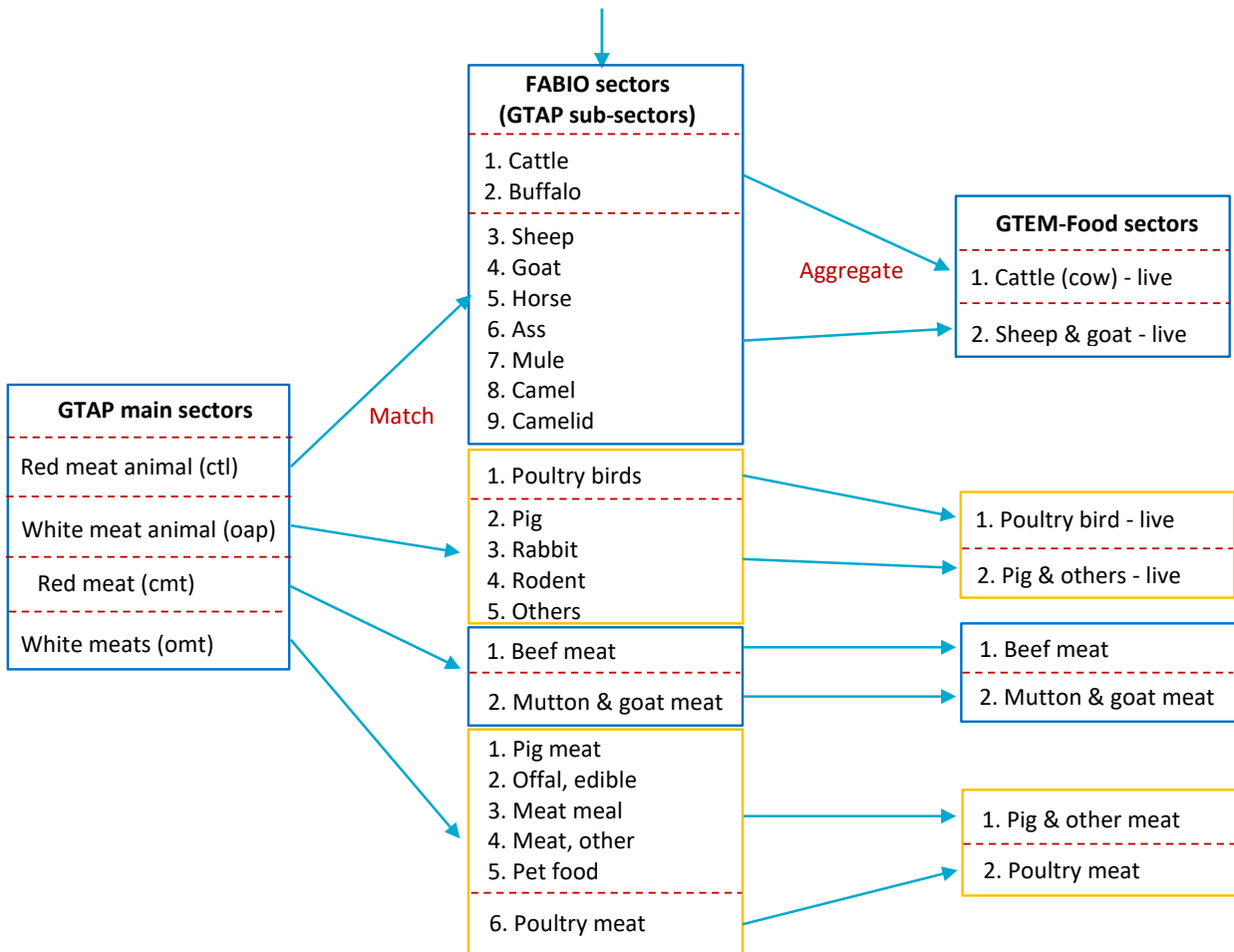


Figure 3: The main features of the FABIO data set and its application for GTEM food data (cont.)

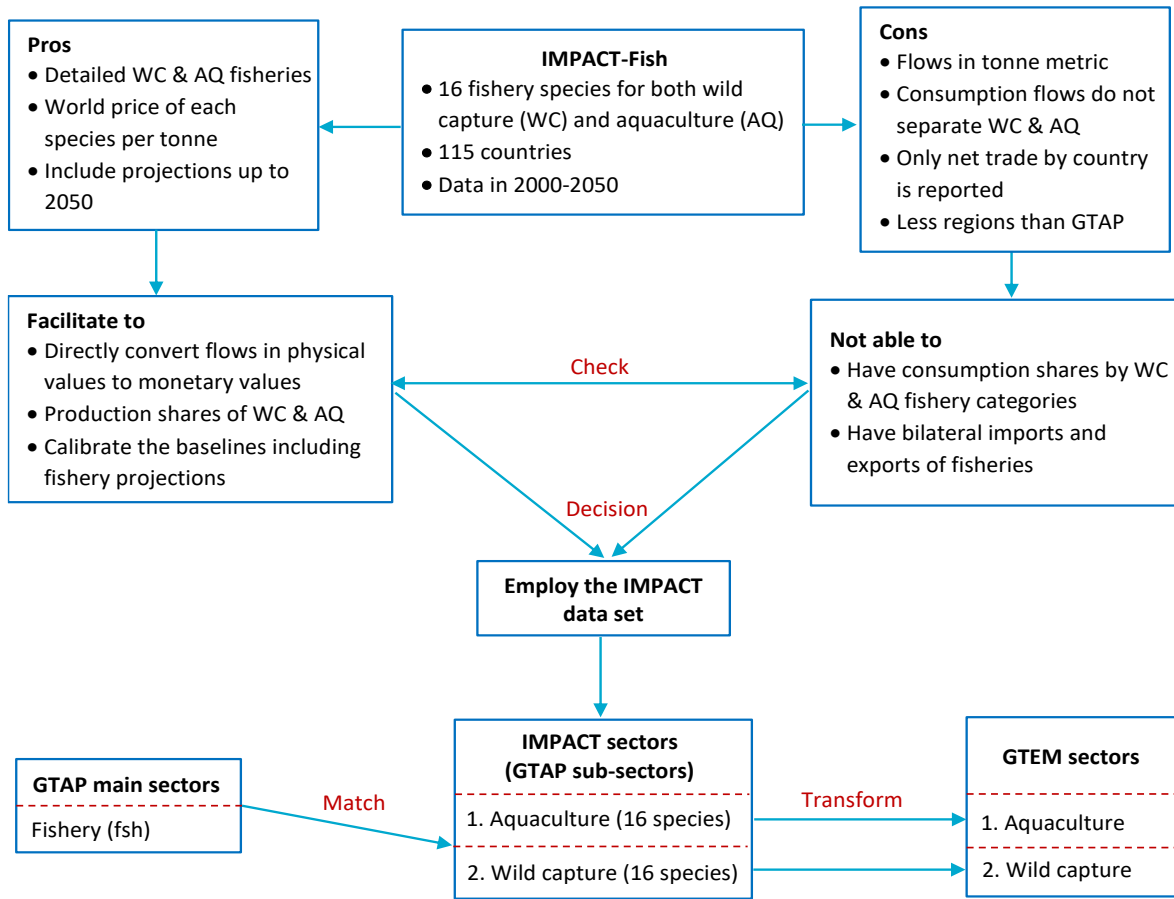


Figure 4: The main features of the IMPACT-Fish data set and its application for GTEM food data

Technology and processing bundle industries (one output, multiple technology or processing inputs)

- Three 'technology bundle' industries
 - Electricity generation
 - Iron and steel manufacturing
 - Land transportation
- Two new 'processing bundle' industries
 - Meat processing (beef and lamb)
 - Fish processing (aquaculture and wild capture fishery)

Structures in GTEM-Food

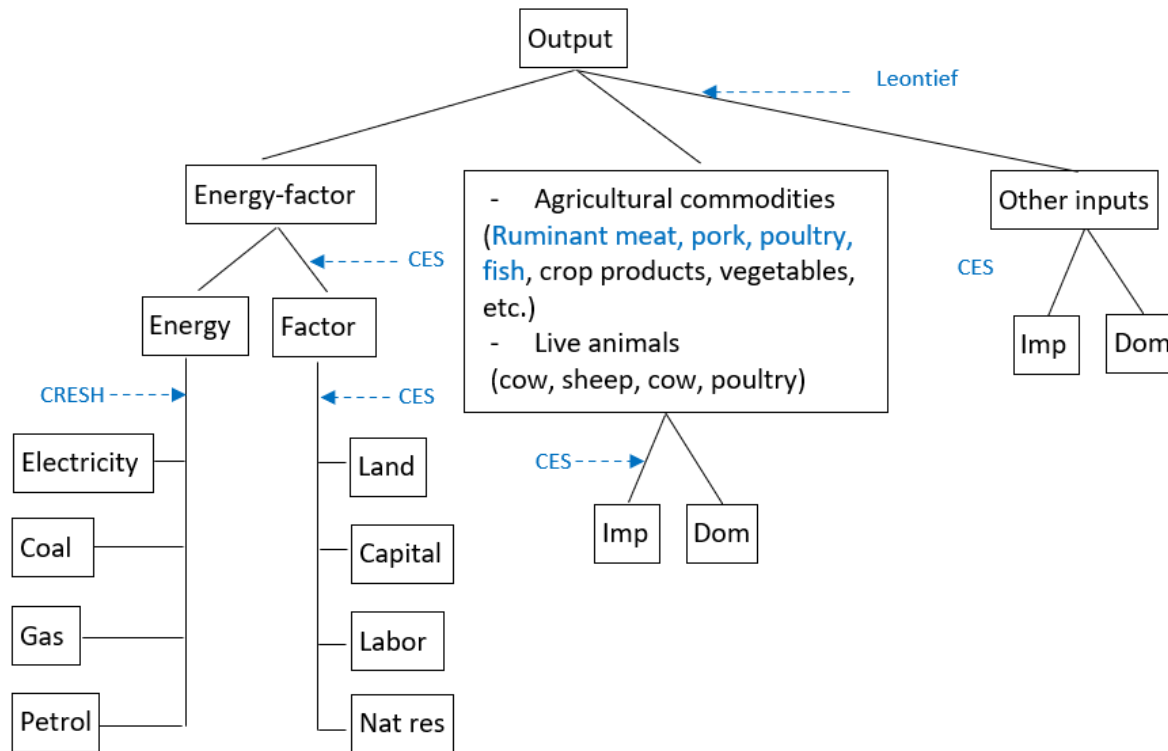


Figure 5: The production structure of **non-food industrial sectors** proposed in GTEM-Food

Note: Non-food industrial sectors include live cattle, sheep-goat, poultry, and pig-others sectors.

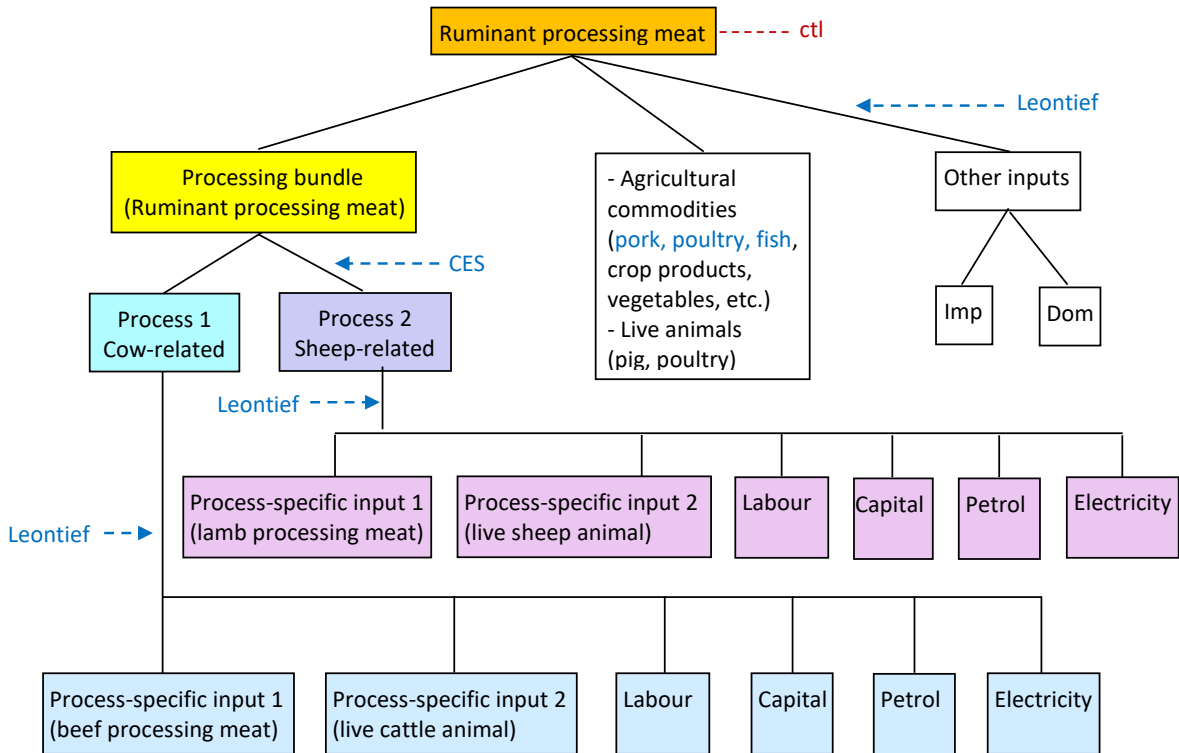


Figure 6: production structure of the 'processing bundle' ruminant meat processing sector in GTEM-Food

Note: The 'processing bundle' fish processing sector has a similar structure.

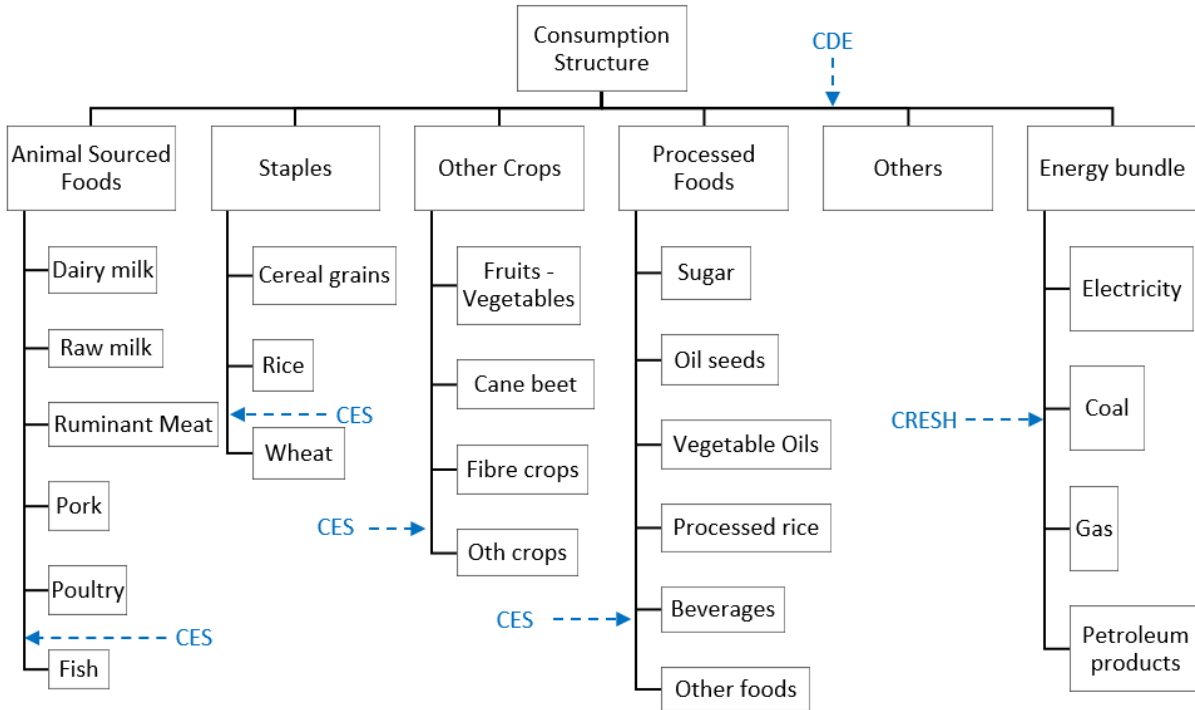


Figure 7: Consumption structure in GTEM-Food

3. Baseline assumptions/shocks

Sectors	Assumptions	GTEM-Food shock variables
Crop sectors	Used pure exogenous productivity assumptions from IMPACT SSP2 projection to approximate the land productivity shocks in GTEM-Food.	af_generic("land", "crop sectors name", REG)
Livestock sectors	Used percentage change of total output (in tonnes) of live animal sectors from IMPACT SSP2 projection to approximate the output efficiency (TFP) in the three livestock sectors.	ao_generic("livestock sectors name",REG)
Forestry sector	Shock the input efficiency from "Forestry" sector into "Farm_Forest" sector (sector which produce paper and wood products) by using the values that were estimated by Tim Baynes from literature when doing IRP project (Hatfield-Dodds et al., 2017).	af_generic("Forestry", "Farm_Forest", REG)
Fishery sector	Use the IMPACT fishery production data on Aquaculture and Wild Capture as the input efficiency shocks from fishery sector to the two processing technologies.	aft("Fishery", "t1/t2", "Fishery",REG)
Food processing sector	Shock eight food processing sectors output efficiency by using the values that were estimated by Tim Baynes from literature when doing IRP project (Hatfield-Dodds et al., 2017).	ao_generic("food processing sectors name",REG);

Sectors	Assumptions	GTEM-Food shock variables
Transport	Coal, gas, petroleum and electricity input efficiency into two transport sectors are shocked by using the efficiency improvement in transport by fuel from IEA's Energy Efficiency report.	af_generic("col/gas/p_c/ely","otp/Oth_trans",REG)
Electricity	Coal, gas, petroleum input efficiency into corresponding generation technologies in the electricity sector are shocked by using the efficiency improvement in electricity generation by fuel from IEA's Energy Efficiency report.	aft("col","t1","ely",REG)
Electricity output	Output of 15 electricity generation technologies following output projections provided by CSIRO Energy Business Unit	f_qtech(tech,"ely",REG)
Energy-intensive sectors	Coal, gas, petroleum and electricity input efficiency into 2 energy-intensive sectors (Iron and steel production, other energy intensive sector) are shocked by using the efficiency improvement in transport by fuel from IEA's Energy Efficiency report.	af_generic(FUEL,"Ene_Intens",REG)
		af_generic(FUEL,"i_s",REG)
		FUEL = (COL,GAS,P_C,ELY)
Other	We apply a uniform shock to fuel input efficiency in all the other sectors are shocked uniformly by a world aggregate improvement rate.	af_generic(FUEL,NON_SHK_IND,REG)
	We also apply a uniform fuel efficiency for final demand (household fuel efficiency) are shocked uniformly by a world aggregate improvement rate.	fuel_economy
	Emission intensity of fuels are shocked uniformly by a world aggregate improvement rate.	f_eo

4. Baseline results

Table 1: The world output level (2014 US\$ billion).

Commodity	2020	2040	2060	CAGR (2020-60)
Wheat	221.7	248.3	270.1	0.49%
Vege & fruit	855.5	1133.6	1434.4	1.30%
Live cattle	422.7	538.1	627.4	0.99%
Live pig	435.6	525.6	543.1	0.55%
Live poultry	299.8	405.2	472.0	1.14%
Meat cattle	792.9	1086.3	1362.6	1.36%
Meat pork	370.4	486.0	569.7	1.08%
Meat poultry	311.5	430.0	523.4	1.31%
Fish	416.1	484.3	529.4	0.60%
Dairy milk	872.6	1174.6	1446.3	1.27%
Processed rice	497.7	616.8	691.4	0.83%
Sugar	232.9	271.9	309.2	0.71%
Coal	478.0	379.1	310.4	-1.07%
Crude oil	2450.4	2494.6	2521.6	0.07%
Natural gas	866.8	778.7	756.7	-0.34%
Petroleum	3986.5	4085.8	4117.6	0.08%
Electricity	2990.7	3281.6	3494.0	0.39%

Table 2: Output of wheat in major producing regions (2014 US\$ billion).

Countries	2020	2040	2060	CAGR (2020-60)
Australia	7.7	10.0	12.3	1.18%
China	48.5	47.7	46.5	-0.10%
India	21.0	24.4	27.1	0.65%
France	6.9	7.5	8.3	0.44%
Russia	11.2	12.4	11.1	-0.02%
USA	11.6	13.3	15.6	0.75%

Table 3: Output of live cow and meat beef (million tonnes).

	Live cow				Meat beef			CAGR (2020-60)
	2020	2040	2060	CAGR (2020-60)	2020	2040	2060	
Australia	4.9	5.7	6.1	0.55%	2.38	2.91	3.09	0.66%
New Zealand	1.3	1.4	1.5	0.40%	1.07	1.16	1.34	0.58%
China	25.3	30.2	31.2	0.53%	7.08	9.71	10.27	0.94%
India	10.4	11.3	12.6	0.49%	2.48	3.14	3.85	1.11%
Japan	0.6	0.6	0.6	0.11%	0.50	0.50	0.52	0.10%
South Korea	0.6	0.7	0.8	0.95%	0.36	0.53	0.60	1.29%
Indonesia	1.2	1.7	2.1	1.49%	0.61	0.97	1.28	1.86%
France	3.8	4.2	4.4	0.33%	1.41	1.65	1.92	0.78%
Germany	2.3	2.1	2.0	-0.32%	1.13	1.09	1.14	0.01%
Italy	1.1	1.2	1.2	0.39%	0.89	0.99	1.13	0.60%
UK	1.4	1.4	1.4	-0.02%	0.85	0.97	1.10	0.66%
Russia	4.7	5.3	5.8	0.54%	1.68	2.15	2.43	0.92%
Canada	2.7	3.4	4.2	1.06%	1.12	1.38	1.69	1.04%
USA	17.6	20.8	22.4	0.60%	12.40	16.42	18.19	0.96%
Mexico	6.1	7.8	8.9	0.93%	1.84	2.33	2.72	0.99%
Argentina	6.7	9.2	10.9	1.22%	2.73	4.74	6.39	2.15%
Brazil	22.9	29.5	35.3	1.09%	9.82	15.38	19.38	1.71%
South Africa	1.5	2.1	2.7	1.43%	1.01	1.64	2.31	2.09%
World	175.4	231.0	294.1	1.30%	70.25	103.20	133.99	1.63%

Table 4: Output of live sheep and meat lamb (million tonnes).

	Live sheep			CAGR (2020-60)	Meat lamb			CAGR (2020-60)
	2020	2040	2060		2020	2040	2060	
Australia	2.0	2.3	2.5	0.55%	0.69	0.84	0.89	0.66%
New Zealand	1.4	1.5	1.6	0.40%	0.49	0.53	0.62	0.58%
China	14.3	17.1	17.6	0.53%	4.23	5.62	5.96	0.86%
India	2.7	2.9	3.3	0.49%	0.77	0.97	1.18	1.08%
Japan	0.0	0.0	0.0	0.11%	0.00	0.00	0.00	0.09%
South Korea	0.0	0.0	0.0	0.95%	0.00	0.00	0.00	1.33%
Indonesia	0.5	0.8	1.0	1.49%	0.12	0.19	0.24	1.83%
France	0.4	0.5	0.5	0.33%	0.13	0.15	0.17	0.73%
Germany	0.1	0.1	0.1	-0.32%	0.04	0.03	0.03	-0.13%
Italy	0.2	0.2	0.2	0.39%	0.03	0.04	0.04	0.54%
UK	0.8	0.8	0.8	-0.02%	0.31	0.33	0.37	0.47%
Russia	0.8	0.9	1.0	0.54%	0.20	0.23	0.25	0.65%
Canada	0.1	0.1	0.1	1.06%	0.02	0.02	0.03	1.04%
USA	0.4	0.5	0.5	0.60%	0.08	0.10	0.11	0.90%
Mexico	0.5	0.7	0.8	0.93%	0.10	0.12	0.13	0.66%
Argentina	0.4	0.6	0.7	1.22%	0.07	0.12	0.15	2.06%
Brazil	0.5	0.7	0.8	1.09%	0.12	0.18	0.23	1.66%
South Africa	0.4	0.6	0.8	1.43%	0.23	0.36	0.49	1.98%
World	50.0	69.8	95.1	1.62%	14.13	22.11	30.92	1.98%

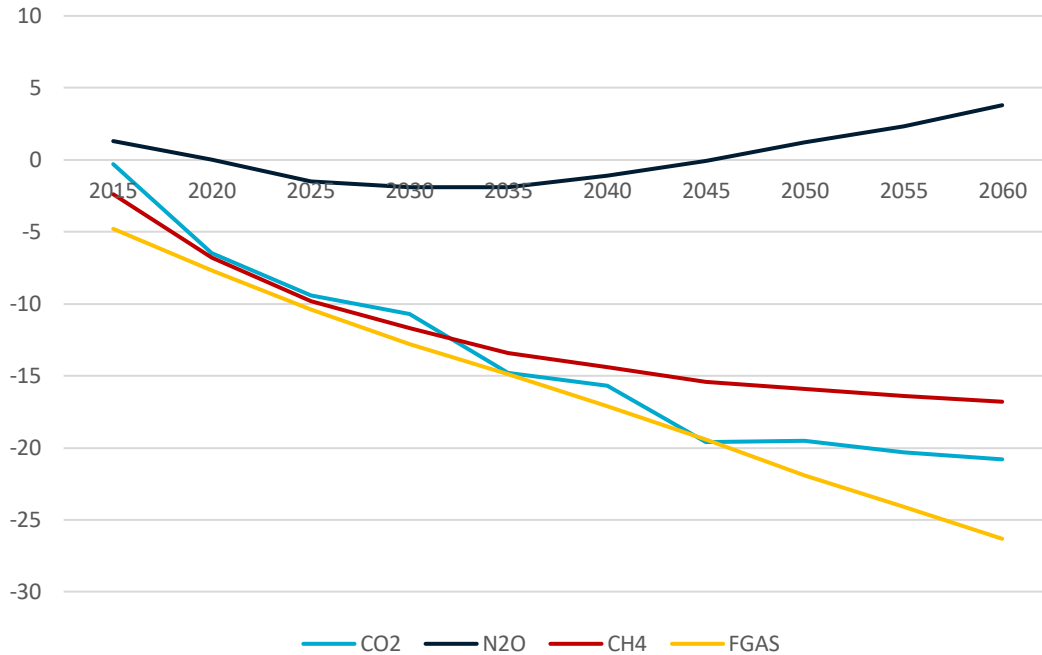
Table 5: Output of aquaculture and wild capture fishery (billion tonnes).

	Aquaculture fishery			CAGR	Wild capture fishery			CAGR
	2020	2040	2060		2020	2040	2060	
Australia	68	76	77	0.31%	173	195	200	0.36%
New Zealand	138	140	141	0.05%	460	501	530	0.35%
China	83872	96420	96717	0.36%	32253	35157	34776	0.19%
India	4890	6558	7684	1.14%	4156	5393	6269	1.03%
Japan	800	828	830	0.09%	4286	4293	4248	-0.02%
South Korea	575	628	632	0.24%	1862	2068	2074	0.27%
Indonesia	2323	2944	3305	0.89%	5421	6667	7445	0.80%
France	274	295	309	0.30%	415	453	476	0.34%
Germany	39	42	44	0.30%	250	260	274	0.23%
Italy	188	204	217	0.36%	257	278	295	0.35%
UK	248	278	300	0.48%	883	981	1060	0.46%
Russia	110	114	116	0.13%	3929	4382	4603	0.40%
Canada	338	366	381	0.30%	1512	1645	1713	0.31%
USA	524	588	616	0.41%	4668	5245	5493	0.41%
Mexico	201	233	255	0.60%	1618	1874	2055	0.60%
Argentina	2	2	3	1.02%	927	1055	1162	0.57%
Brazil	426	496	527	0.53%	830	964	1024	0.53%
South Africa	4	4	5	0.56%	649	771	857	0.70%
World	159377	186658	196344	0.52%	168048	192806	209109	0.55%

Table 6: Results in Australia

Variables	2030	2040	2050	2060
Total emissions, IND + PRI + GOV (Mt CO2e)	438	408	396	406
Aggregate Agricultural sector emission (Mt CO2e)	108.1	114.5	122.1	128.9
Share of agricultural emissions of the total emissions	0.247	0.281	0.309	0.318
Real aggregate agricultural output (cumulative % change compared to 2014)	26.380	41.610	55.380	68.240
Output of food versus output of non-FOOD	0.043	0.042	0.041	0.041
Share of agriculture sector to all sectors	0.063	0.062	0.063	0.063
Agricultural export share of total agricultural output	0.208	0.213	0.216	0.215
Agricultural export share of all commodity exports	0.016	0.016	0.016	0.015
Ratio of aggregate import by agriculture sector to its production level	0.061	0.061	0.061	0.061
Agricultural productivity measured by real output per real input	1.022	1.023	1.023	1.023
Shares of aggregate agricultural product consumption of the total expenditure (household)	0.093	0.090	0.089	0.089
Share of food expenditure of total expenditure (household)	0.070	0.067	0.066	0.066
Share of staple food expenditure of total food expenditure (household)	0.001	0.001	0.001	0.001

Figure 7: Global emission levels (cumulative % change compared to 2014).



5. Future development and applications

- Future model development

- Improve the climate damage function
- Incorporate material demands
- Incorporate water resources following GTAP-W
- Incorporate land use resources following GTAP-AEZ

- Potential applications

- Carbon taxes
- Carbon border adjustments
- Negative emissions technologies
- Climate change impacts
- African Swine fever

Thank you

Agriculture and Food

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Table A1: Output of fish in major producing regions (2014 US\$ billion).

	2020	2040	2060	CAGR (2020-60)
Australia	4.1	4.5	4.5	0.25%
China	170.3	188.1	183.1	0.18%
India	21.9	28.3	32.3	0.98%
Japan	13.7	13.7	13.5	-0.02%
South Korea	7.4	8.0	7.9	0.16%
Indonesia	17.8	21.9	23.9	0.74%
France	3.6	3.9	4.1	0.30%
Italy	3.5	3.8	4.0	0.34%
UK	3.3	3.7	3.9	0.43%
Russia	6.4	7.1	7.3	0.34%
USA	7.5	8.3	8.6	0.33%
Brazil	3.6	4.1	4.3	0.44%

Table A2: Output of live cattle in major producing regions (2014 US\$ billion).

Countries	2020	2040	2060	CAGR (2020-60)
Australia	13.7	15.9	17.1	0.55%
China	95.8	114.6	118.2	0.52%
India	10.5	11.3	12.7	0.48%
Canada	7.8	9.7	11.9	1.06%
USA	64.8	76.6	82.4	0.60%
Argentina	8.9	12.2	14.4	1.22%
Brazil	31.1	40.1	48.0	1.09%

Table A3: Output of meat cattle in major producing regions (2014 US\$ billion).

Countries	2020	2040	2060	CAGR (2020-60)
Australia	15.9	19.3	20.0	0.57%
China	151.4	191.3	193.7	0.62%
India	9.1	11.7	14.1	1.10%
Canada	15.8	19.7	23.8	1.03%
USA	148.0	188.4	202.3	0.78%
Argentina	11.9	19.6	25.4	1.91%
Brazil	50.8	74.0	91.2	1.47%

Table A4: Output of live pig and meat pork (thousand of head).

	Live pig			CAGR (2020-60)	Meat pork			CAGR (2020-60)
	2020	2040	2060		2020	2040	2060	
Australia	1.0	1.2	1.2	0.45%	1.12	1.43	1.67	1.00%
New Zealand	0.1	0.1	0.1	-0.69%	0.34	0.36	0.40	0.42%
China	155.3	183.9	178.9	0.35%	60.91	81.70	80.51	0.70%
India	2.4	5.0	8.1	3.05%	1.17	6.62	15.42	6.66%
Japan	3.3	3.2	2.9	-0.29%	1.55	1.54	1.48	-0.11%
South Korea	2.8	3.4	3.5	0.54%	1.40	1.80	1.84	0.68%
Indonesia	3.4	7.0	10.4	2.85%	1.23	1.83	2.38	1.66%
France	5.1	5.1	5.0	-0.04%	3.46	4.02	4.56	0.69%
Germany	9.5	8.2	7.5	-0.61%	6.75	6.01	6.01	-0.29%
Italy	2.8	2.9	3.0	0.17%	2.43	2.81	3.23	0.71%
UK	2.0	2.2	2.4	0.41%	1.20	1.37	1.55	0.64%
Russia	6.8	8.3	8.9	0.66%	4.09	4.57	4.26	0.10%
Canada	6.4	6.9	7.2	0.27%	2.14	2.04	2.18	0.04%
USA	23.4	32.1	38.2	1.23%	13.08	19.44	22.67	1.38%
Mexico	3.7	5.1	6.4	1.40%	1.87	2.96	3.89	1.86%
Argentina	1.1	1.8	2.6	2.23%	1.13	2.85	4.54	3.53%
Brazil	7.8	9.5	10.3	0.71%	4.96	10.33	14.20	2.66%
South Africa	0.7	1.2	1.6	2.05%	0.62	1.81	3.96	4.74%
World	318.2	387.3	419.3	0.69%	148.94	217.09	279.74	1.59%

Table A5: Output of live poultry and meat poultry (million tonnes).

	Live poultry			CAGR (2020-60)	Meat poultry			CAGR (2020-60)
	2020	2040	2060		2020	2040	2060	
Australia	1.9	2.5	2.9	1.05%	1.11	1.46	1.75	1.15%
New Zealand	0.3	0.3	0.3	-0.07%	0.18	0.21	0.25	0.84%
China	41.3	52.1	50.7	0.52%	19.42	26.03	25.15	0.65%
India	7.2	13.5	20.5	2.65%	2.49	6.17	10.74	3.73%
Japan	2.2	2.2	2.2	-0.03%	1.42	1.38	1.33	-0.16%
South Korea	2.6	3.1	3.1	0.42%	0.69	0.88	0.90	0.65%
Indonesia	8.1	13.2	17.5	1.93%	1.94	2.95	3.93	1.78%
France	3.6	3.9	4.1	0.31%	1.70	1.88	2.12	0.56%
Germany	3.1	2.6	2.3	-0.72%	1.47	1.27	1.31	-0.28%
Italy	1.7	1.9	2.1	0.50%	1.29	1.43	1.63	0.59%
UK	3.2	3.8	4.4	0.83%	1.63	1.79	2.00	0.52%
Russia	6.9	8.2	8.8	0.62%	3.60	4.10	3.98	0.25%
Canada	2.0	2.3	2.6	0.64%	1.25	1.36	1.54	0.52%
USA	29.9	38.2	42.3	0.87%	20.84	29.26	33.56	1.20%
Mexico	5.4	7.5	9.2	1.33%	2.90	4.51	6.04	1.86%
Argentina	2.3	3.0	3.5	1.00%	2.00	3.94	5.46	2.55%
Brazil	19.0	23.1	25.2	0.70%	12.74	18.93	22.40	1.42%
South Africa	3.9	6.5	8.7	2.04%	1.76	3.45	5.19	2.75%
World	223.9	303.4	367.3	1.25%	111.46	166.60	217.33	1.68%