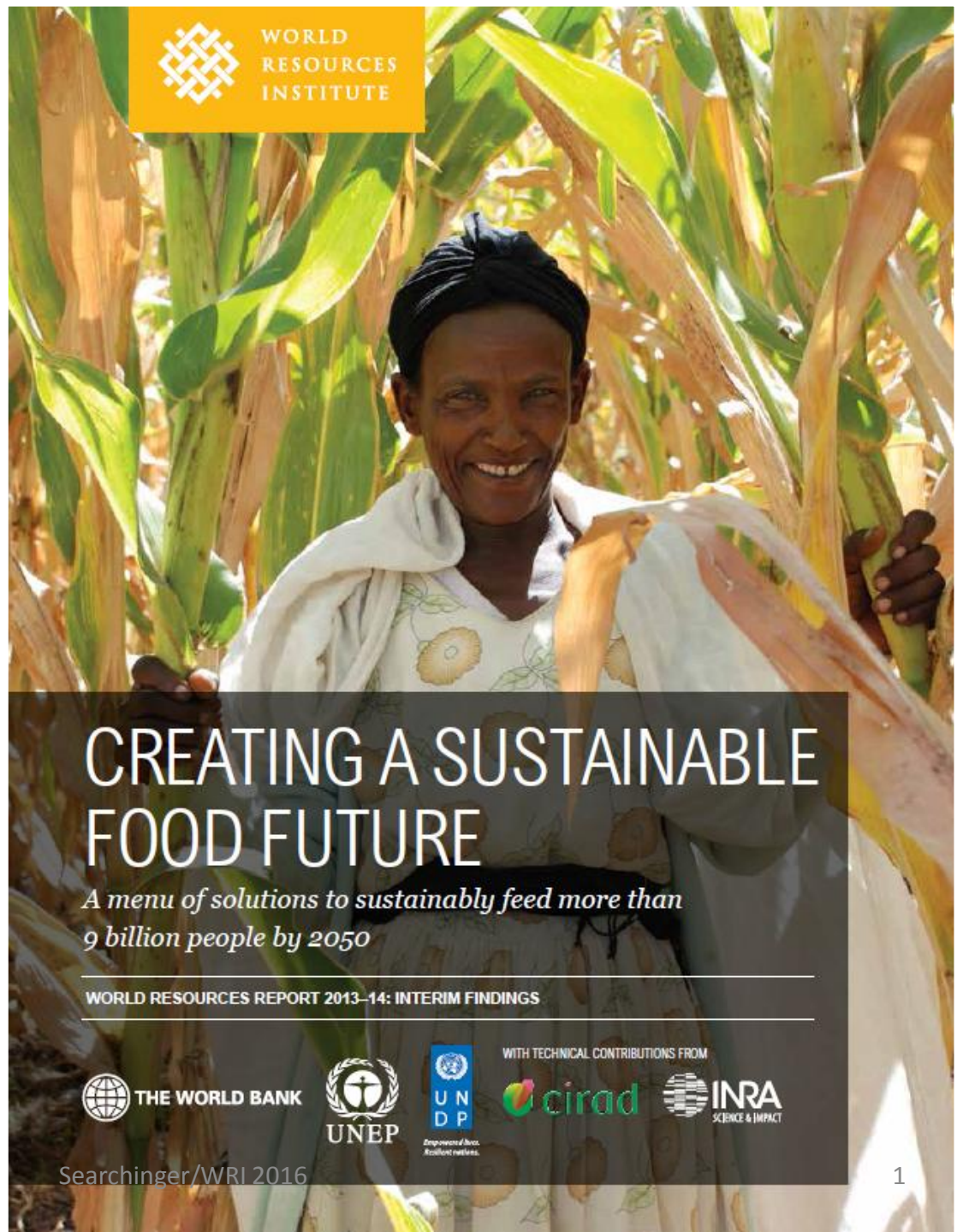


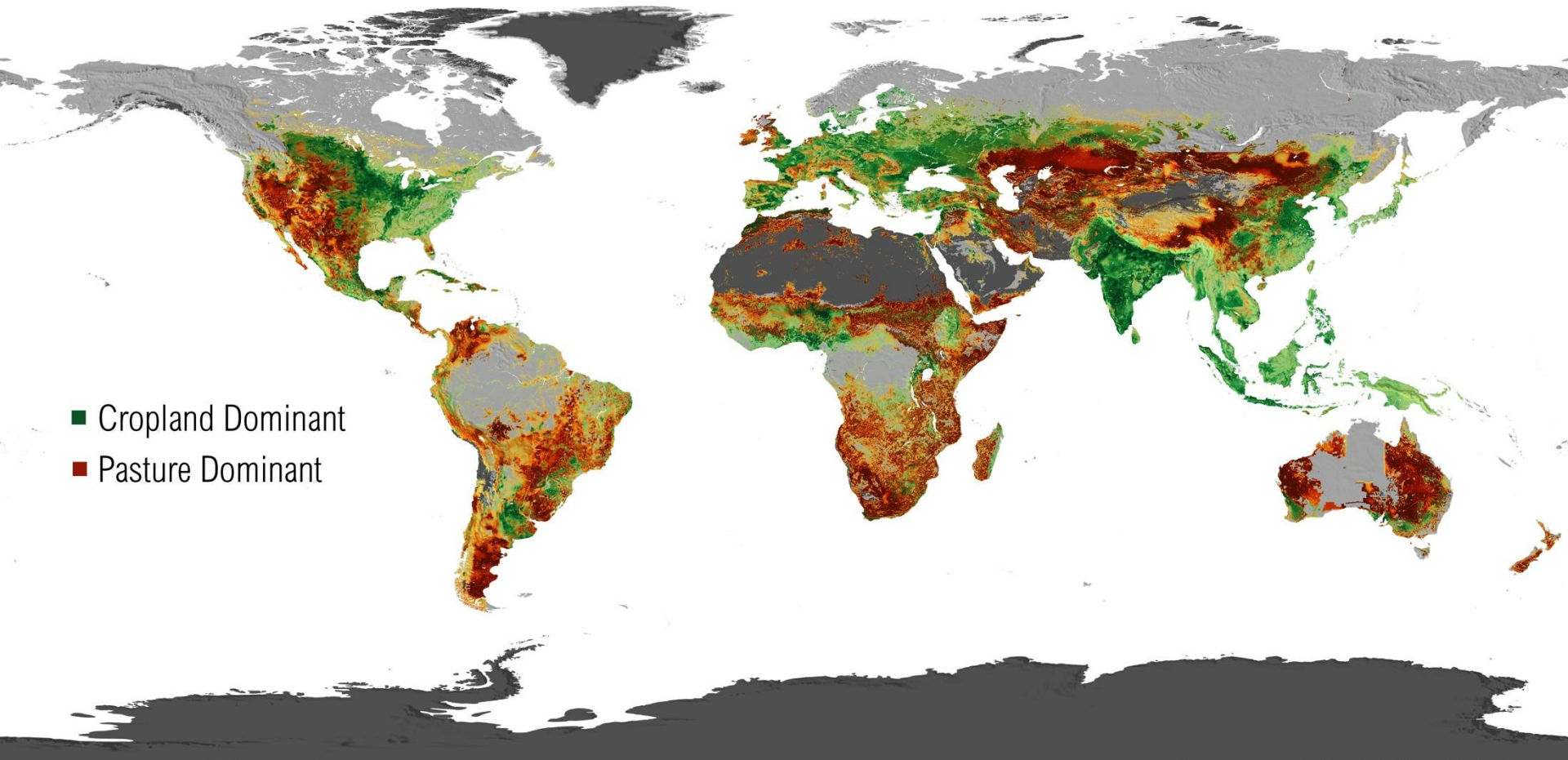
Tim Searchinger,
Princeton University
tsearchi@princeton.edu

<http://www.wri.org/our-work/project/world-resources-report/publications>



Croplands and pasture occupy half of the world's vegetated lands

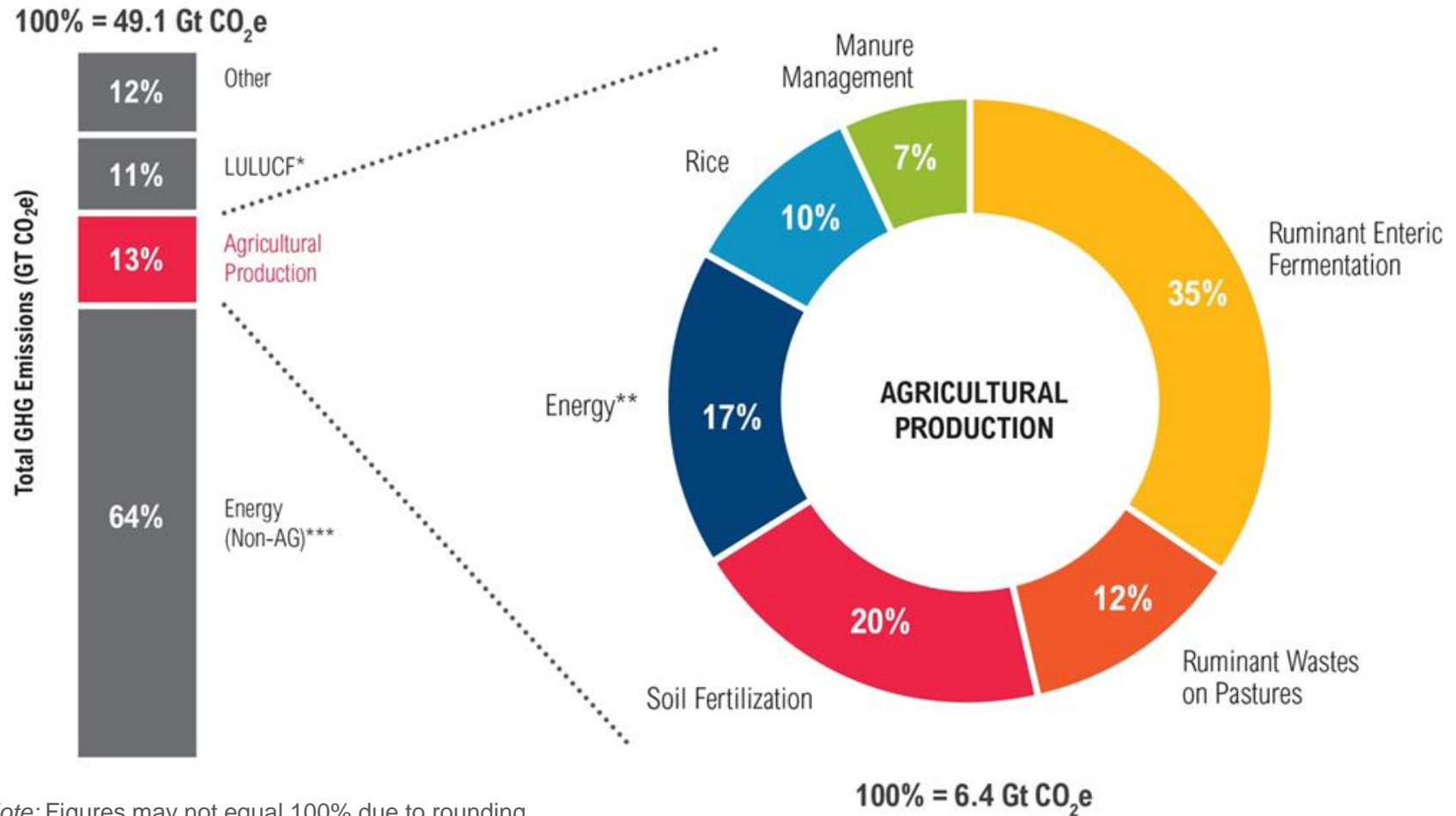
Distribution of croplands and pastures (2000)



Note: "Vegetated lands" excludes permanent ice cover, deserts, and inland water bodies.

Source: Data: Ramankutty, N., A. T. Evan, C. Monfreda, and J. A. Foley. "Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000." *Glob. Biogeochem. Cycles* 22: GB1003, doi:10.1029/2007GB002952. Map: Navin Ramankutty, Dept. of Geography, McGill University.

Agriculture Roughly 25% of World Emissions in 2010 and ruminants half of agricultural emissions and land use change



Note: Figures may not equal 100% due to rounding.

* LULUCF = Land Use, Land Use Change, and Forestry.

** Includes emissions from on-farm energy consumption as well as from manufacturing of farm tractors, irrigation pumps, other machinery, and key inputs such as fertilizer. It excludes emissions from the transport of food.

*** Excludes emissions from agricultural energy sources described above.

One way to (unsustainably) feed the planet . . .

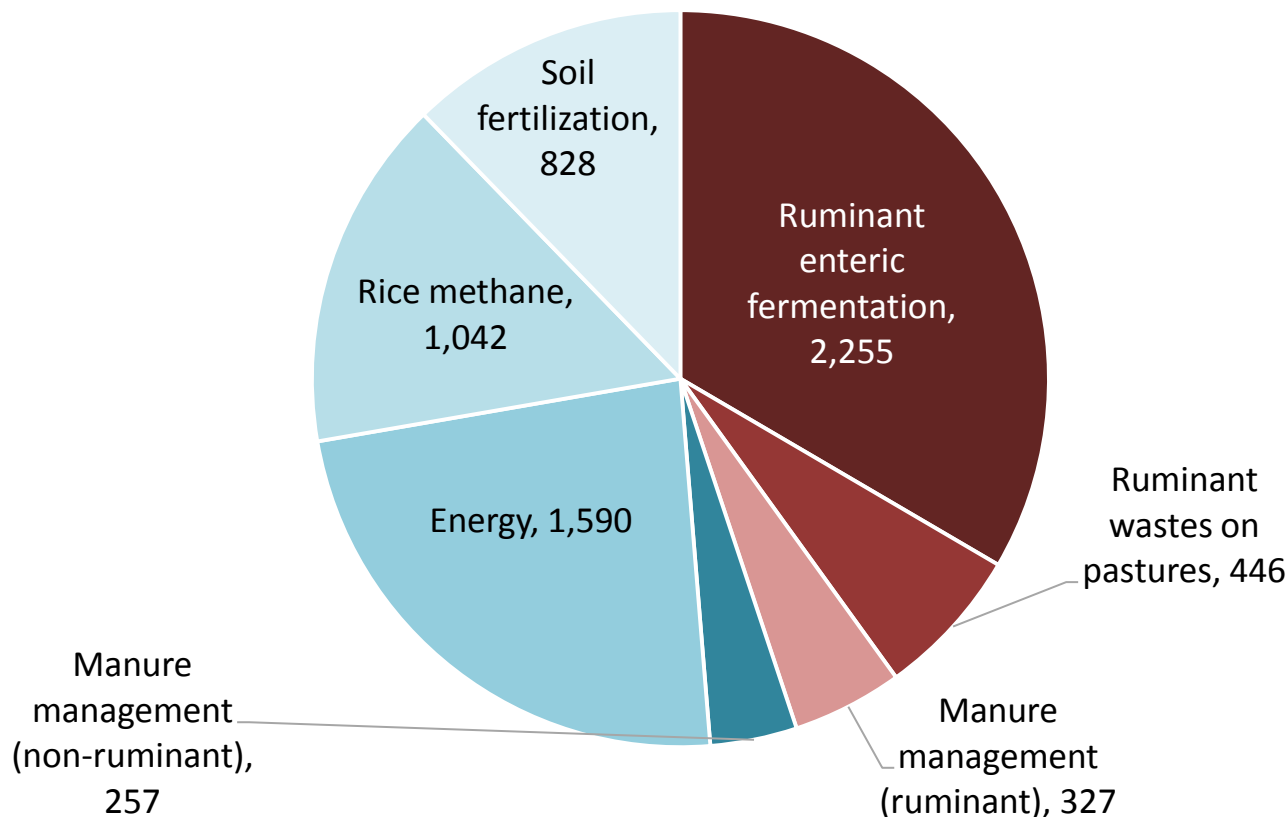


GLOBAGRI-WRR Model

- Accounting/biophysical
- Incorporates many detailed separate models re: livestock, rice, aquaculture, JRC land use, waste
- Modular – every country, more than 100 crops & crop components
- No explicit economics
- Solves by-products, trade, livestock allocation & feeds, land use.



GLOBAGRI – WRR - Agricultural production emissions by source, 2008 reference – **Million tonnes CO₂e, 100% = 6,746 million**



Source: GlobAgri-WRR model.

What's Driving Global Change

- Population: 6.9 billion (2008) to 9.7 billion (2050)
- Richer diets: 23% global increase per capita (meat, milk, fish)
- Shifts in shares of demand and production

Growing demand for livestock products + population drive consumption growth

79% increase all livestock products

80% increase for dairy

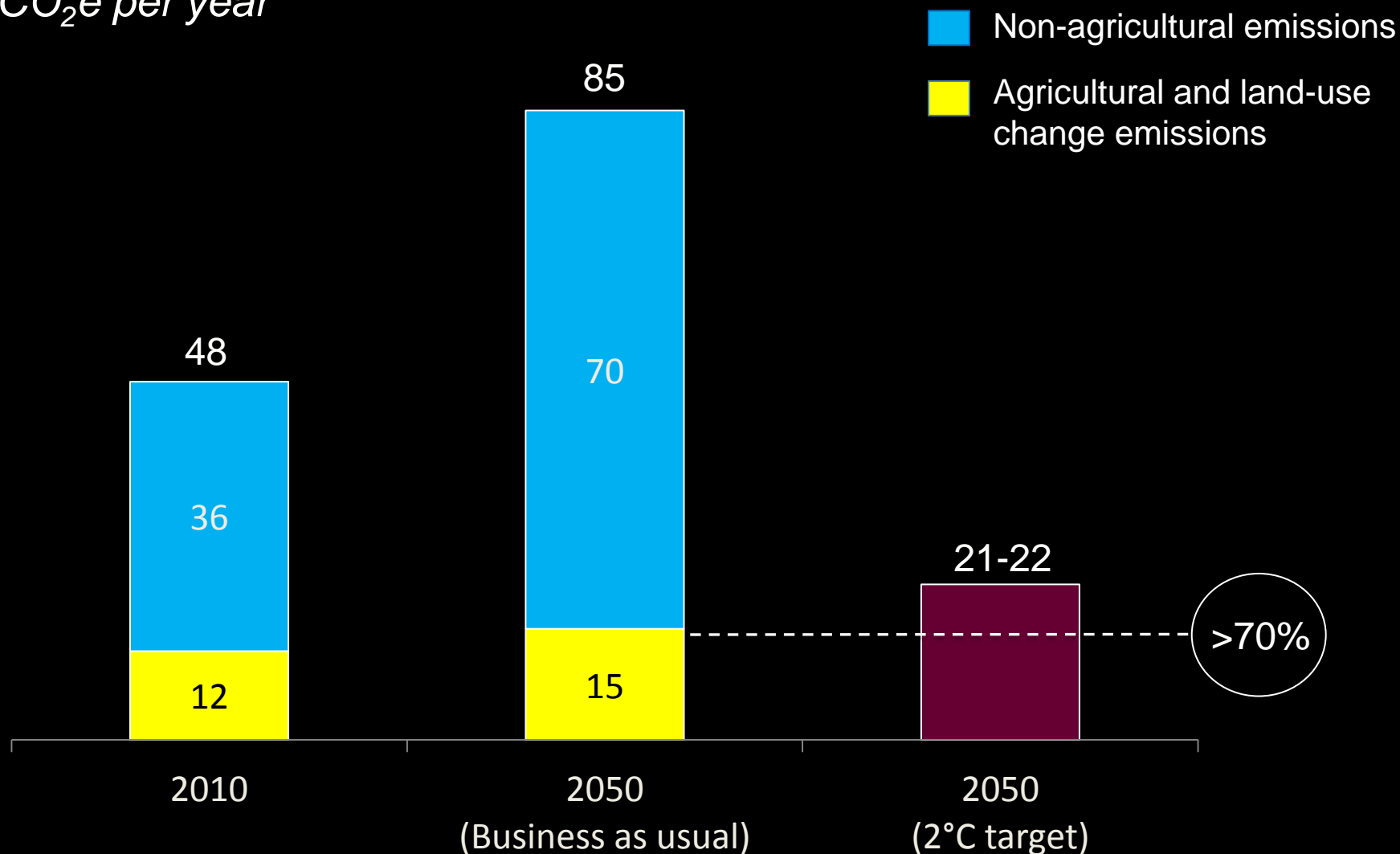
80% increase for beef

Holding down consumption of milk and meat by those who consume too much is necessary to allow more room for those who consume little

Region	Livestock (kcal/person/day)			Beef and mutton (kcal/person/day)		
	2006	2050	% change	2006	2050	% change
Canada & USA	907	887	-2%	117	95	-19%
European Union	864	925	7%	80	75	-6%
Brazil	606	803	33%	151	173	15%
Former Soviet Union	601	768	28%	118	156	32%
China	561	820	46%	41	89	116%
Other OECD	529	674	27%	64	84	31%
Latin America (ex Brazil)	475	628	32%	96	116	21%
Middle East & North Africa	303	416	37%	59	86	45%
Asia (ex. China, India)	233	400	72%	24	43	79%
India	184	357	94%	8	19	138%
Sub-Saharan Africa	144	185	29%	41	51	26%
World	413	506	23%	50	65	30%

Figure 25. “Business as usual” (BAU) agriculture emissions would comprise >70% of allowable emissions to achieve a 2°C world

Gt CO₂e per year



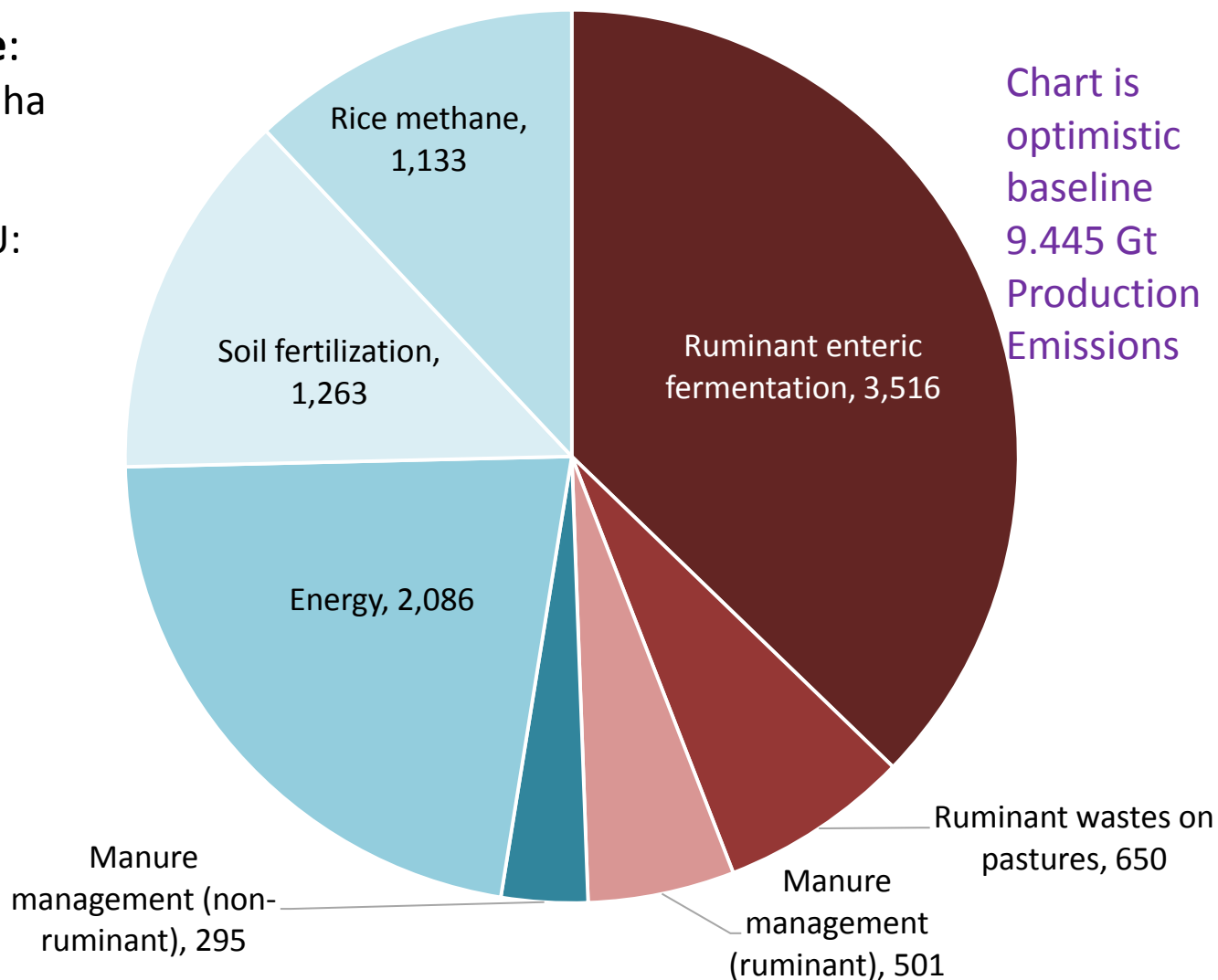
Agricultural production emissions by source, 2050 Baseline –

Production: ~ 9.5 Gt; Land Use Change - ~4 – 5.6 Gt CO₂e,

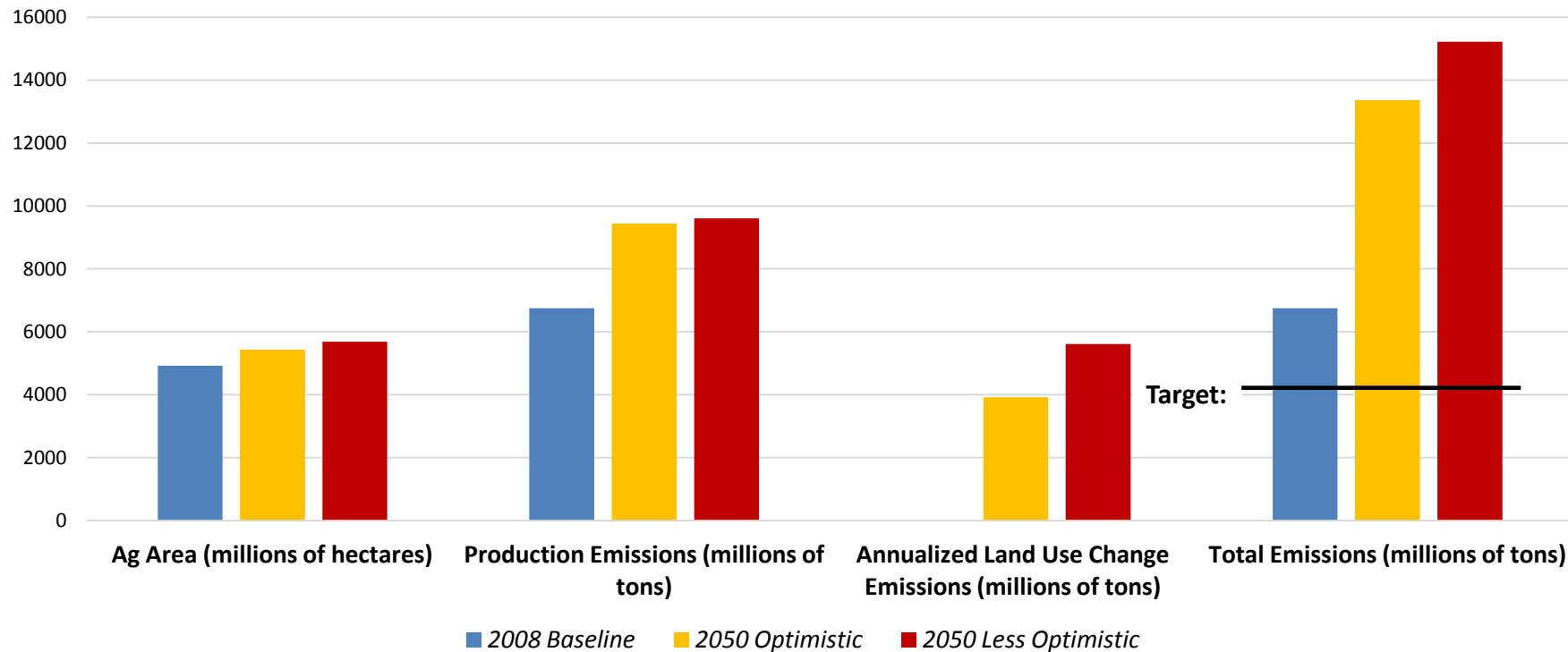
Land Use Change:

Optimistic: ~500 Mha
~ 4 Gt

Less optimistic BAU:
~750 Mha
5.6 Gt



Comparing 2008, Optimistic & Less Optimistic 2050 Baselines



Optimistic baseline

- FAO projections - Crop yields on average match 1962-2006
- Livestock efficiency gains match our best estimate of historical rates of growth in feed efficiency (15% dairy and 20% beef by 2050), and forage output per hectare for ruminants (27%)
- Globally beef & dairy output per hectare of grazing land grow by 70-73% (more than 3 billion hectares, half arid)

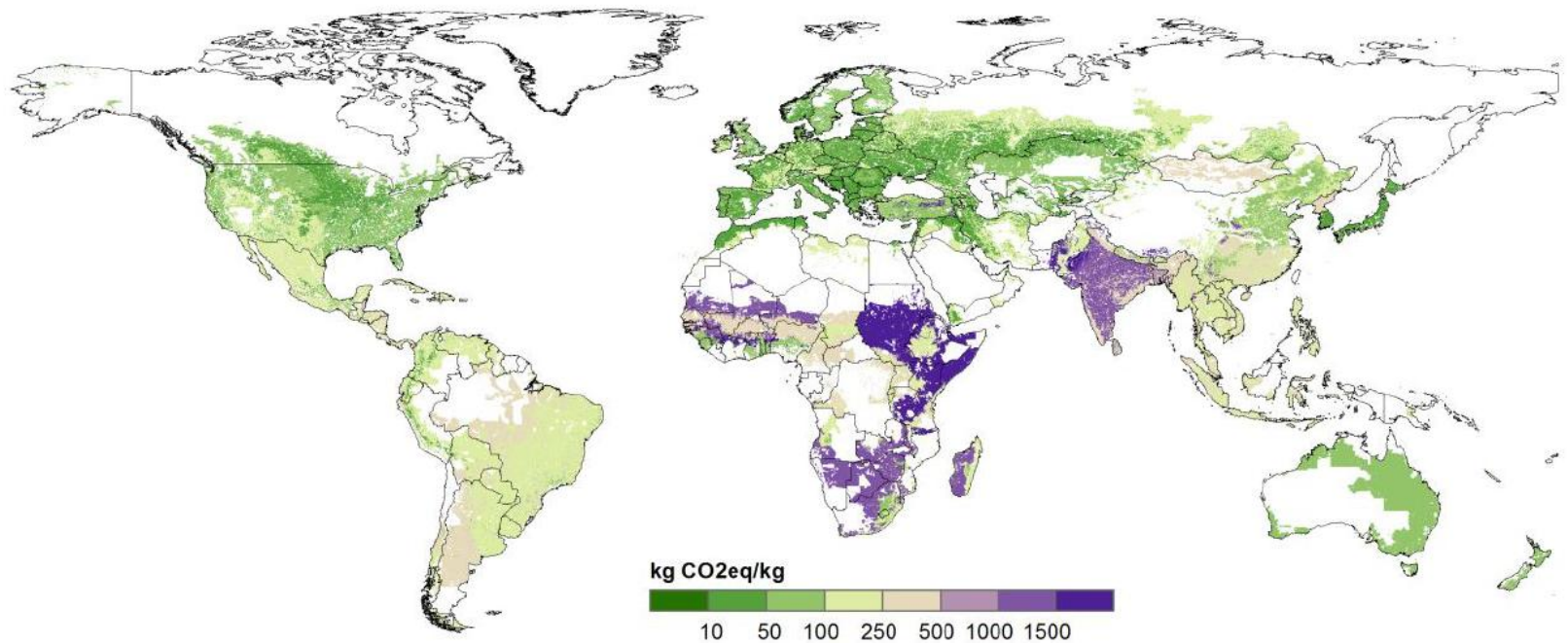
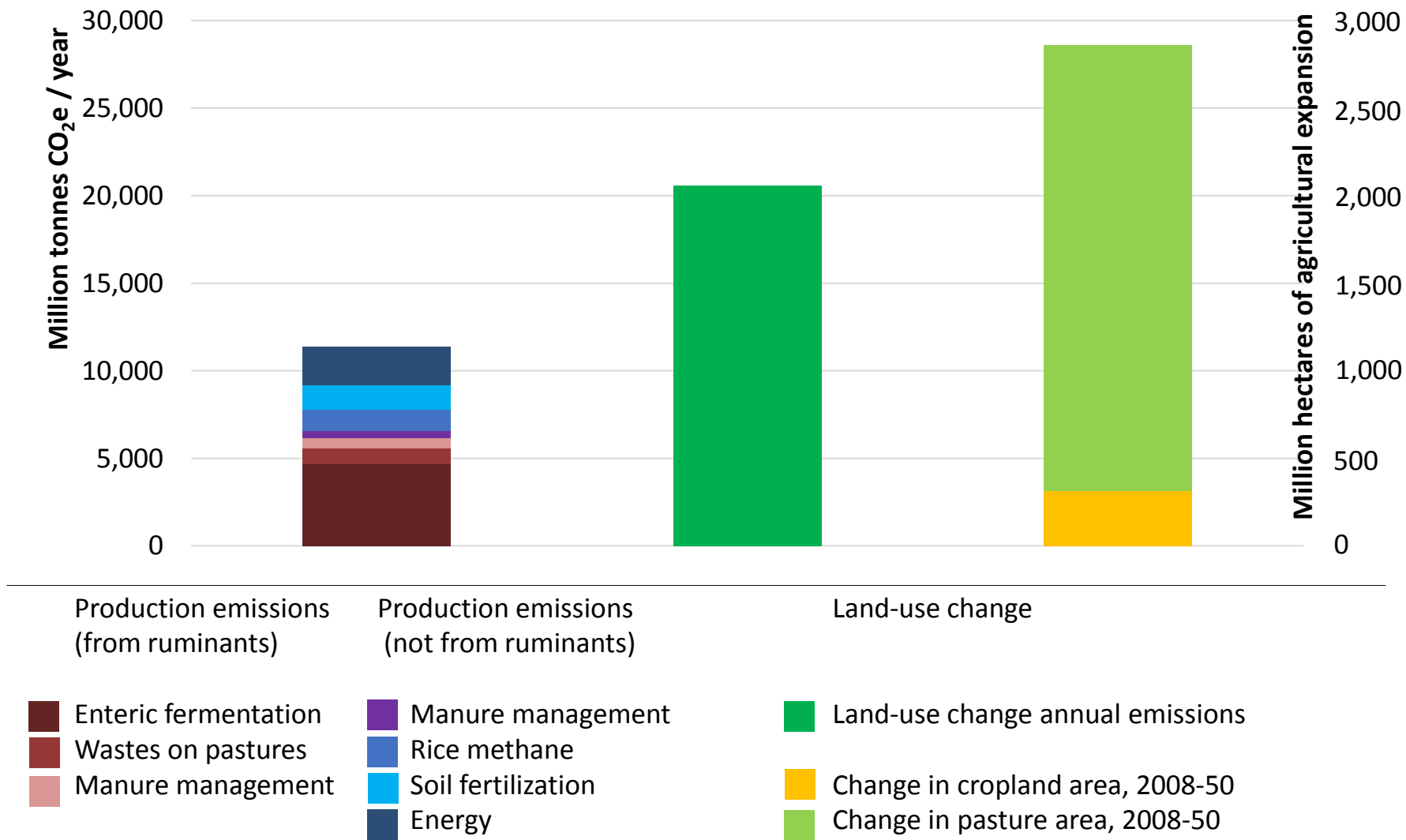


Figure S 47. GHG efficiency of bovine meat production (expressed in kg CO₂eq/g protein) in the year 2000

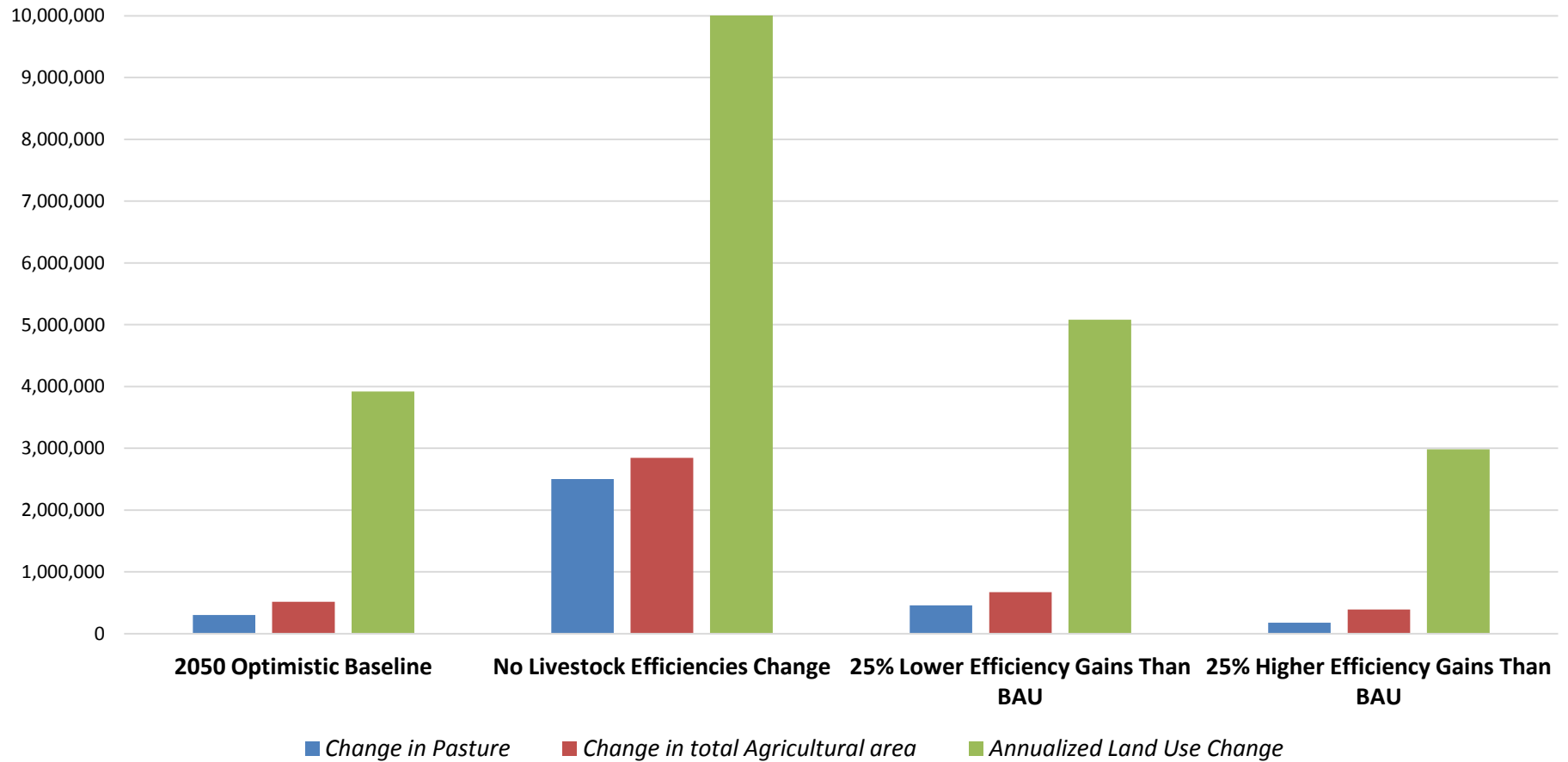
Herrero et al., PNAS (2013)

Importance of Productivity Gains: If livestock efficiencies remain unchanged between 2008 and 2050...

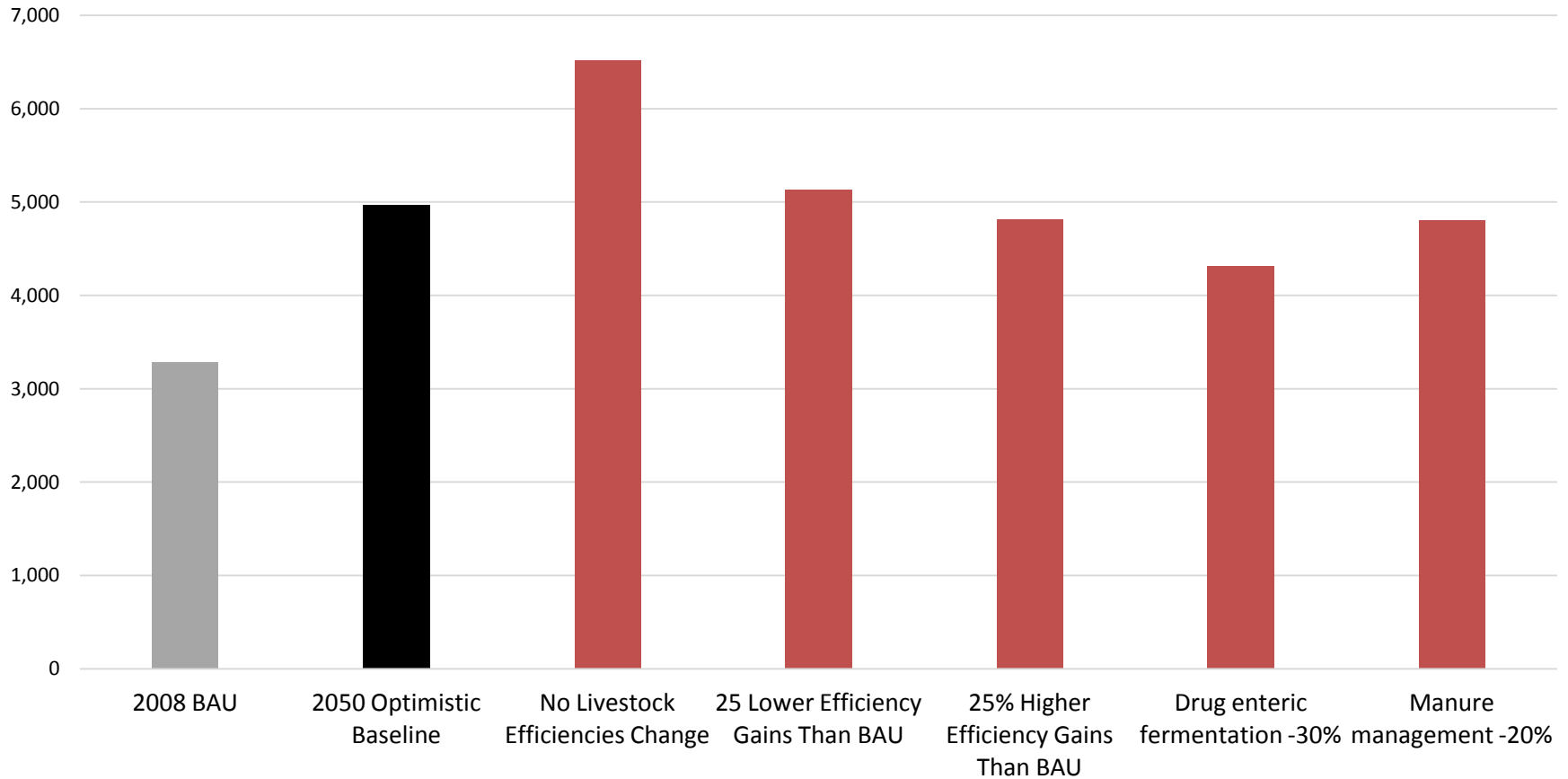


Source: GlobAgri model.

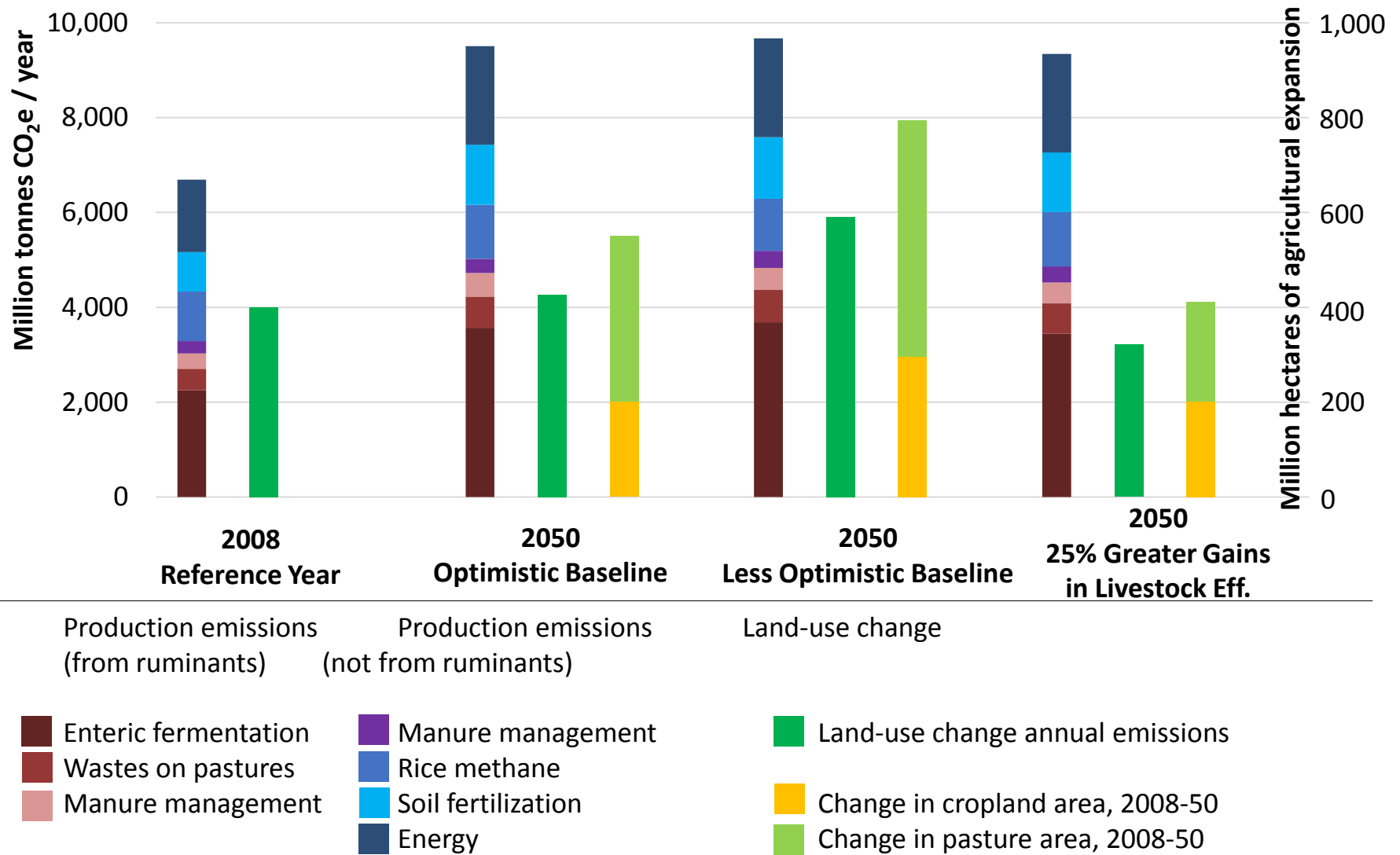
Land Use Change (thousand hectares)



Livestock Production Emissions (millions of tonnes CO₂e)



Comparing scenarios



Source: GlobAgri model.

Livestock Product Consumption and Particularly Beef Drive Both Agricultural Emissions and Land Use in Full Diets

Per capita values, 2009



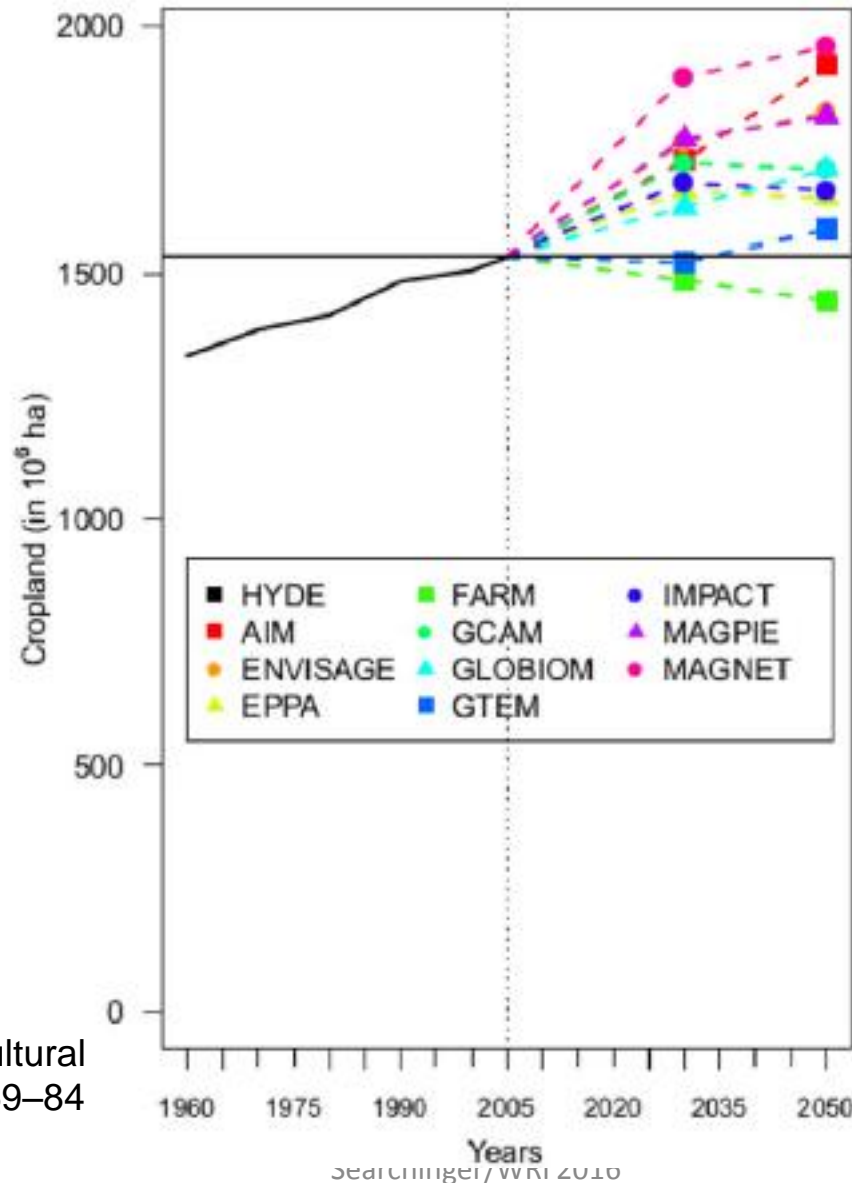
Source: GlobAgri model, based on FAOSTAT (2015) in WRI, Shifting Diets for a Sustainable Food Future, <http://www.wri.org/publication/shifting-diets>

Tasks for European Beef

- Steady, continued improvements in efficiency
- Feed additives or breeding to reduce enteric emissions
- Feed additives to improve nitrogen uptake by animals
- Nearly 100% digestion of wet manure
- Rapid
- Breeding forage with nitrification inhibitors

Other Cropland Area Predictions

Future Cropland
Projections –
Different Models



Also:

Bajzelj et. al., Nature CC
(2014)

Cropland + 660
Pasture + 430

Tilman et al. (2011)
~1 billion total additional
agricultural land

C. Schmitz et al. Agricultural
Economics 45 (2014) 69–84