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Will sustainable intensification help us avoid exceeding 2 °C?

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Sustainable intensification is the current paradigm for agricultural development

RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

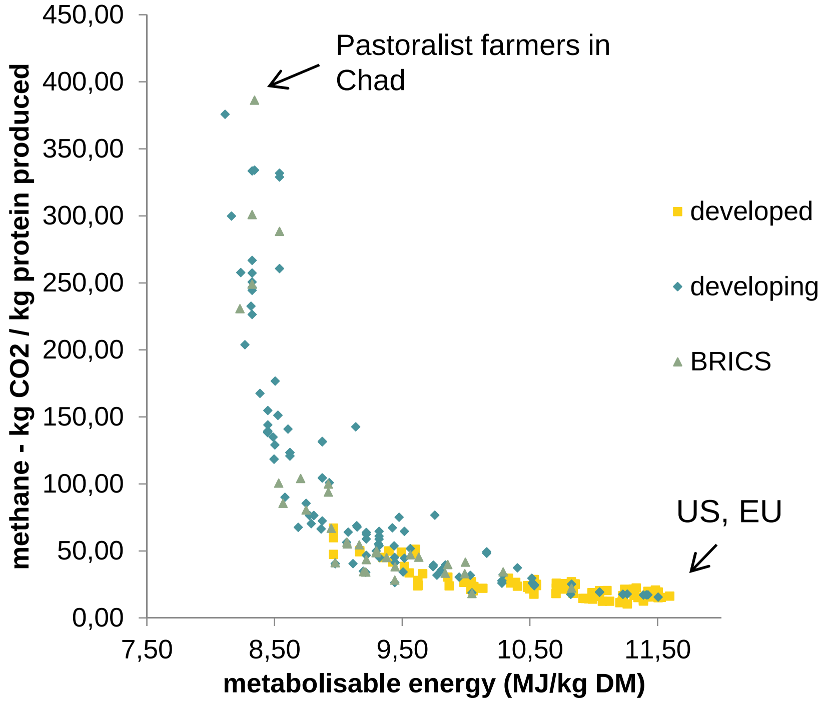
CLIMATE-SMART Agriculture 2015

Claims to mitigation: increase GHG emissions efficiency and sparing of high C ecosystems

Livestock productivity, feed

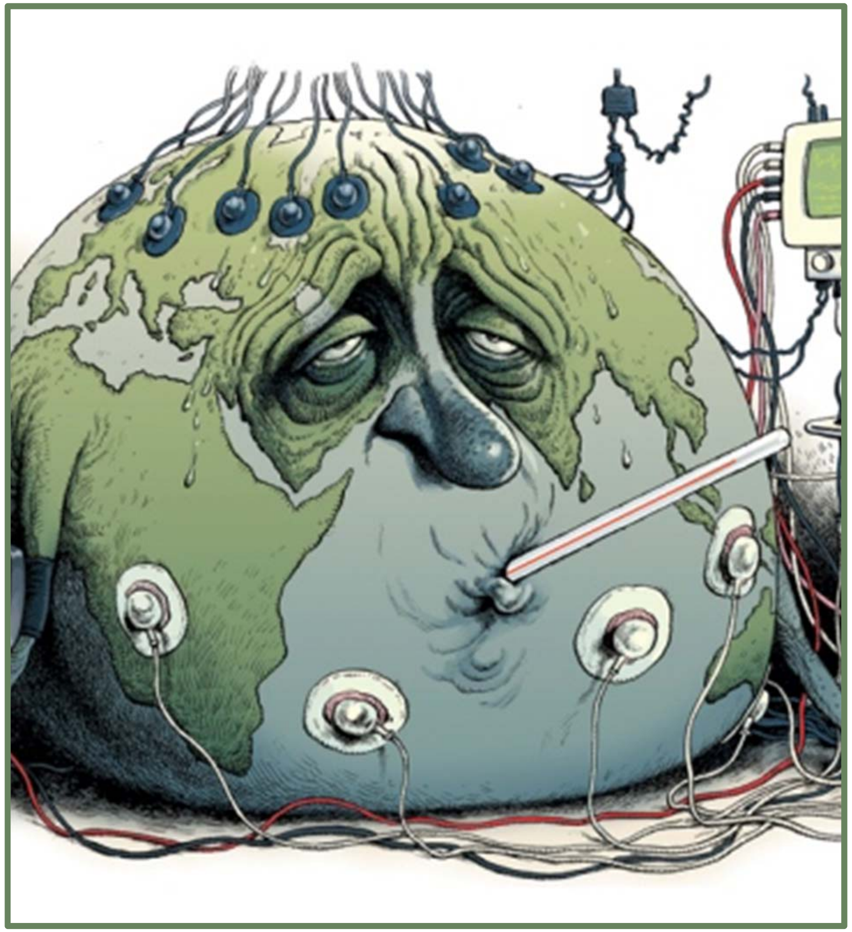
Efficient N fertilizer use

Residue mgmt.



Herrero et al. 2013, PNAS

Can intensification also help meet hard climate goals?



Meet future food needs and achieve climate policy targets in agriculture such as 2 °C?

- Reduce the GHG emissions of production
- Avoid conversion of carbon-rich forests, grasslands and peatlands

Agricultural baseline to 2050

FAO global perspective studies (Alexandratos and Bruinsma 2012)
146 countries, 34 crops

9-10 billion people, ⇧income, diet

60% more food

Intensified & expanded agriculture

CH_4 & N_2O emissions

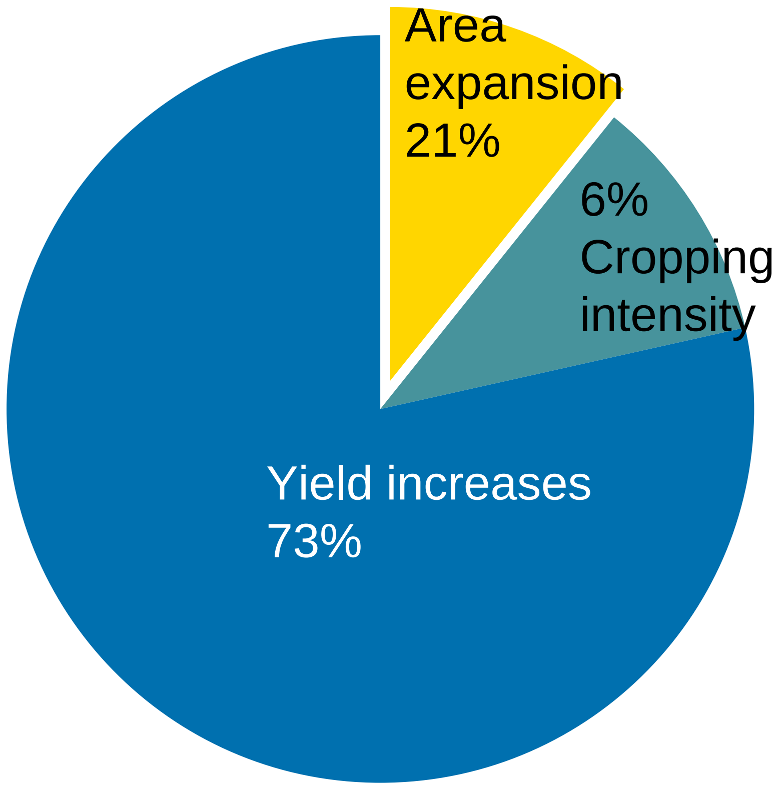
Land use change and CO_2

90% of increase in annual production in developing countries, esp. from livestock

Expected sources of growth in crop production (%) 2005/7 to 2050

	Arable land expansion	Increases in cropping intensity	Yield increases
Developing countries	21	6	73
World	10	10	80

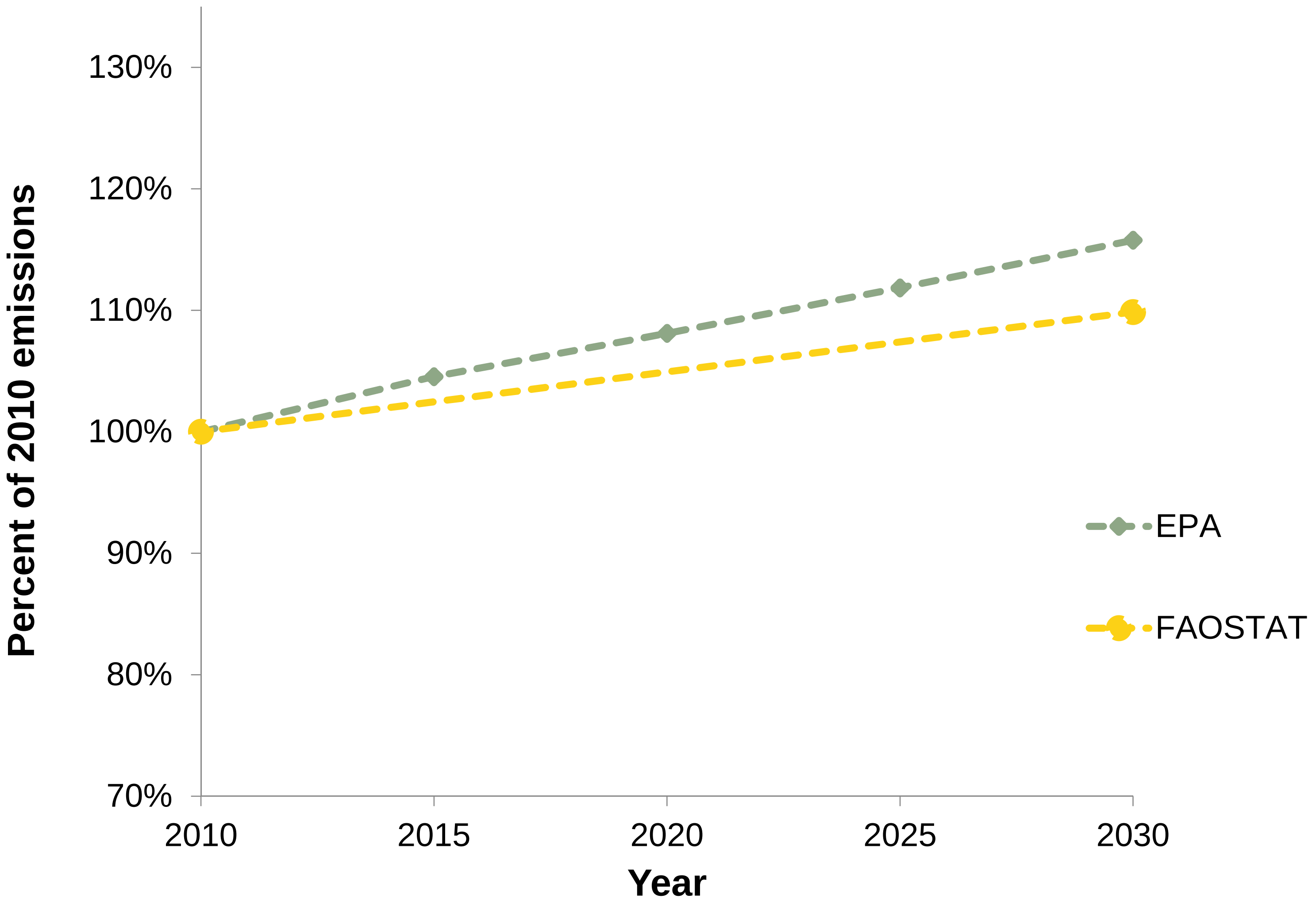
Adapted from Bruinsma 2009 FAO



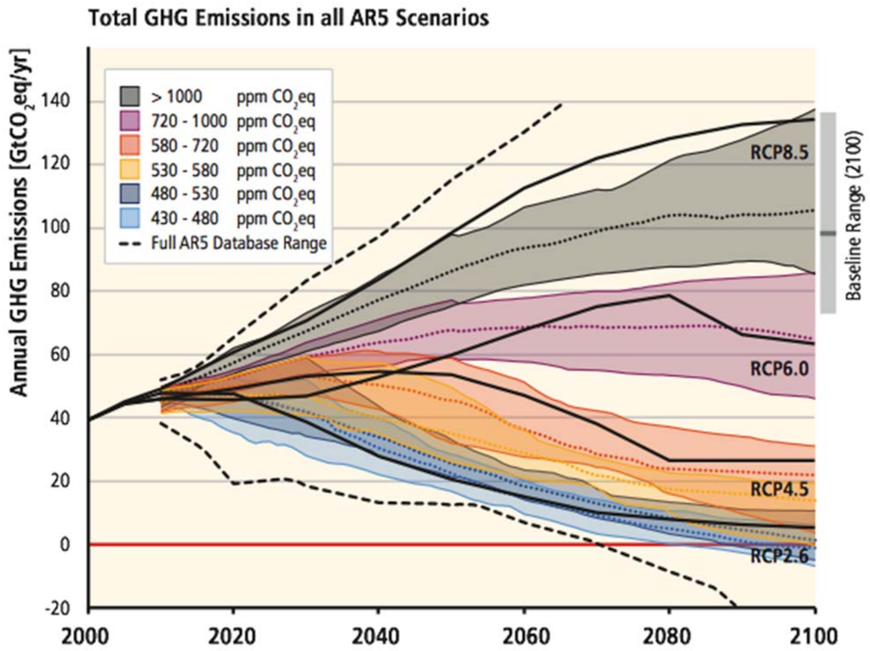
Developing countries

Scenario of intensification

Projected emissions for the FAO agriculture baseline



Calculating emissions for a 2°C aspirational target

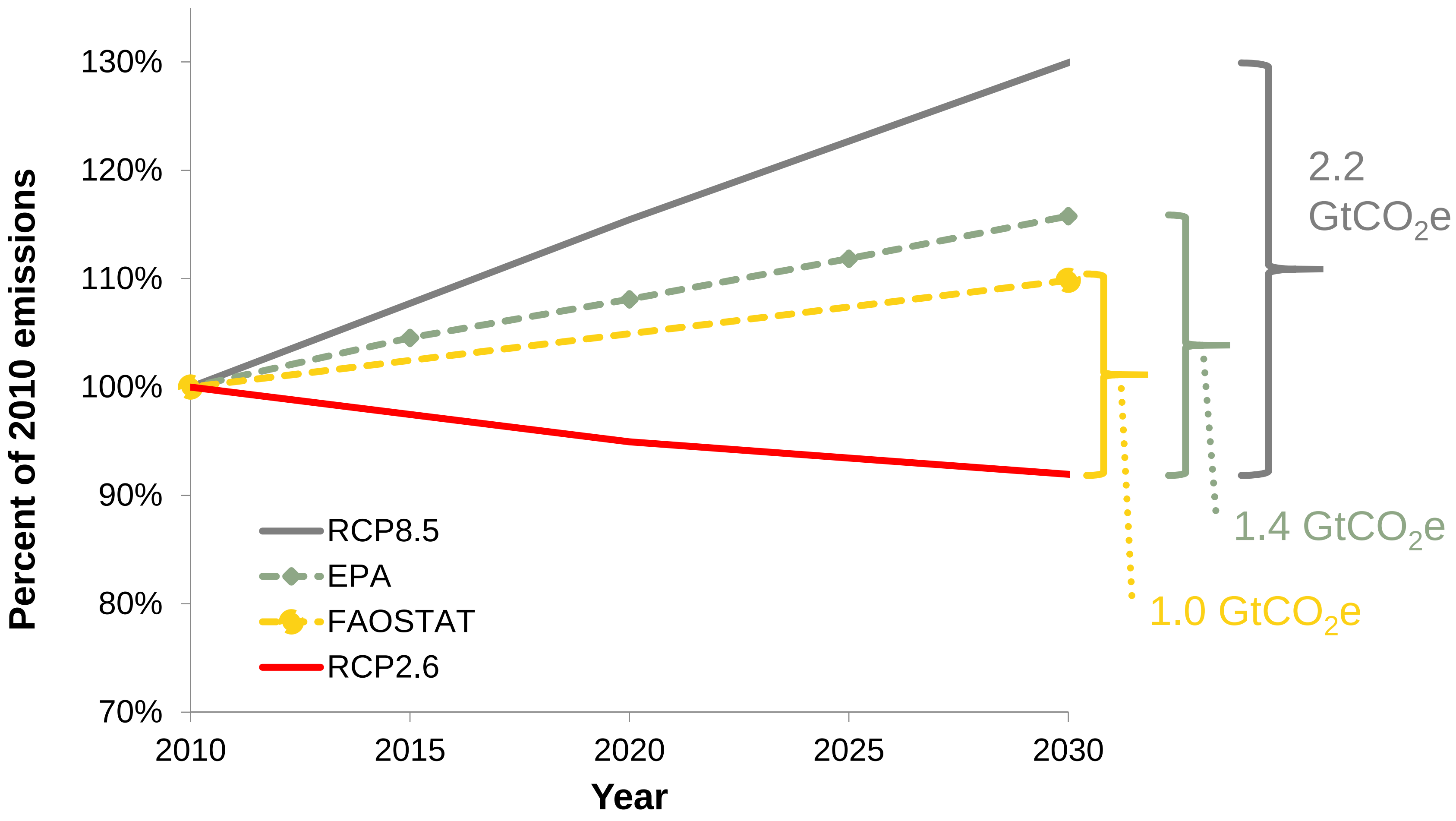


2030 emissions reflect assumptions of each pathway

RCP Scenarios:

- RCP2.6 represents 2.6 W/m^2 radiative forcing in 2100, ~450 ppm CO_2e
- Limits warming to 0.3 to 1.7 °C during 2081 - 2100
- Contrast to the RCP 8.5, representing 8.5 W/m^2 , 1370 ppm CO_2e, ~4.9 °C

Target emissions compared against baselines: Mitigation needed in 2030



I. Business-as-usual intensification will not achieve the mitigation needed in the agriculture sector by 2030

How much can mitigation practices contribute to the 2 °C policy target?





Selected mitigation practices compatible with food production

- Cropland management
- Grazing land management
- Livestock

Not

- Rewetting peatlands
- Cropland set aside

IPCC AR5 Table 11.2

Categories	Practices and Impacts	Technical Mitigation Potential	Ease of Implementation	Timescale for implementation
	Land-based agriculture			
Cropland management				
Croplands—plant management	**C**: High input carbon practices, e.g., improved crop varieties, crop rotation, use of cover crops, perennial cropping systems, agricultural biotechnology.			
	N_2O: Improved N use efficiency.			
Croplands—nutrient management	**C**: Fertilizer input to increase yields and residue inputs (especially important in low-yielding agriculture).			
	N_2O: Changing N fertilizer application rate, fertilizer type, timing, precision application, inhibitors.			
Croplands—tillage/residues management	**C**: Reduced tillage intensity; residue retention.			
	N_2O:			
	CH_4:			
Croplands—water management	**C**: Improved water availability in cropland including water harvesting and application.			
	CH_4: Decomposition of plant residues.			
	N_2O: Drainage management to reduce emissions, reduce N runoff leaching.			
Croplands—rice management	**C**: Straw retention.			
	CH_4: Water management, mid-season paddy drainage.			
	N_2O: Water management, N fertilizer application rate, fertilizer type, timing, precision application.			
Grazing Land Management				
Grazing lands—plant management	**C**: Improved grass varieties/sward composition, e.g., deep rooting grasses, increased productivity, and nutrient management. Appropriate stocking densities, carrying capacity, fodder banks, and improved grazing management.			
	N_2O			
Grazing lands—animal management	**C**: Appropriate stocking densities, carrying capacity management, fodder banks and improved grazing management, fodder production, and fodder diversification.			
	CH_4			
	N_2O: Stocking density, animal waste management.			
Grazing land—fire management	**C**: Improved use of fire for sustainable grassland management. Fire prevention and improved prescribed burning.			
	Livestock			
Livestock—feeding	**CH_4**: Improved feed and dietary additives to reduce emissions from enteric fermentation; including improved forage, dietary additives (bioactive compounds, fats), ionophores/antibiotics, propionate enhancers, archaea inhibitors, nitrate and sulphate supplements.			
Livestock—breeding and other long-term management	**CH_4**: Improved breeds with higher productivity (so lower emissions per unit of product) or with reduced emissions from enteric fermentation; microbial technology such as archaeal vaccines, methanotrophs, acetogens, defaunation of the rumen, bacteriophages and probiotics; improved fertility.			
Manure management	**CH_4**: Manipulate bedding and storage conditions, anaerobic digesters; biofilters, dietary additives.			
	N_2O: Manipulate livestock diets to reduce N excreta, soil applied and animal fed nitrification inhibitors, urease inhibitors, fertilizer type, rate and timing, manipulate manure application practices, grazing management.			

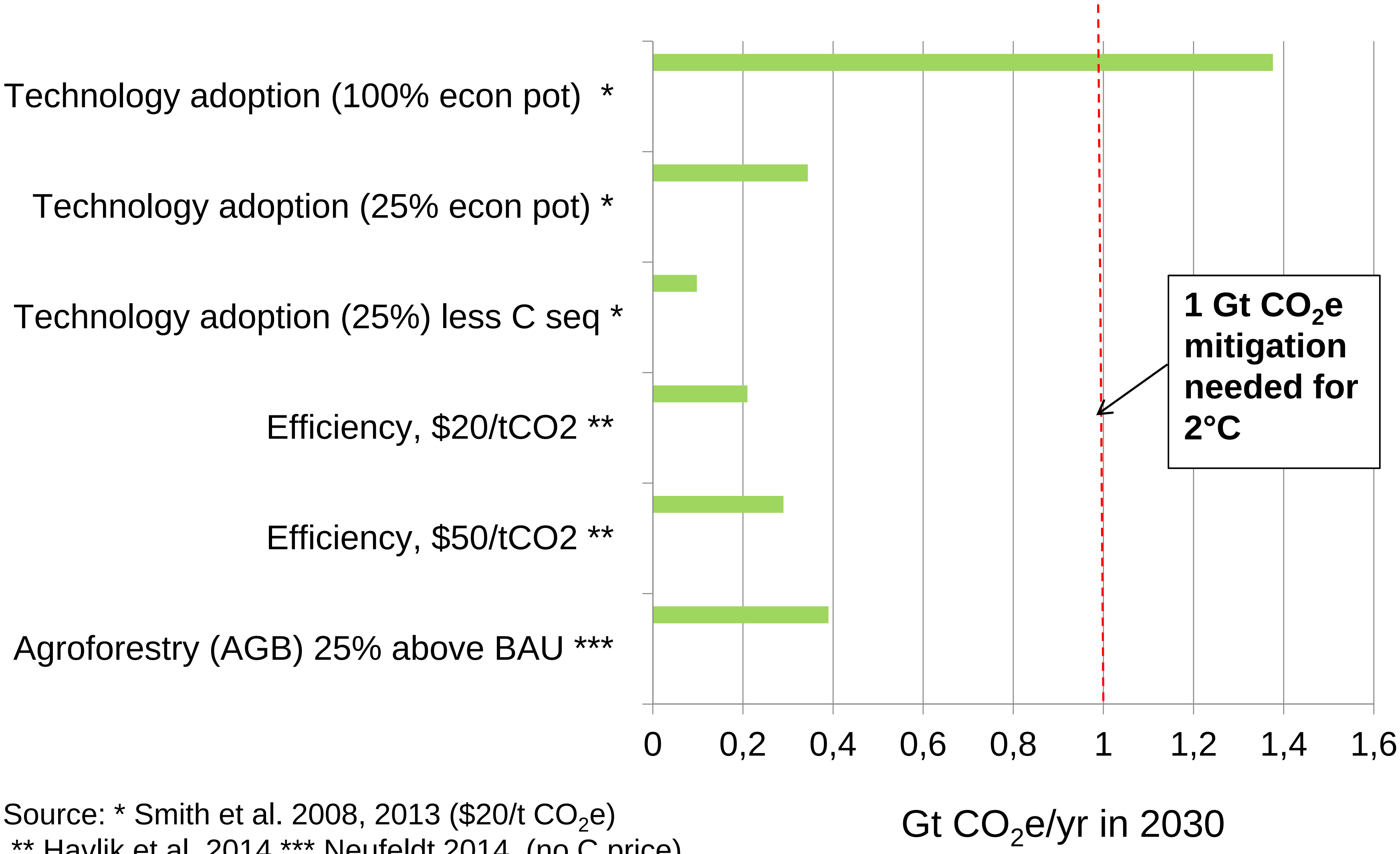
Calculated mitigation with global data sets

1. Bottom-up technology-by-technology estimates (Smith 2007, 2008, University of Aberdeen, IPCC) \$20 tCO_2

2. Production efficiency gains (trade and location, production system) using integrated assessment modeling (Havlík 2014, IIASA) \$20, \$50 tCO_2

3. Bottom-up agroforestry (Neufeldt 2014, ICRAF)

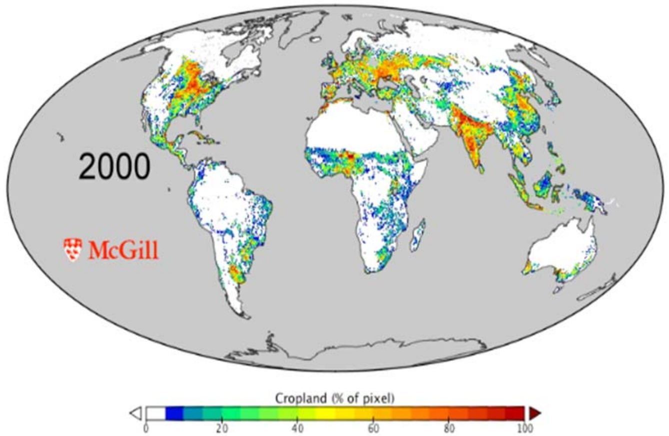
How close to the 2°C goal can we get?



Source: * Smith et al. 2008, 2013 ($20/t CO_2e)
** Havlik et al. 2014 *** Neufeldt 2014 (no C price)

II. Plausible interventions will achieve only 10-40% of mitigation needed in agriculture by 2030

Will future food needs and intensification increase deforestation?



In theory, plenty of land:

~81-147 Mha cropland needed by 2030
~445-598 Mha will be available

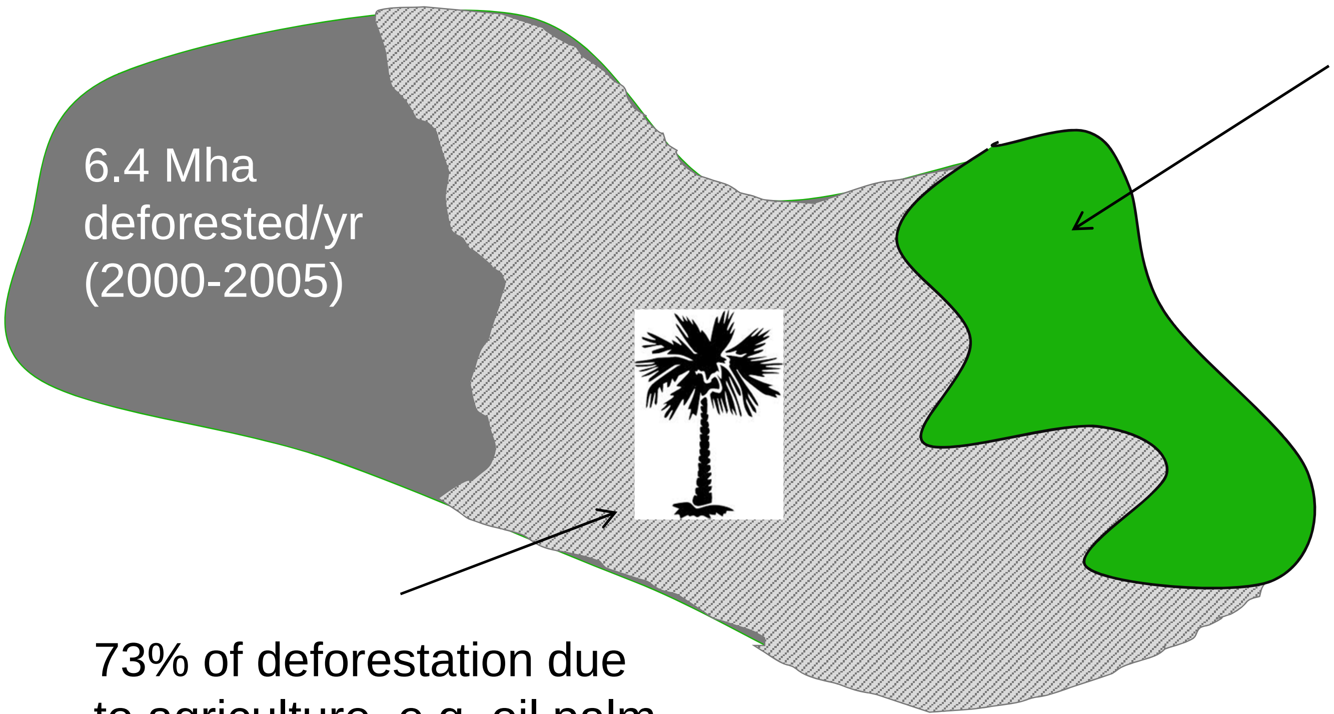
But global "cropland availability" is no guarantee of local availability or avoided deforestation

Location matters and trade-offs already occur:

- Remaining land mostly: Brazil, Argentina, DRC, Mozambique, Russia
- Agriculture is already a primary driver of deforestation
- Environmental governance needed

Meeting climate targets therefore requires location-specific interventions

3.69 billion ha forest globally in 2005

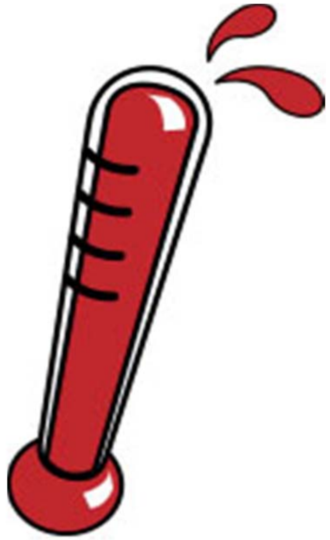


Avoiding 25% of forest emissions (1.08 Gt CO_2e/yr) due to agriculture would require conserving ~1.2 Mha/yr globally **in threatened forest areas**

73% of deforestation due to agriculture, e.g. oil palm
(Hosonuma 2012)
~4.7 Mha/yr
~ 4.32 Gt CO_2e/yr

III. Significant mitigation can be achieved by reducing conversion of forest to agriculture, but requires location-specific interventions

Conclusion



- Preliminary calculations indicate an aspirational sectoral target of ~1 $GtCO_2e/y$. by 2030.
- Business-as-usual and low emissions intensification won’t be enough to meet this goal.
- Massive innovation and scale needed

Is more radical mitigation possible?

- Build on current options: combinations of strategies, more efficient structural changes in production, more effective governance of forests

- Invest in promising innovations: e.g., biomass carbon capture & sequestration, reduced-methane ruminants, crops with biological nitrification inhibitors

- Explore mitigation from dietary shifts and reducing waste