Scenarios of improved agriculture efficiencies and diet modification consistent with representative concentration pathways (RCPs) of nitrous oxide

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Table 1-2. Global Greenhouse Gas (GHG) Emissions for 2000 ($MtCO_2eq$)

Sectors	CO_2[a]	CH_4	N_2O	High GWP	Global Total	Percentage of Global Total
Energy	23,408	1,646	237		25,291	61%
Agriculture	7,631	3,113	2,616		13,360	32%
Industry	829	6	155	380	1,370	3%
Waste		1,255	106		1,361	3%
Global Total	31,868	6,020	3,114	380	41,382	100%
Percentage of Global Total	77%	15%	8%	1%		

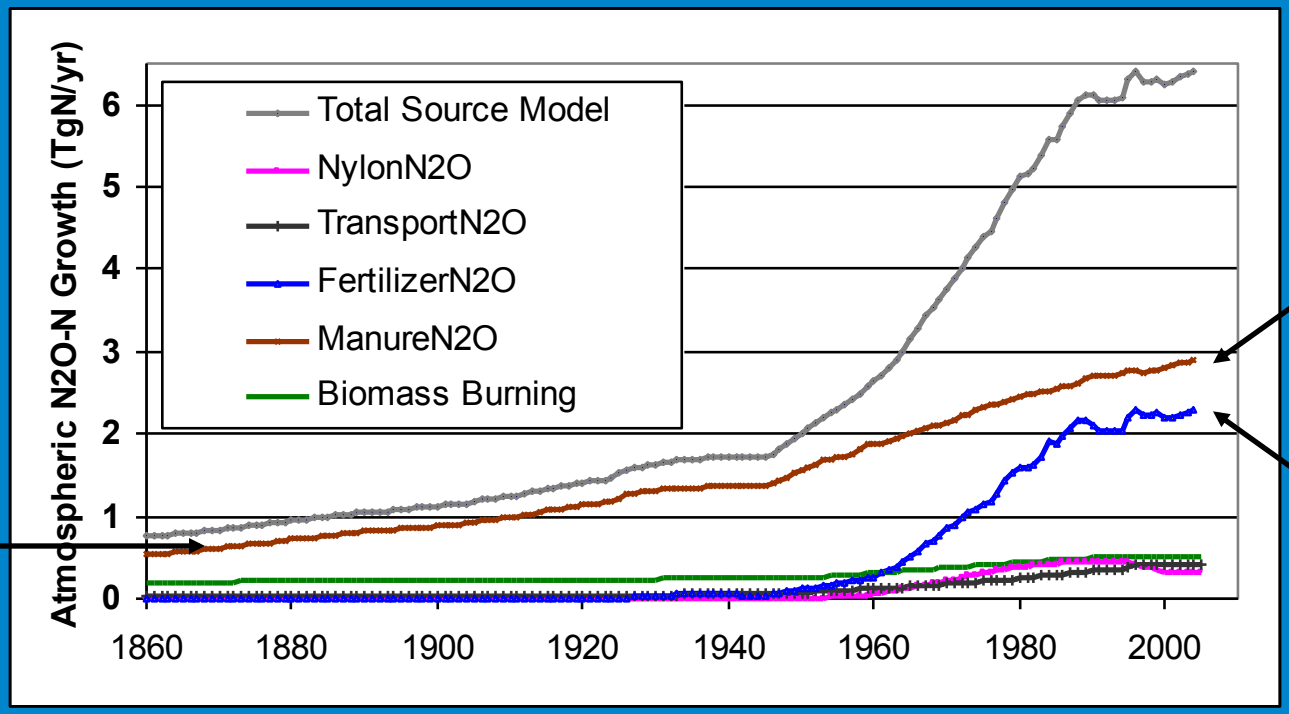
[a] Source: de la Chesnaye, F.C., et al., 2006

EPA. 2006. *Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2020.*

Anthropogenic Biological N_2O source = 0.0203*manure-N + 0.0254*fertilizer-N ($p < 0.0001$ for each coefficient; adjusted $R^2 = 0.98$)

These fractions include all N_2O emissions, direct and indirect, associated with use of fertilizer-N and manure, including the downwind and downstream emissions and consumption of the agricultural products.

Manure was the dominant source in the 19th century



Manure still dominates, but fertilizers are also important

Davidson. 2009. Nature Geoscience, 2:659-662.

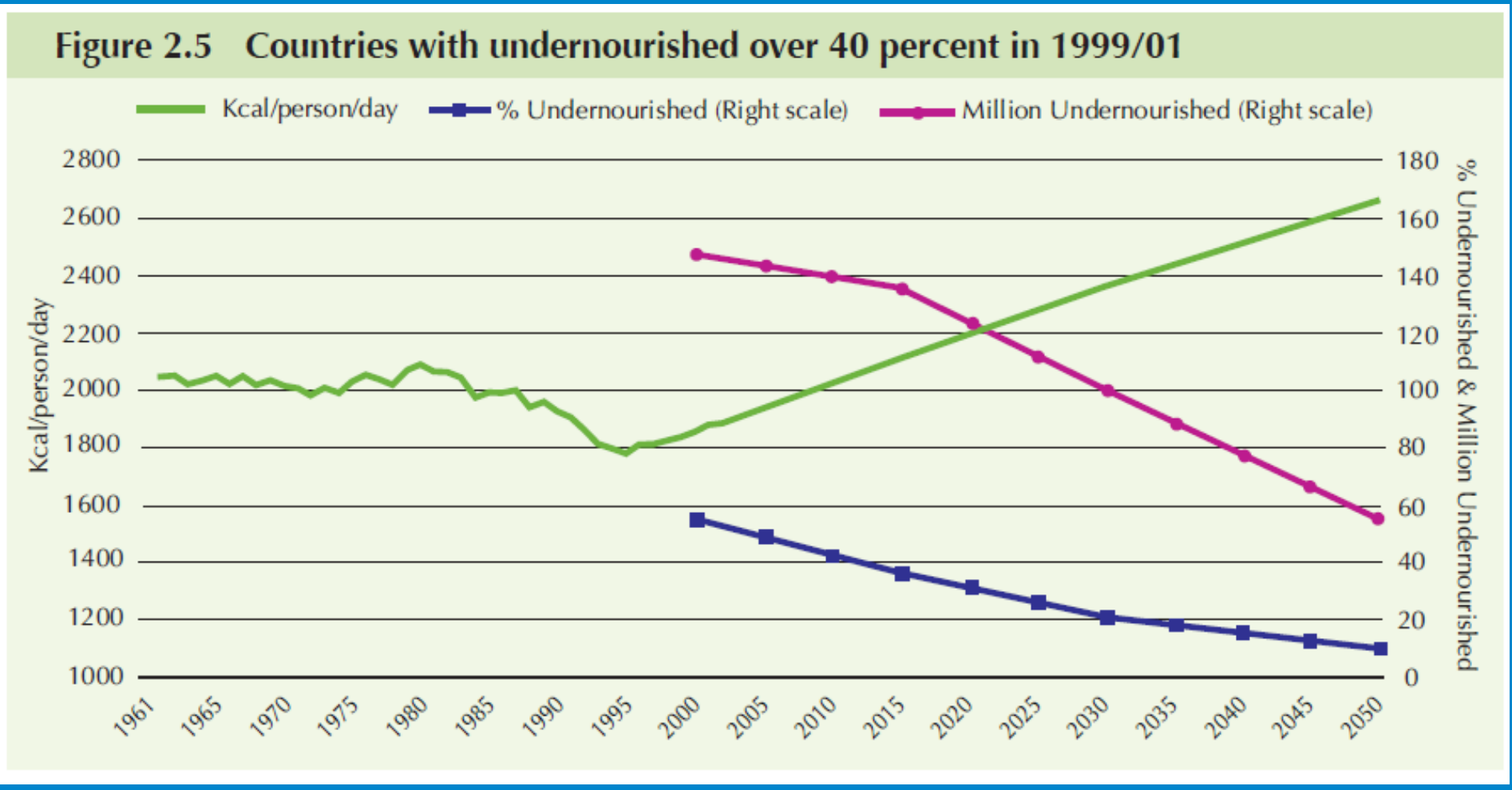
Predictions of future fertilizer-N use and manure-N production depend upon assumptions of:

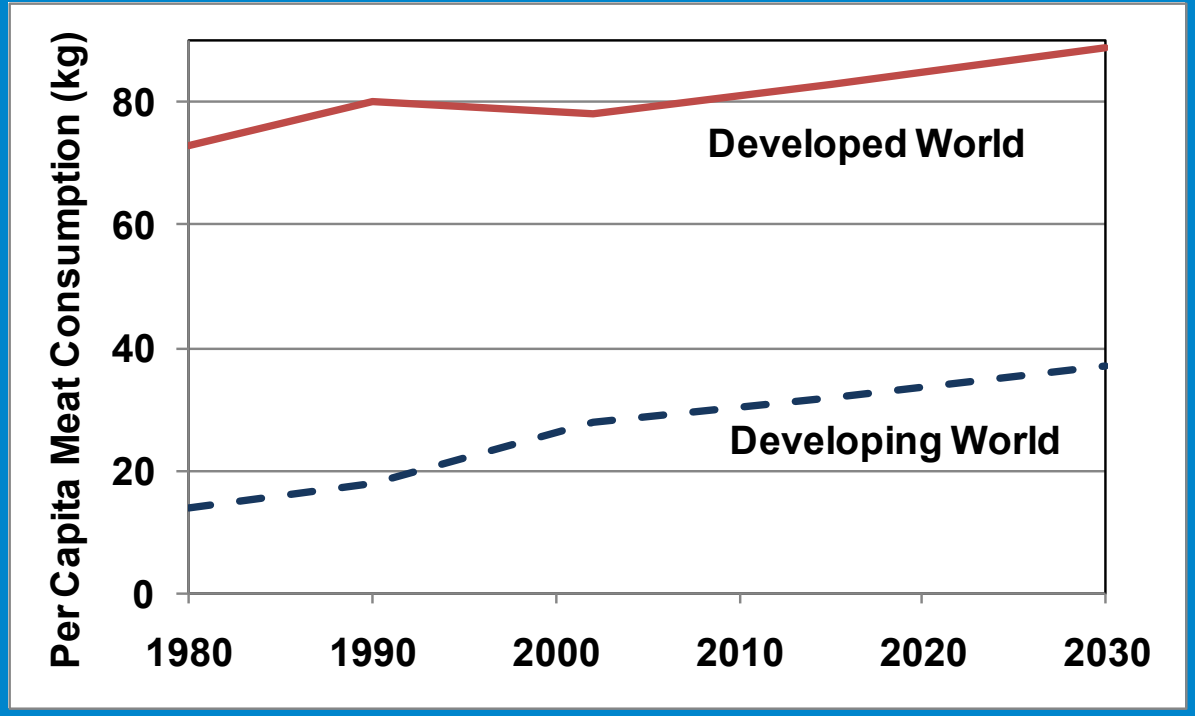
- **Population growth**
- **Diets**

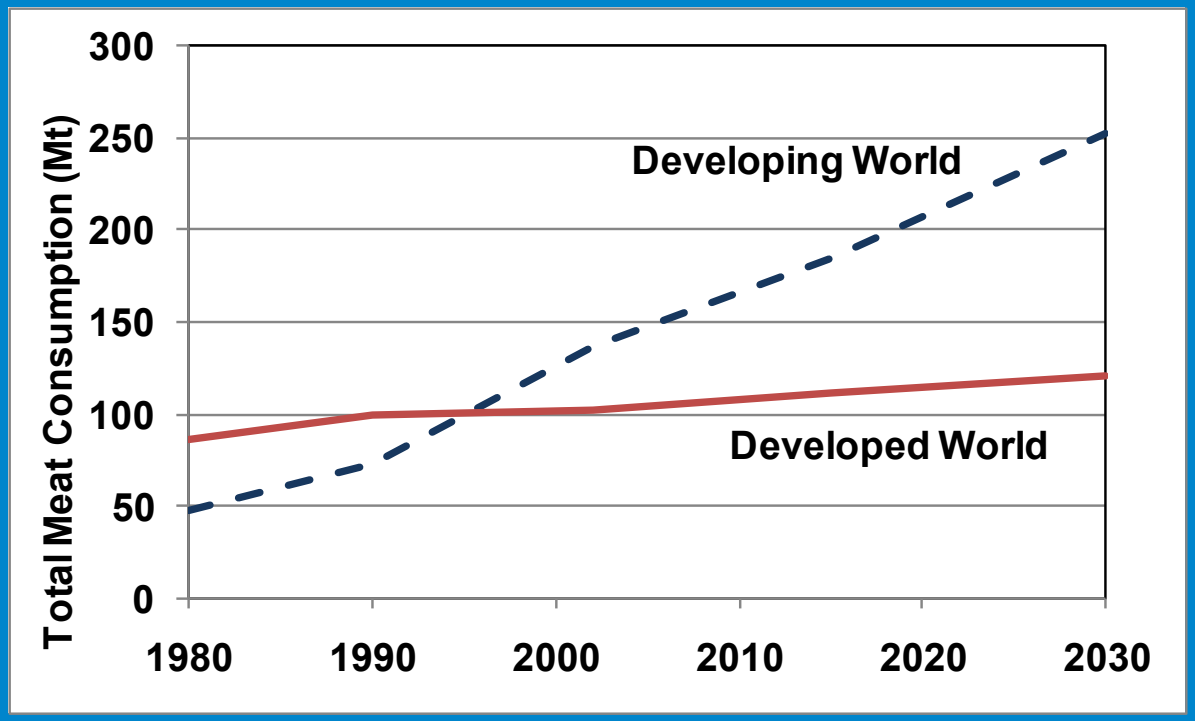
Predictions of future N_2O emissions from the agricultural sector depend upon assumptions of:

- **Fertilizer-N use, resulting from changes in**
  - **Food production demand**
  - **N-use efficiency**
- **Manure-N production, resulting from changes**
  - **Meat and dairy demand**
  - **N-use efficiency for animal production and manure management**

FAO. 2006. World agriculture: towards 2030/2050. Interim report. Prospects for food, nutrition, agriculture and major commodity groups.







FAO. 2006. Livestock's Long Shadow

Scenarios of N_2O production:

1. FAO population/diet scenarios with factors for N_2O emissions attributable to fertilizer-N (2.5%) and manure-N (2.0%), with no improvements in efficiencies.

2. Same as #1, but per-capita meat consumption in the developed world declines to 50% of 1980 levels by 2030, thus reducing manure-N production and fertilizer-N use by about 21%.

3. Same as #1, but improvements in N-use efficiency and manure management reduce the emission factors by 50% by 2050.

4. Same as #3, but industrial and transportation emissions of are similarly reduced by 50% by 2050.

5. Scenarios 2 (less meat) and 4 (all sector efficiencies) combined.

6. RCP3PD (Representative Concentration Pathways; 2100 Radiative Forcing ($W\ m^{-2}$).

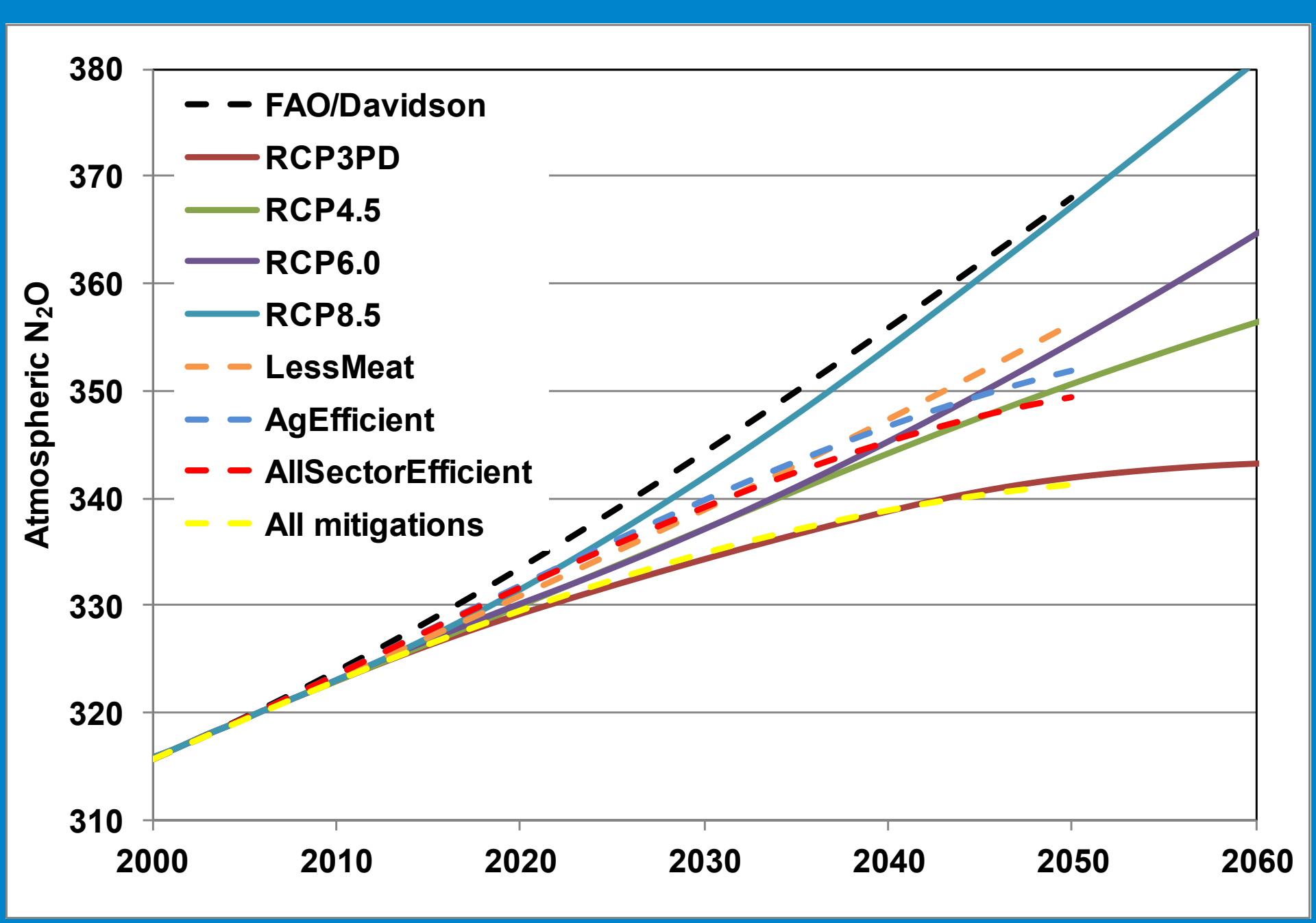
7. RCP4.5

8. RCP6.0

9. RCP8.5

These ***concentration pathways*** are not THE final, new, fully integrated scenarios, but instead are representative of internally consistent sets of projections of the components of radiative forcing that are used in subsequent phases. Van Vuuren et al. Climatic Change (2011) 109:5–31.

Davidson. 2012. Environmental Research Letters, in press.



Davidson. 2012. Environmental Research Letters, in press.

Conclusions

- Significantly reducing N_2O emissions while also improving the diets of the growing global human population will be very challenging.
- RCP8.5 is a reasonable representation of N_2O concentrations with growing agricultural production to feed a growing and better nourished population, without major new improvements in agricultural efficiencies.
- The RCP6.0 trajectory might be achievable if major improvements in agricultural efficiencies on the order of 50% are realized or if the developed world cuts per capita meet consumption by about 50% from 1980 levels.
- The RCP4.5 trajectory might be achievable if, in addition to the agricultural/diet efficiencies needed for RCP6.0, transportation, energy, and industrial sectors also decrease their emissions by about 50%.
- RCP 3PD for stabilizing atmospheric N_2O concentrations by 2050 is achievable only if all efficiencies – agricultural emissions, diet modification, and other sector emission reductions – are adopted together.