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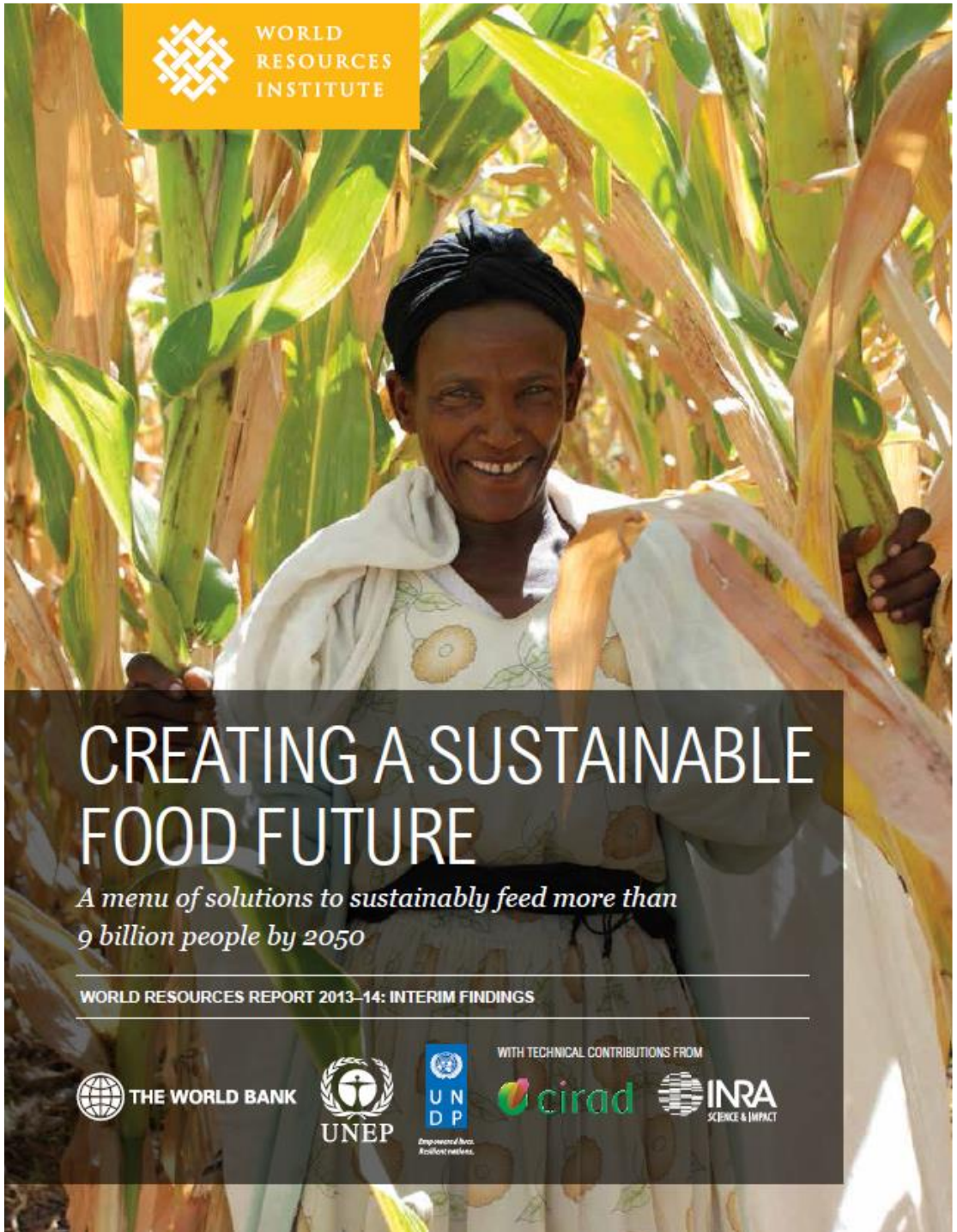


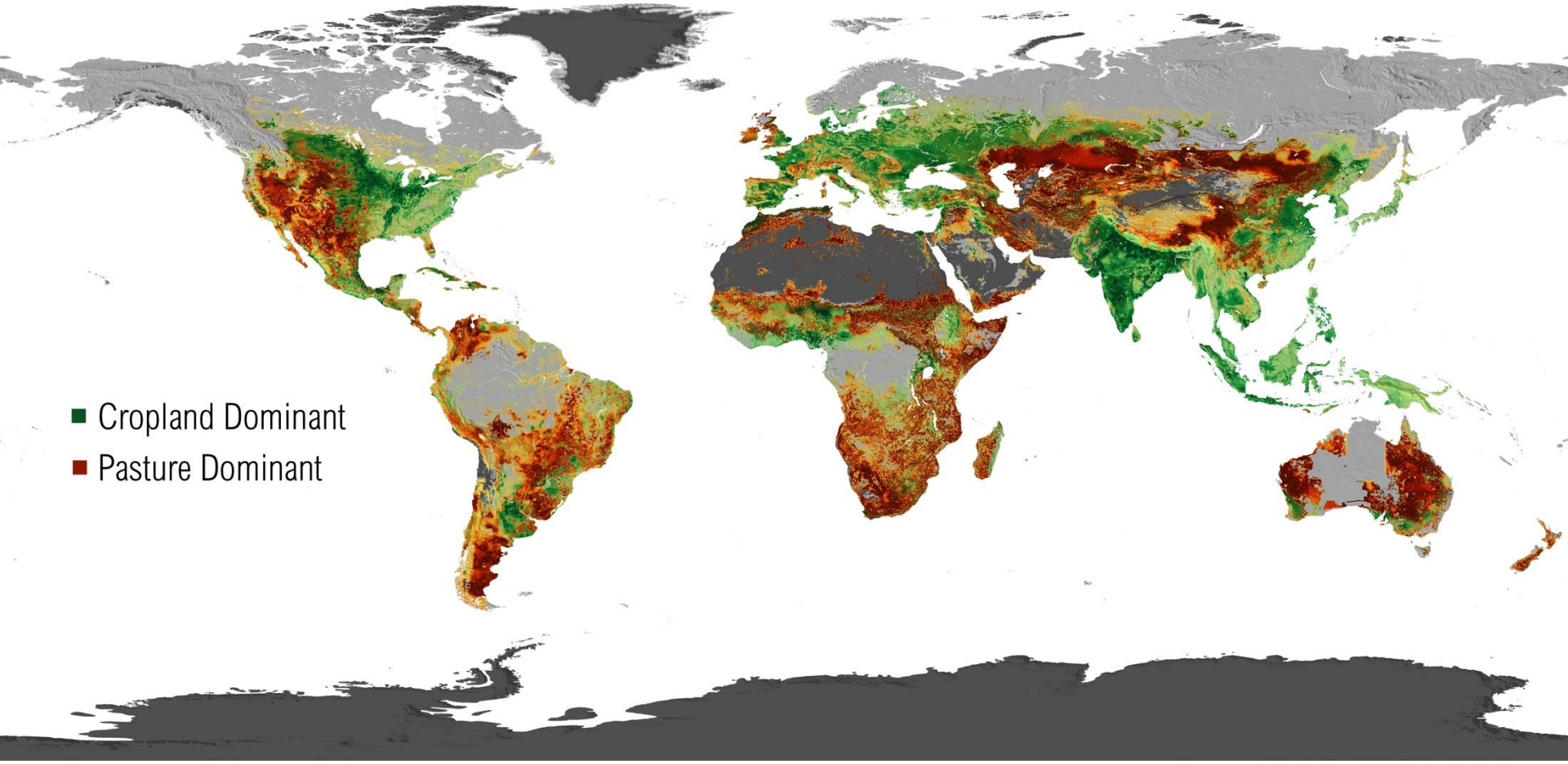
~10 to 12% of world chronically malnourished

1/3 of children in developing world stunted

5 million children die annually from causes related to lack of nutrition

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:1010.1029/2007GB002952. Map: Navin Ramankutty, Dept. of Geography, McGill University.

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

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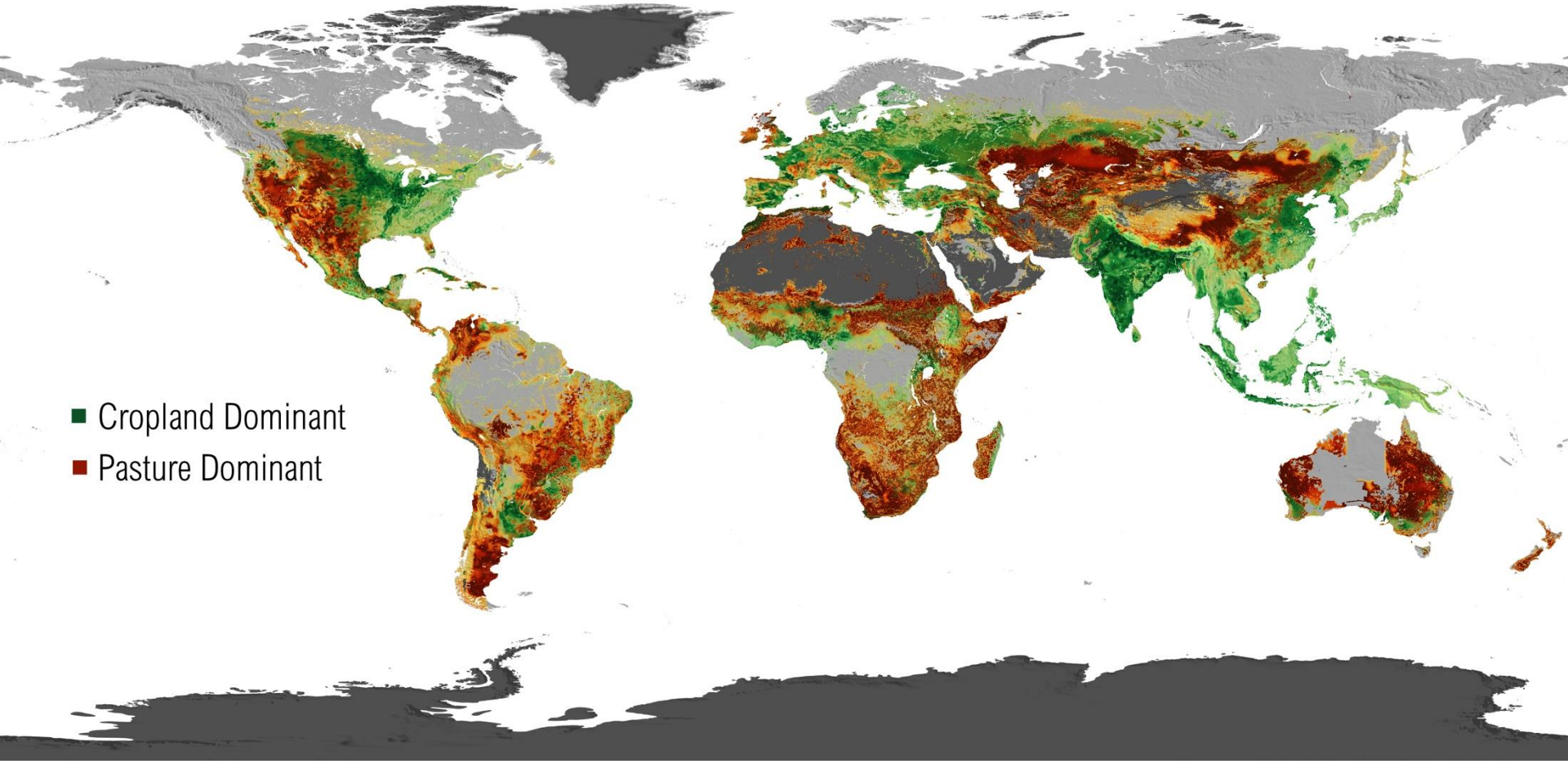

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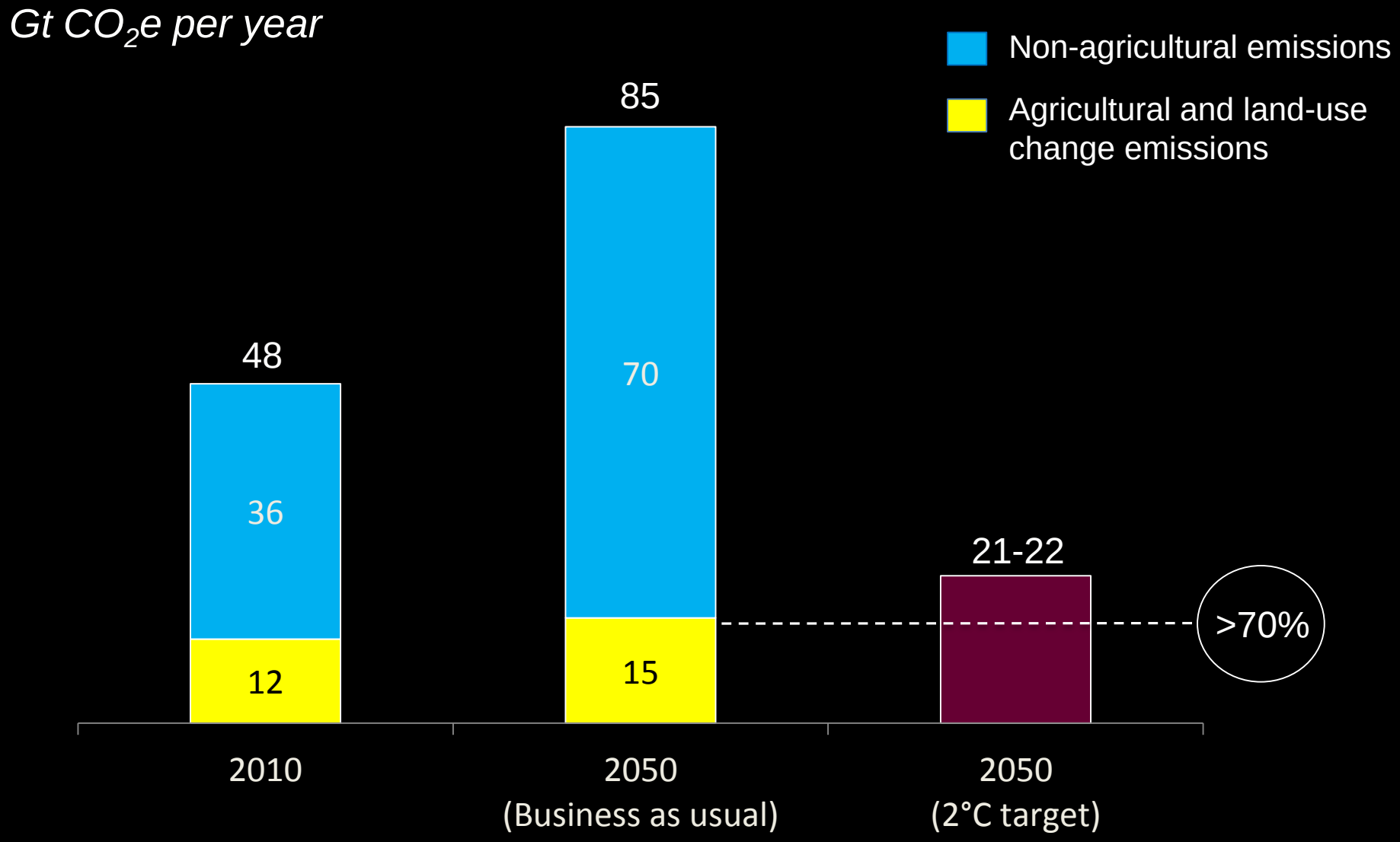
Figure 25. "Business as usual" (BAU) agriculture emissions would comprise >70% of allowable emissions to achieve a 2°C world



Sources: WRI analysis based on IEA 2012, EIA 2012, EPA 2012, Houghton 2008, and OECD 2012.

A menu of solutions is required to sustainably close the food gap

Global annual crop production (kcal trillion)*

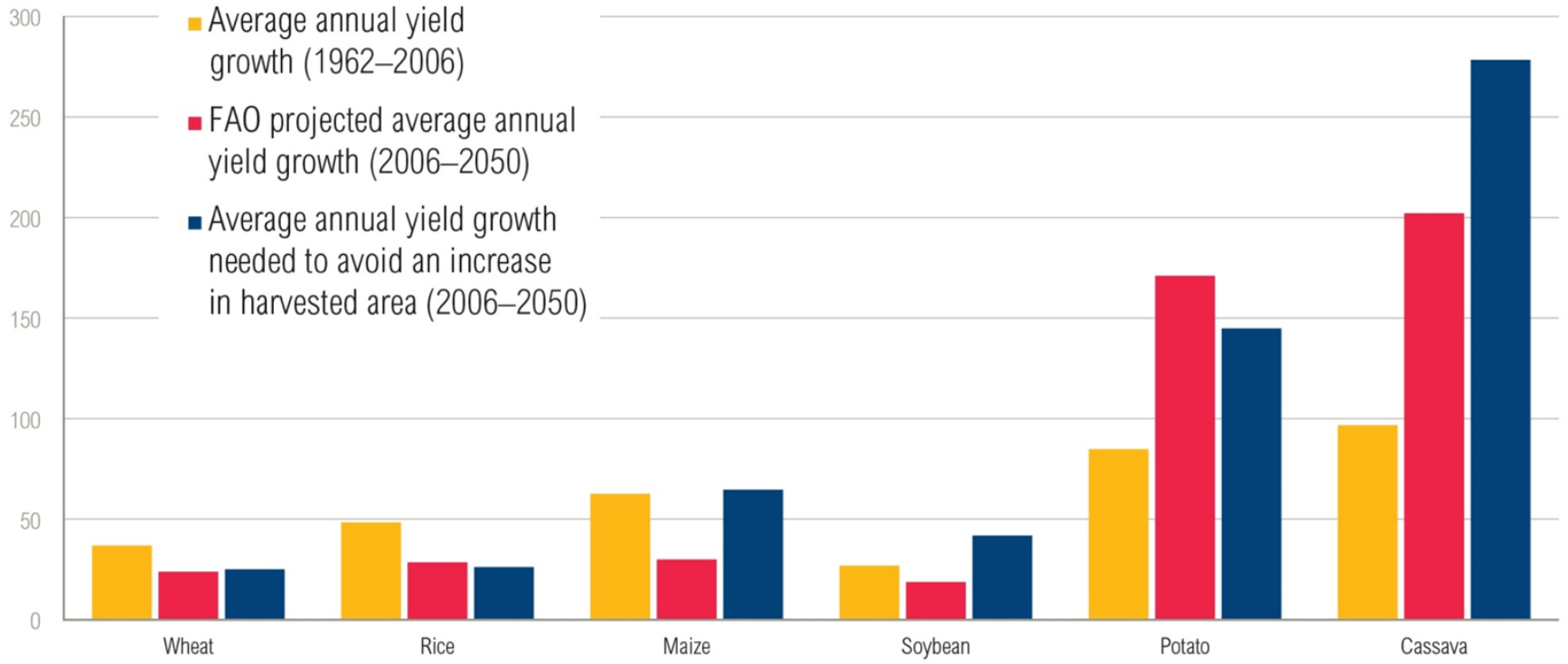
Illustrative

* Includes all crops intended for direct human consumption, animal feed, industrial uses, seeds, and biofuels

Source: WRI analysis based on Bruinsma, J. 2009. *The Resource Outlook to 2050: By how much do land, water and crop yields need to increase by 2050?* Rome: FAO; Alexandratos, N., and J. Bruinsma. 2012. *World agriculture towards 2030/2050: The 2012 revision.* Rome: FAO.

Future yields overall will need to grow faster than historical rates to prevent new land conversion

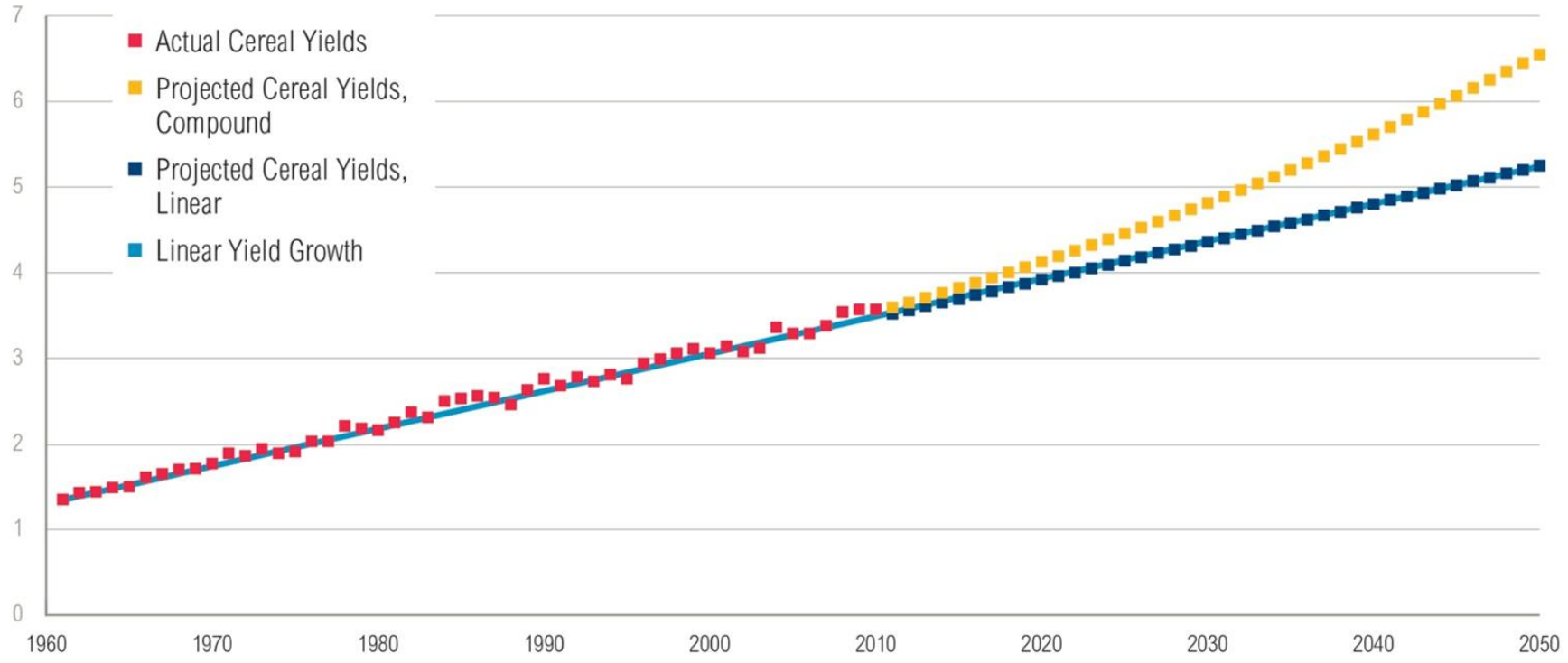
Kg/ha/year



Source: Alexandratos, N., and J. Bruinsma. 2012. *World agriculture towards 2030/2050: The 2012 revision.* Rome: FAO; ACE and WRI analysis.

Compound growth and absolute growth produce varying estimates of future cereal yields

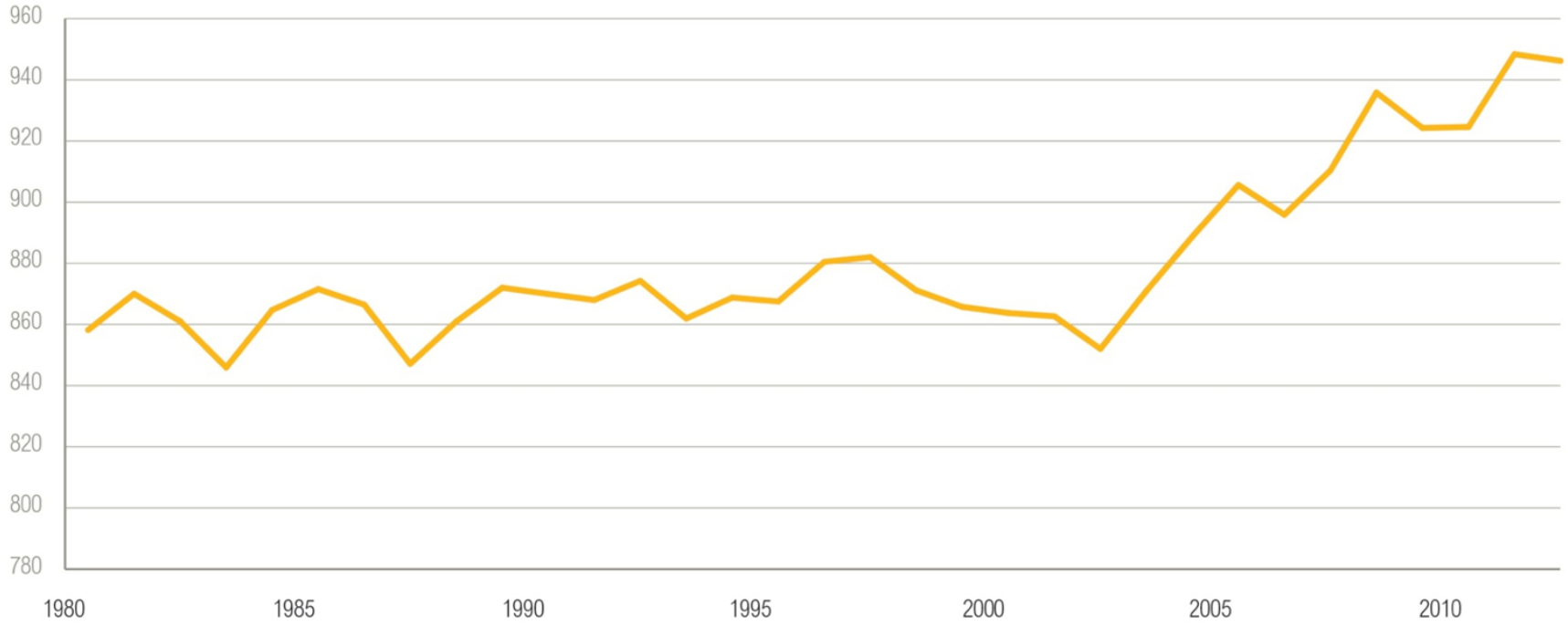
Tons/ha/year



Source: WRI analysis based on FAO. 2012. "FAOSTAT." Rome: FAO.

Harvested area for 15 major crops has expanded by almost 100 million hectares in the last ten years

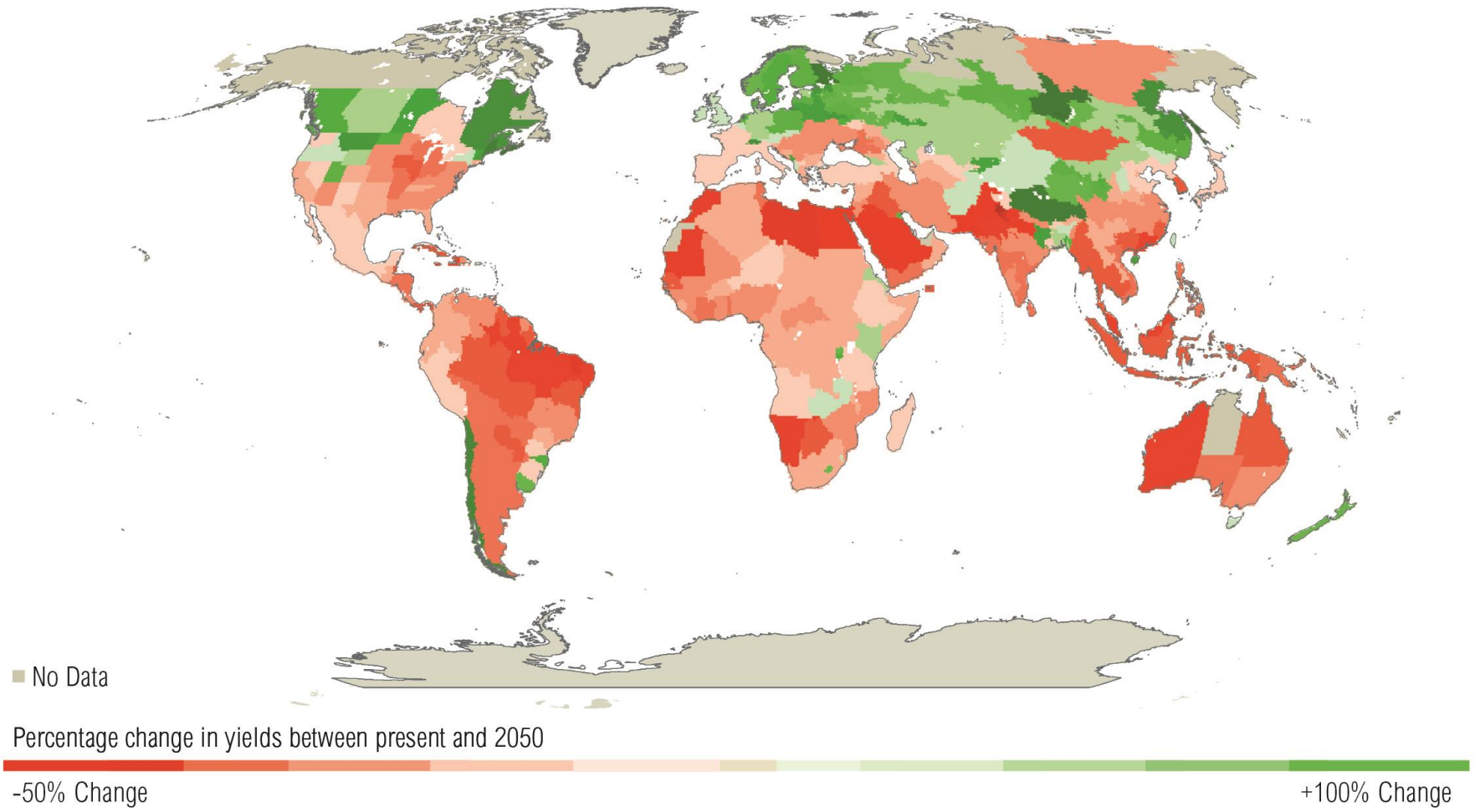
Million hectares



Source: WRI analysis based on FAO. 2012. “FAOSTAT.” Rome: FAO.

Most studies now project adverse impacts on crop yields due to climate change

3° C warmer world



Source: World Bank. 2010. *World Development Report 2010: Development and Climate Change.* Washington, DC: World Bank.

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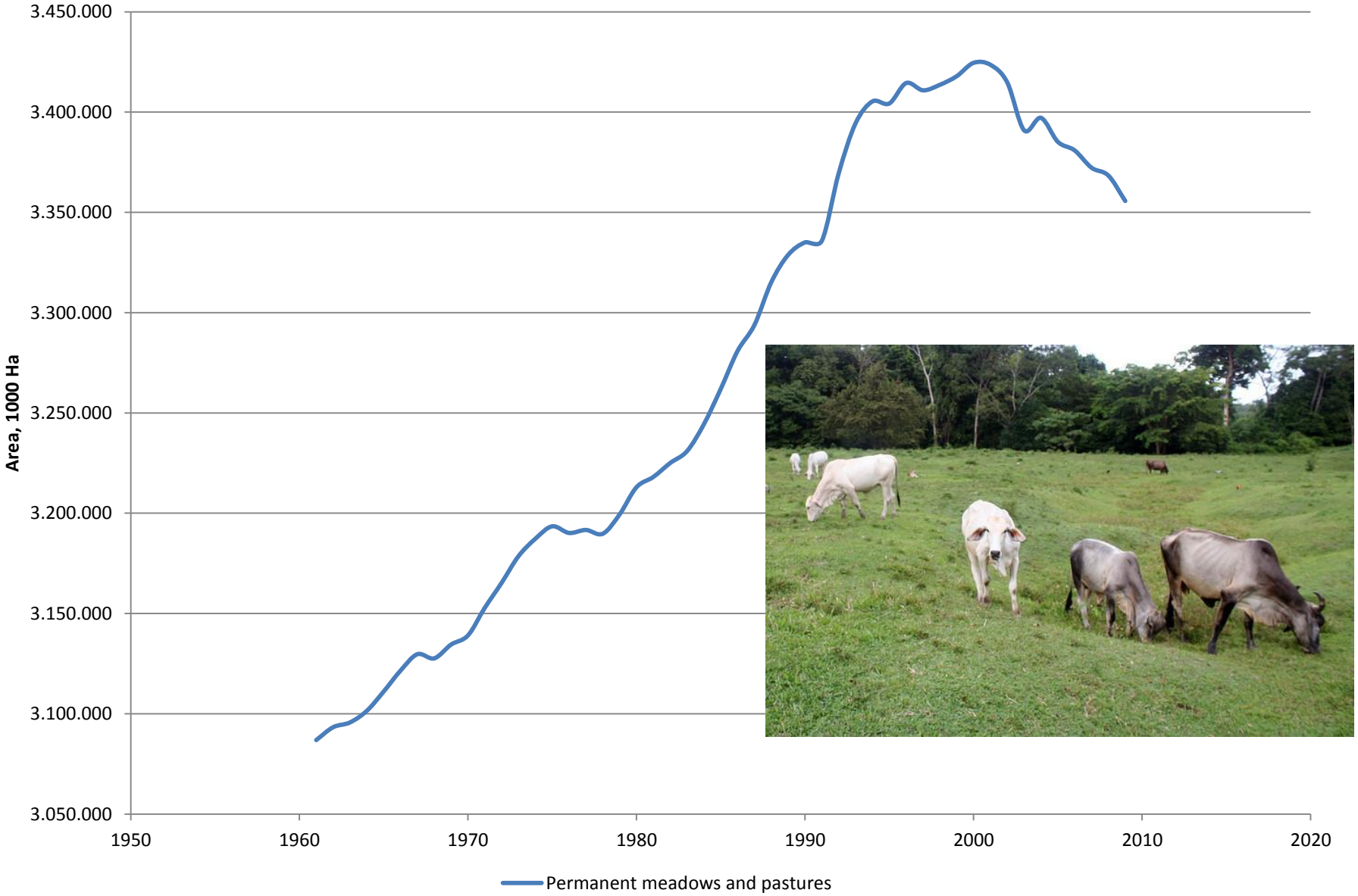
Projected Increase in meat and milk calories from pasture 2006-2050 is 140% of increase from 1962-2006

	Beef Increase	Dairy Increase	
FAO Projection	81%	71%	Pasture increases equal
Adjusted for 9.6 billion population	90%	80%	to increases in crop-based beef and dairy

Permanent meadows and pastures, World (FAO)



Additional Land Demands

- 100 million hectares of agricultural loss to urban expansion (FAO 2002)
- Demand for industrial use
- Sawn timber growth 1.4% per year (72% by 2050) & 3% paper

(Smith 2010)

- Potential high pop.

of 10.6 billion (UN)

Menu for a sustainable food future

Consumption

- Reduce food loss and waste (Installment 2)
- Shift diets (Installment 10)
- Achieve replacement level fertility (Installment 3)
- Reduce biofuel demand for food crops (Installment 9)

Production

- Sustainably increase crop yields
  - Improved crop breeding (Installment 7)
  - Improve soil and water management (Installment 4)
  - Expand onto low-carbon degraded lands (Installment 9)
- Sustainably increase “livestock” productivity
  - Increase productivity of pasture and grazing lands
  - Reduce then stabilize wild fish catch (Installment 5)
  - Improve productivity and environmental performance of aquaculture (Installment 5)

Production methods

- Improve livestock feeding efficiency (Interim Findings)
- Increase the efficiency of fertilizer use (Interim Findings)
- Manage rice paddies to reduce emissions (Installment 8)

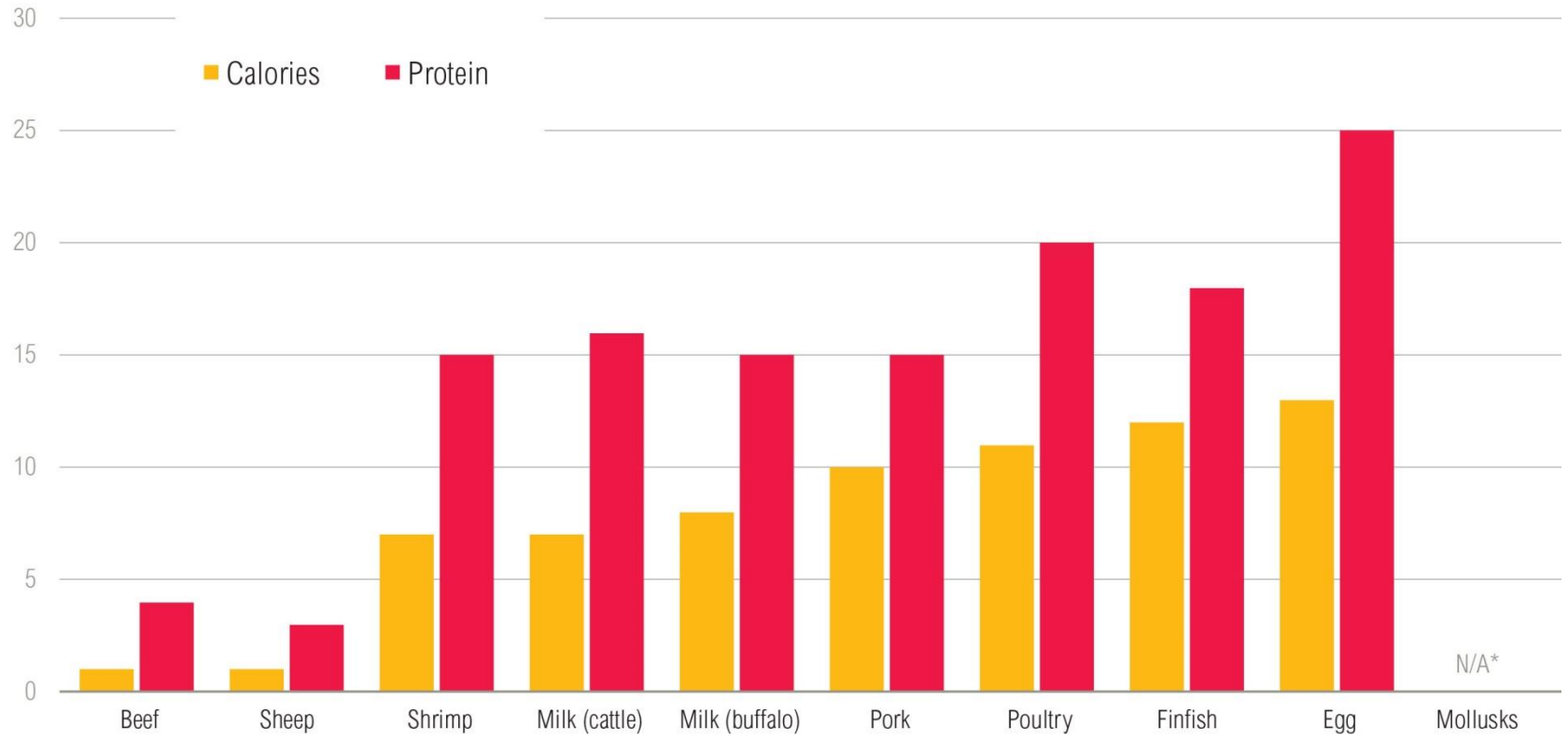
Holding down consumption of milk and meat by those who consume too much is necessary to allow more room for those who consume little

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%

Source: WRI analysis of FAO 2012 data.

Menu Item: A more efficient balance of livestock products could save hundreds of millions of hectares because beef efficiency is low

- Percent or "units of edible output per 100 units of feed input"



* Mollusks independently produce calories and protein without any human-managed inputs.

Note: "Edible output" refers to the calorie and protein content of bone-free carcass.

Source: Terrestrial animal products: Wirsenius et al. (2010) (extra unpublished tables), Wirsenius (2000). Finfish and shrimp: WRI analysis based on USDA (2013), NRC (2011), Tacon and Metian (2008), Wirsenius (2000), and FAO (1989).

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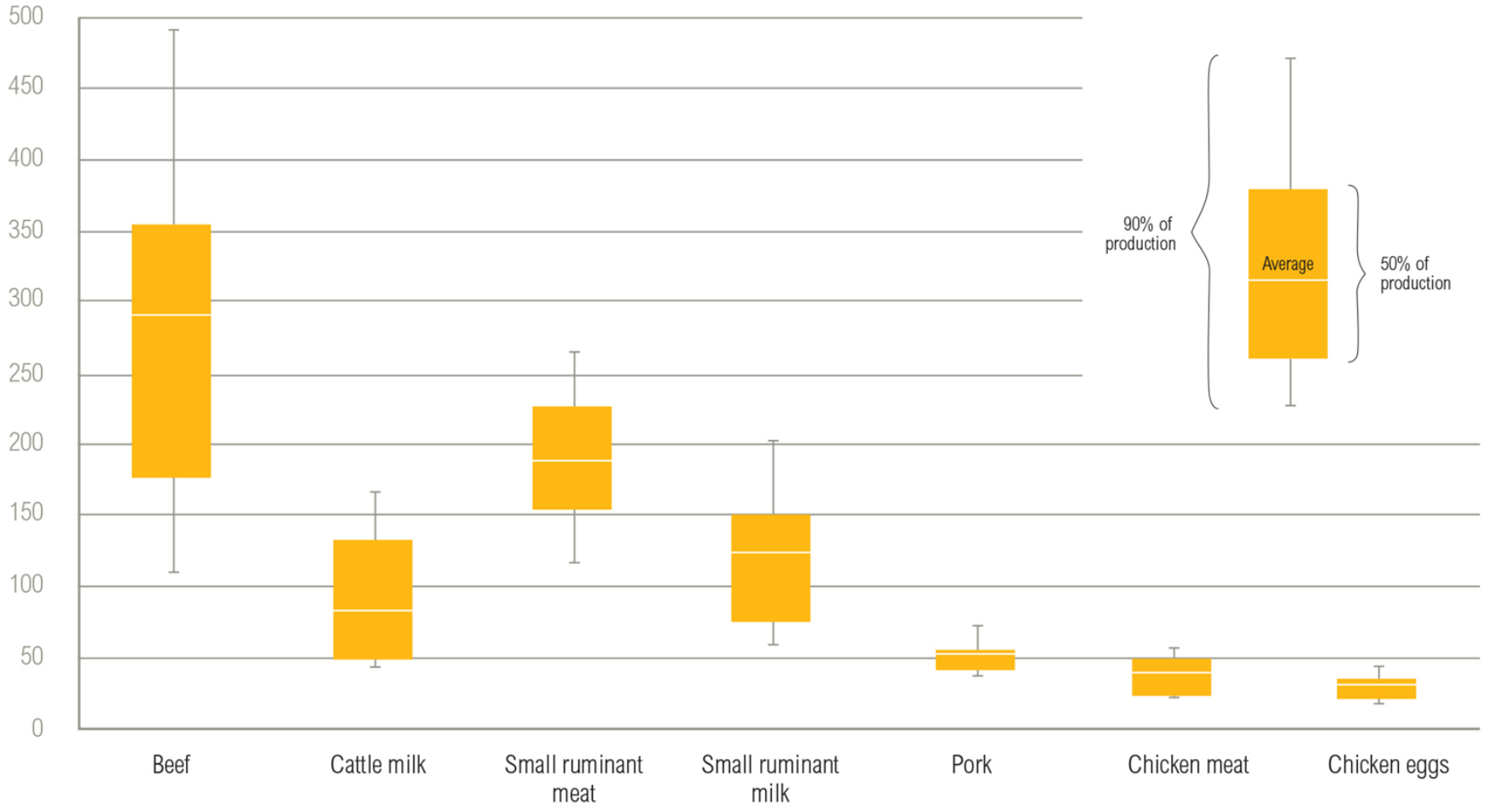
Beef production generates 6 times more greenhouse gas emissions per unit of protein than pork, chicken, and egg production

Kilograms of CO_2e per kilogram of protein



Source: GLEAM in Gerber, P. J., H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci, and G. Tempio. 2013. *Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities.* Rome: FAO.

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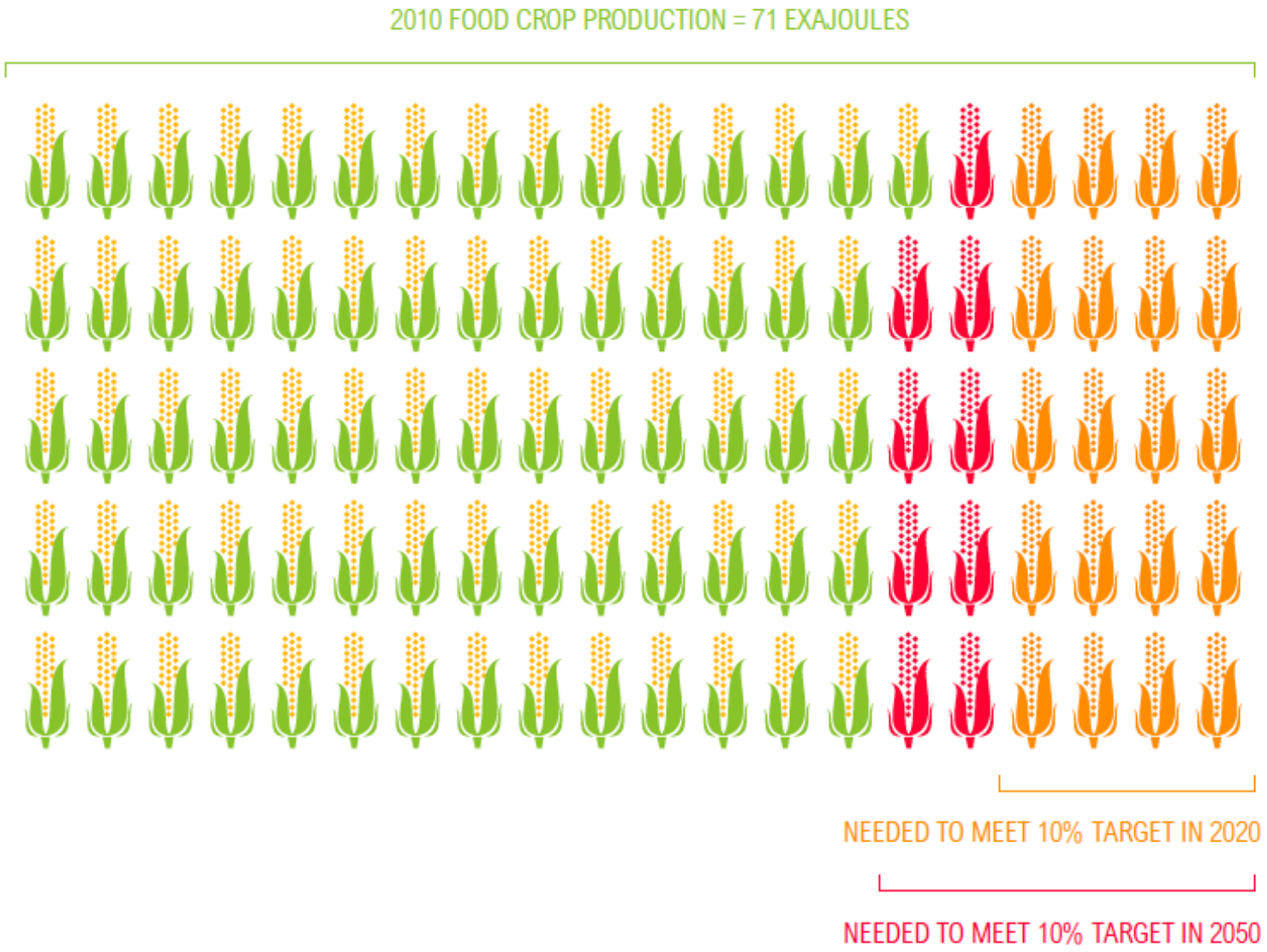
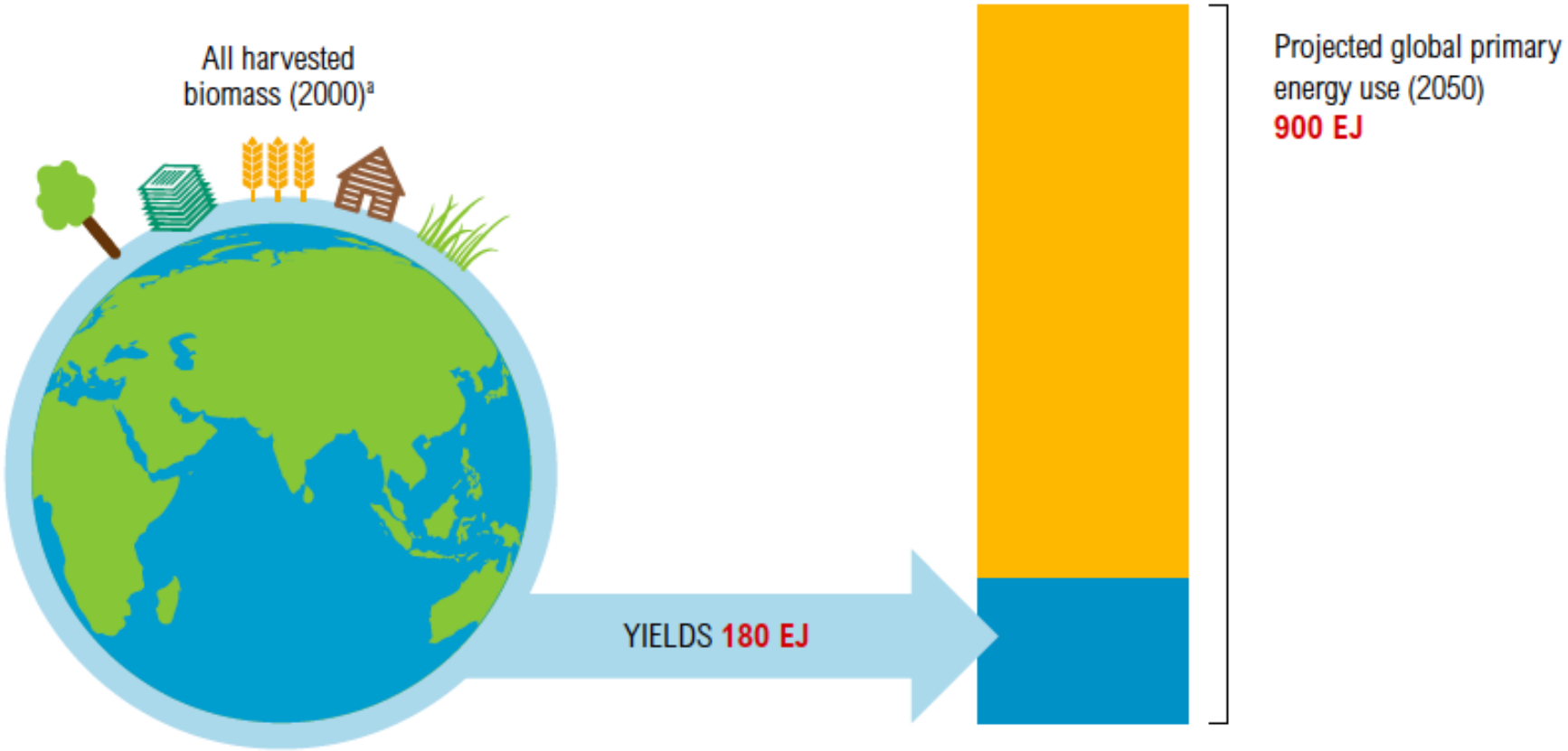
Figure 3 | **A Global 10% Transportation Biofuel Target in 2020 Would Consume 20% of 2010's Food Crop Calories. By 2050, This Target Would Consume 29%.**



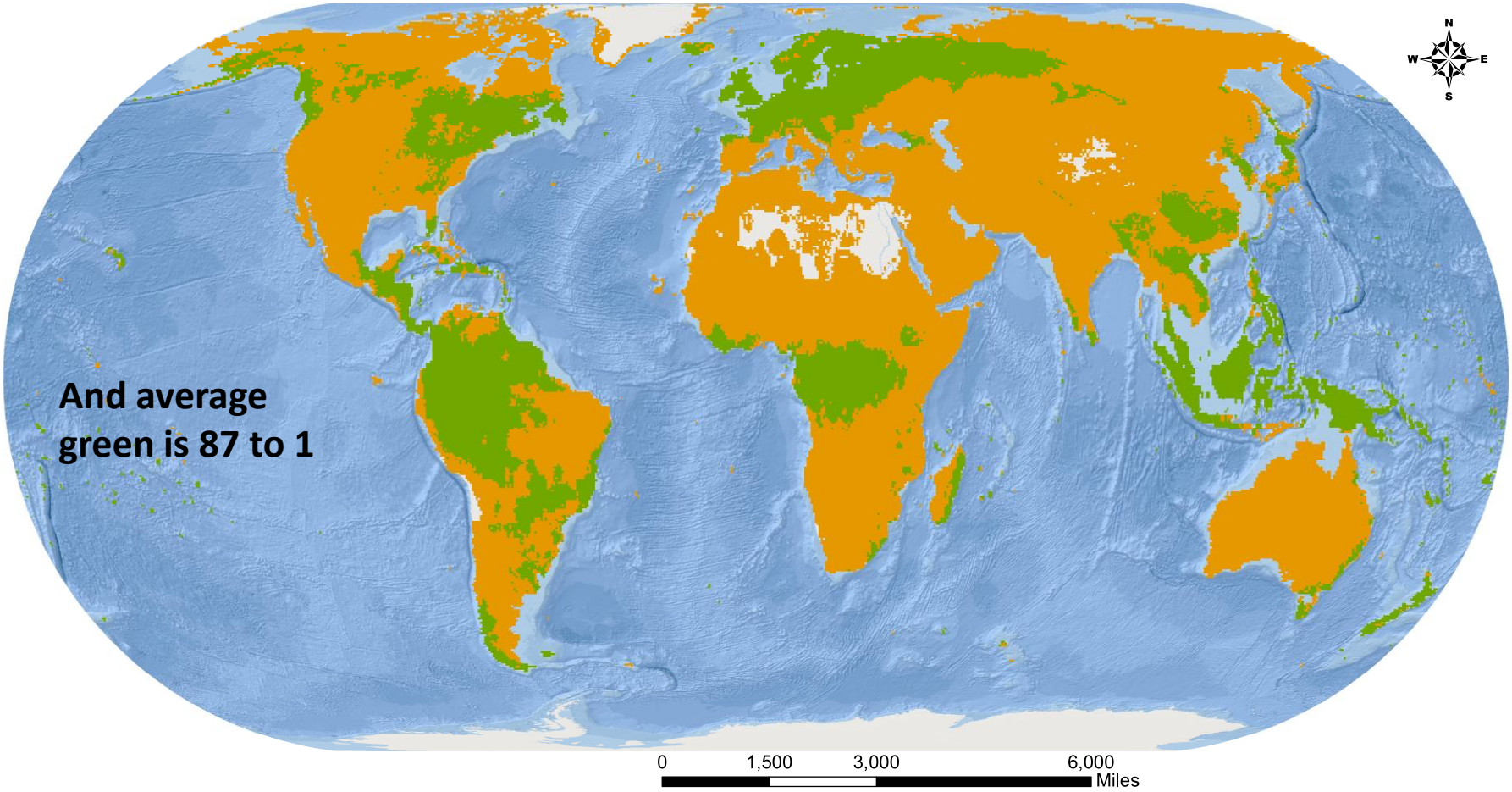
Source: Authors' calculations based on EIA (2013a), FAO (2013), and Wirsenius (2000).

Figure 4 | **Using All of the World's Harvested Biomass for Energy Would Provide Just 20 Percent of the World's Energy Needs in 2050** (Exajoules per year)



Source: Authors' calculations based on Haberl et al. (2007), IEA (2008), and JRC (2011).
Note: a. Total amount of crops, harvested residues, grass eaten by livestock, and harvested wood contained 225 EJ, but would replace only 180 EJ of fossil fuels because of conversion efficiencies from biomass to useable energy.

Where is Solar Energy 100 Times More Efficient Than Bioenergy?



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

Relative Comparison of Bioenergy to Photovoltaics

Relative Production Efficiency

- Solar Energy Produces Less Than 100x Bioenergy
- Solar Energy Produces More Than 100x Bioenergy

This analysis calculated that on 73 percent of the world's land, the useable energy output of PV would exceed that of bioenergy by a ratio of more than 100 to 1. Even on the 27 percent of land with a ratio less than 100 to 1, the average ratio would be 87 to 1.

The GIS analysis was completed by Asa Strong and Susan Minnemeyer of WRI.

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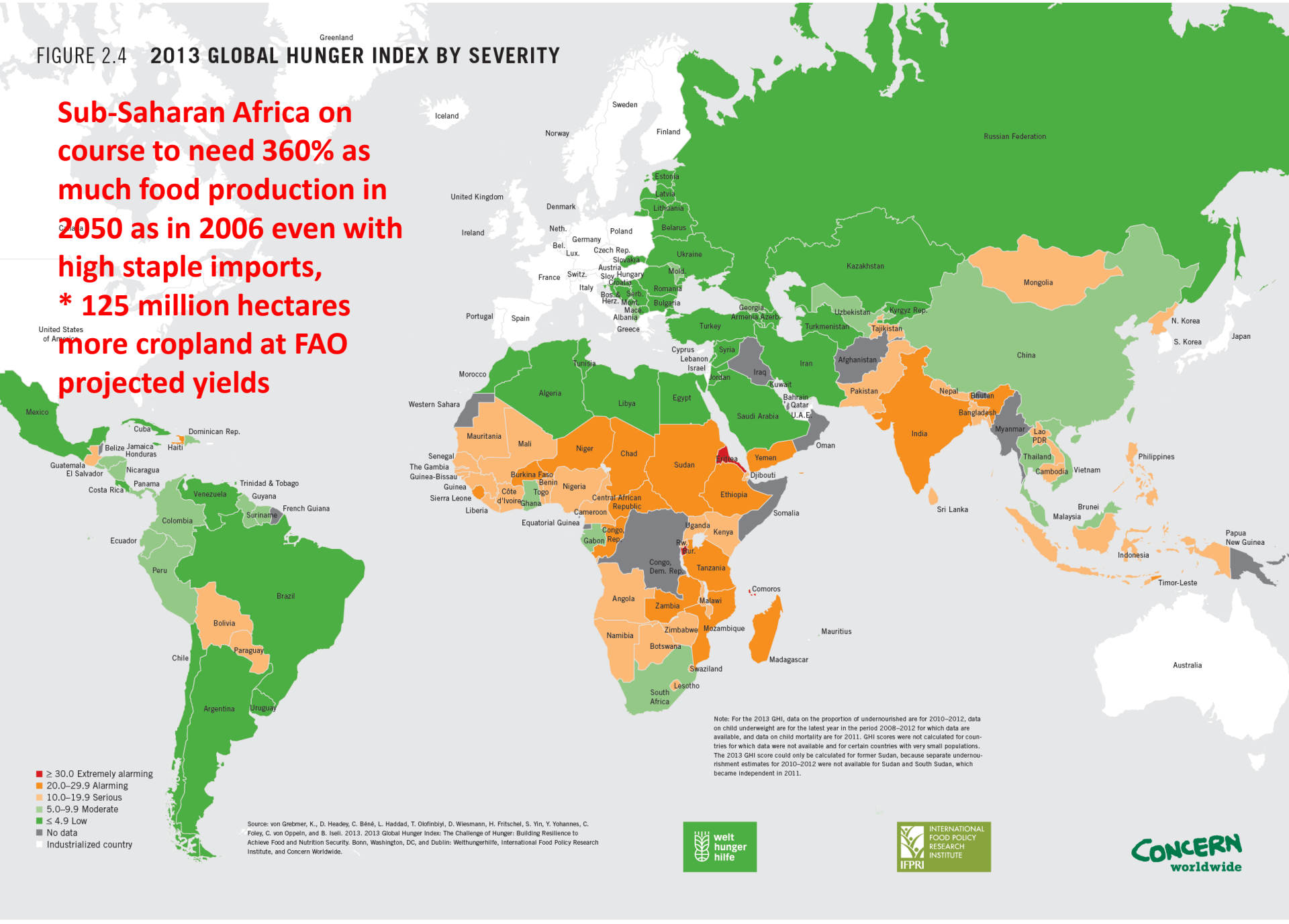
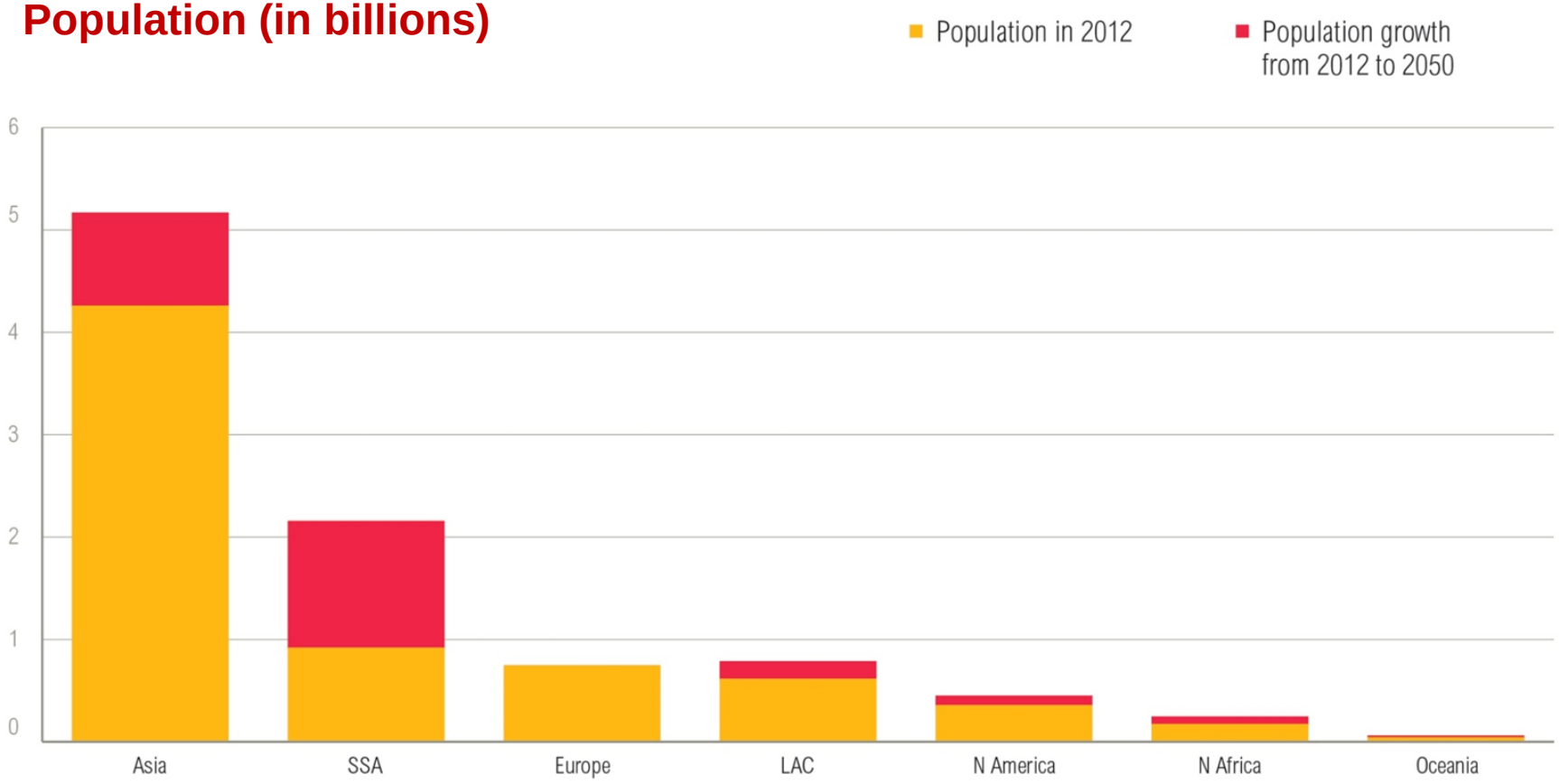


FIGURE 2.4 2013 GLOBAL HUNGER INDEX BY SEVERITY
Sub-Saharan Africa on course to need 360% as much food production in 2050 as in 2006 even with high staple imports,
* 125 million hectares more cropland at FAO projected yields
Greenland
Iceland
Sweden
Norway
Finland
Russian Federation
United Kingdom
Denmark
Ireland
Estonia
Latvia
Lithuania
Belarus
Neth.
Bel.
Lux.
Germany
Poland
Czech Rep.
Slovakia
Ukraine
Austria
Hungary
Moldova
France
Switz.
Italy
Slov.
Croatia
Bosn. & Herz.
Serb. Mont. Mace.
Albania
Romania
Bulgaria
Greece
Portugal
Spain
Turkey
Georgia
Armenia
Azerb.
Kazakhstan
Uzbekistan
Turkmenistan
Kyrgyz Rep.
Tajikistan
Mongolia
China
N. Korea
S. Korea
Japan
Cyprus
Lebanon
Israel
Syria
Iraq
Iran
Afghanistan
Pakistan
Jordan
Kuwait
Bahrain
Qatar
U.A.E.
Saudi Arabia
Oman
Yemen
Nepal
Bhutan
Bangladesh
India
Myanmar
Sri Lanka
Thailand
Lao PDR
Cambodia
Vietnam
Philippines
Brunei
Malaysia
Indonesia
Papua New Guinea
Timor-Leste
Australia
Morocco
Western Sahara
Algeria
Tunisia
Libya
Egypt
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Djibouti
Ethiopia
Somalia
Senegal
The Gambia
Guinea-Bissau
Guinea
Sierra Leone
Liberia
Burkina Faso
Benin
Nigeria
Togo
Côte d'Ivoire
Ghana
Central African Republic
Cameroon
Equatorial Guinea
Gabon
Congo, Rep.
Rw.
Bur.
Uganda
Kenya
Congo, Dem. Rep.
Tanzania
Angola
Zambia
Malawi
Namibia
Zimbabwe
Mozambique
Botswana
Swaziland
Lesotho
South Africa
Comoros
Mauritius
Madagascar
United States of America
Mexico
Cuba
Dominican Rep.
Haiti
Belize
Jamaica
Honduras
Guatemala
El Salvador
Nicaragua
Panama
Costa Rica
Venezuela
Trinidad & Tobago
Guyana
Suriname
French Guiana
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Argentina
Uruguay
≥ 30.0 Extremely alarming
20.0–29.9 Alarming
10.0–19.9 Serious
5.0–9.9 Moderate
≤ 4.9 Low
No data
Industrialized country
Note: For the 2013 GHI, data on the proportion of undernourished are for 2010–2012, data on child underweight are for the latest year in the period 2008–2012 for which data are available, and data on child mortality are for 2011. GHI scores were not calculated for countries for which data were not available and for certain countries with very small populations. The 2013 GHI score could only be calculated for former Sudan, because separate undernourishment estimates for 2010–2012 were not available for Sudan and South Sudan, which became independent in 2011.
Source: von Grebmer, K., D. Headey, C. Béné, L. Haddad, T. Olofinbiyi, D. Wiesmann, H. Fritschel, S. Yin, Y. Yohannes, C. Foley, C. von Oppeln, and B. Iseli. 2013. 2013 Global Hunger Index: The Challenge of Hunger: Building Resilience to Achieve Food and Nutrition Security. Bonn, Washington, DC, and Dublin: Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide.
welt hunger hilfe
INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI
CONCERN worldwide

The world's population is projected to grow from about 7 billion people in 2012 to nearly 9.6 billion in 2050, with half of growth in sub-Saharan Africa

Population (in billions)

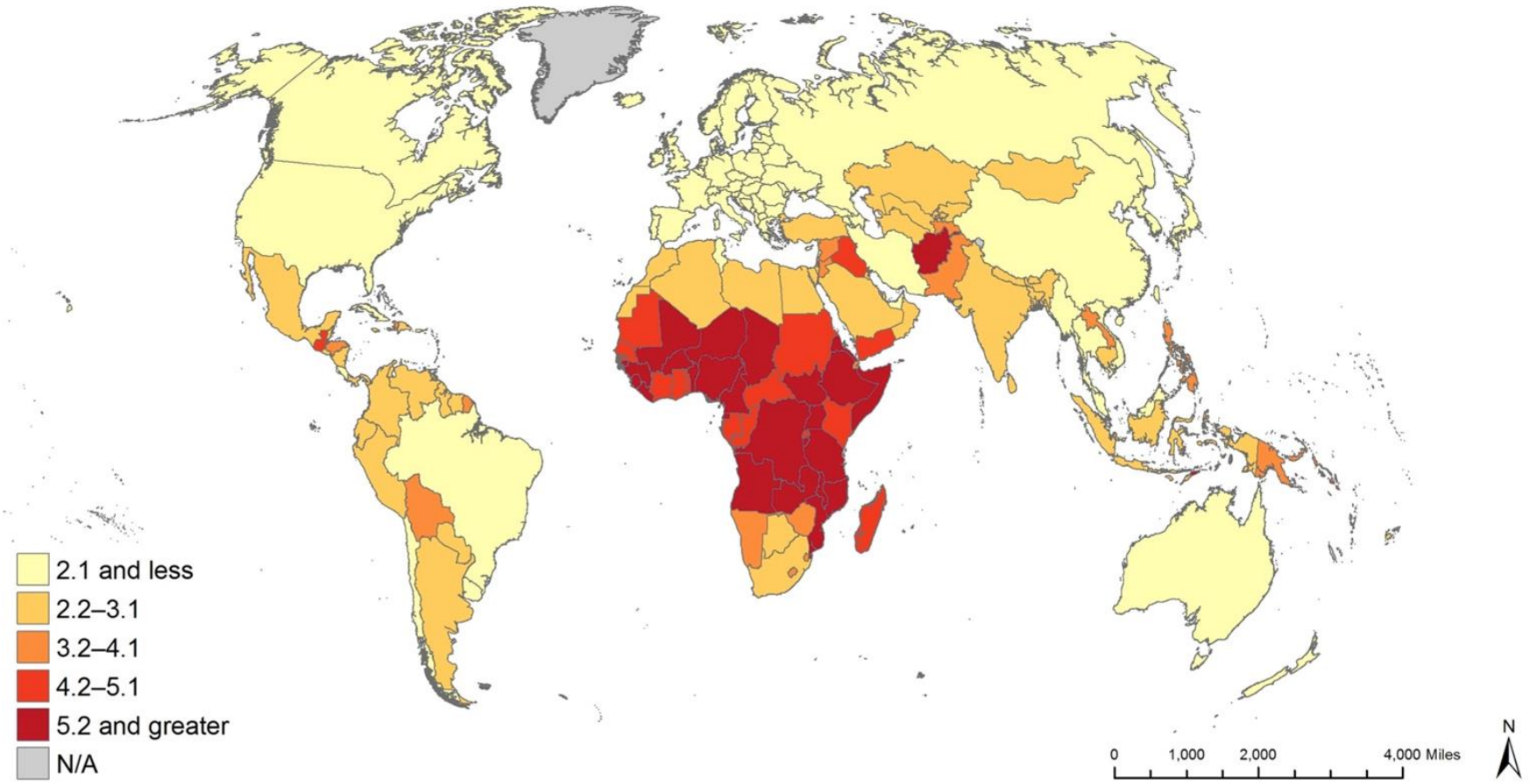


Note: "SSA" = Sub-Saharan Africa, including Sudan. "LAC" = Latin America and Caribbean. "N America" = North America. "N Africa" = Rest of Africa.

Source: United Nations Department of Economic and Social Affairs, Population Division (UNDESA). 2013. *World Population Prospects: The 2012 Revision.* New York: United Nations. Total population by major area, region, and country. Medium fertility scenario.

Sub-Saharan Africa has the highest total fertility rates

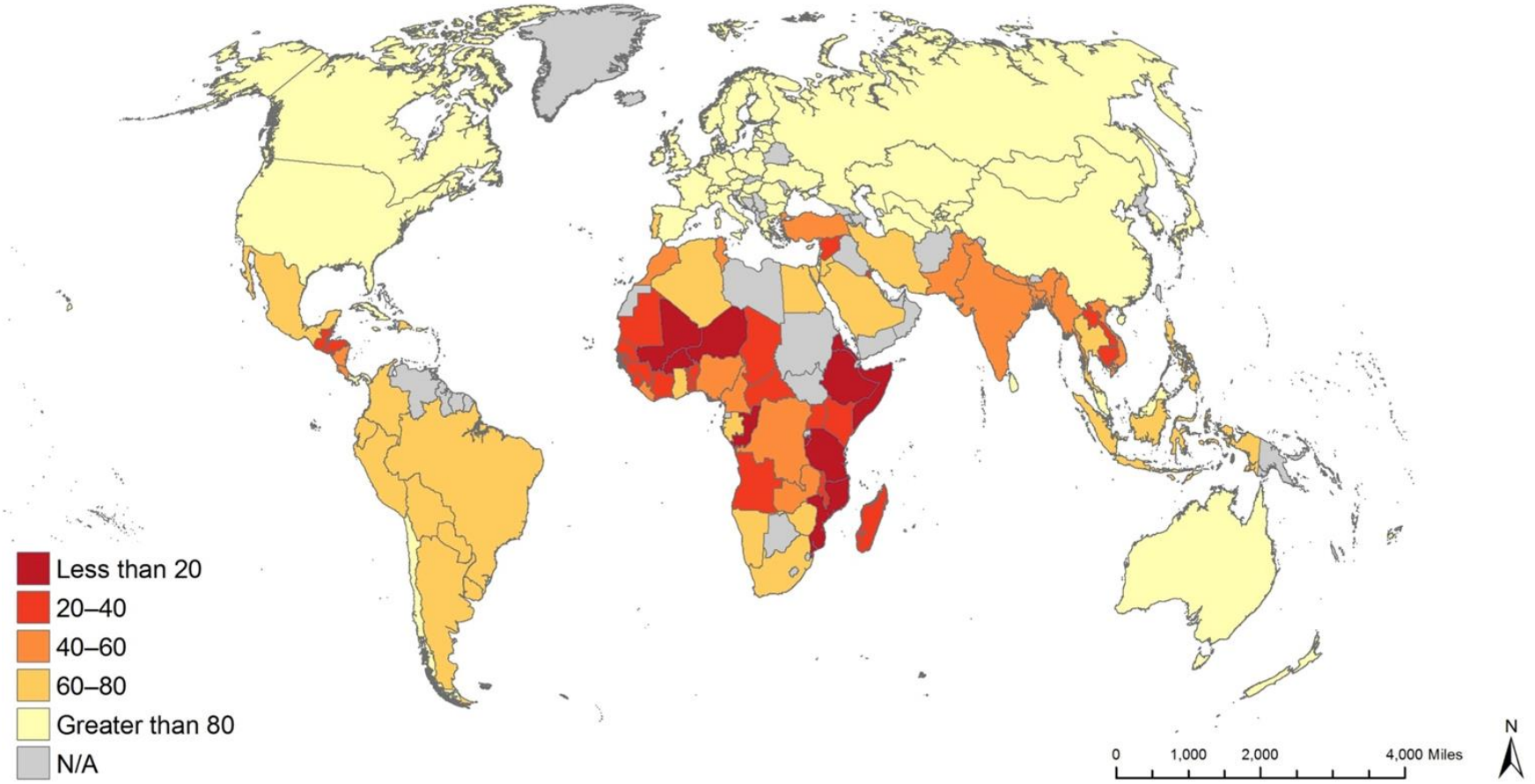
Total fertility rate (2005–2010)



Source: United Nations Department of Economic and Social Affairs, Population Division (UNDESA). 2013. *World Population Prospects: The 2012 Revision.* New York: United Nations.

Sub-Saharan Africa has the lowest total share of women with at least lower secondary education

Percent of women ages 20–39 with at least lower secondary education (2005–2010)



Source: Harper, S. 2012. "People and the planet." University of Oxford. Presentation at The Royal Society, London, April 2012.

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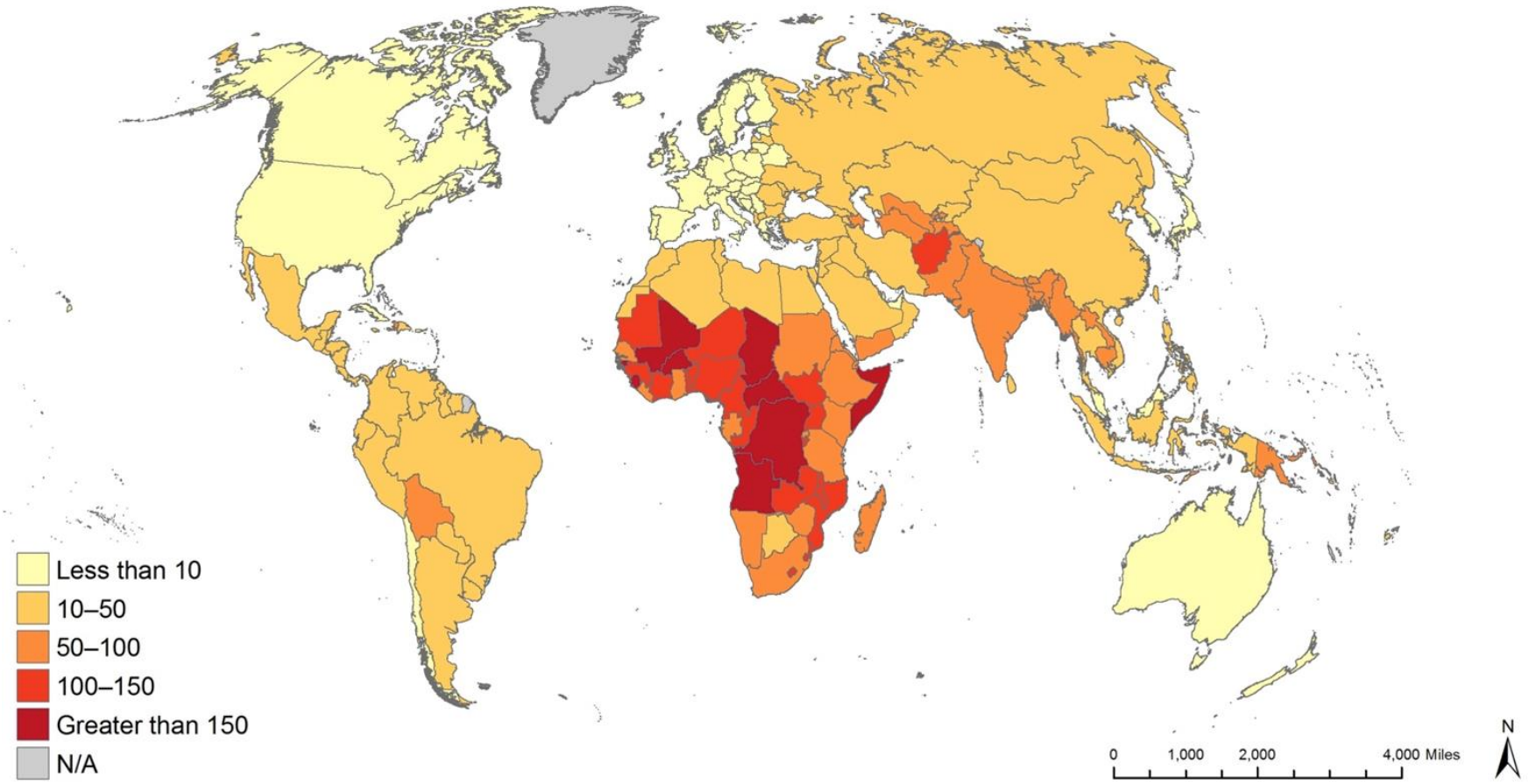
Sub-Saharan Africa has the highest child mortality rates

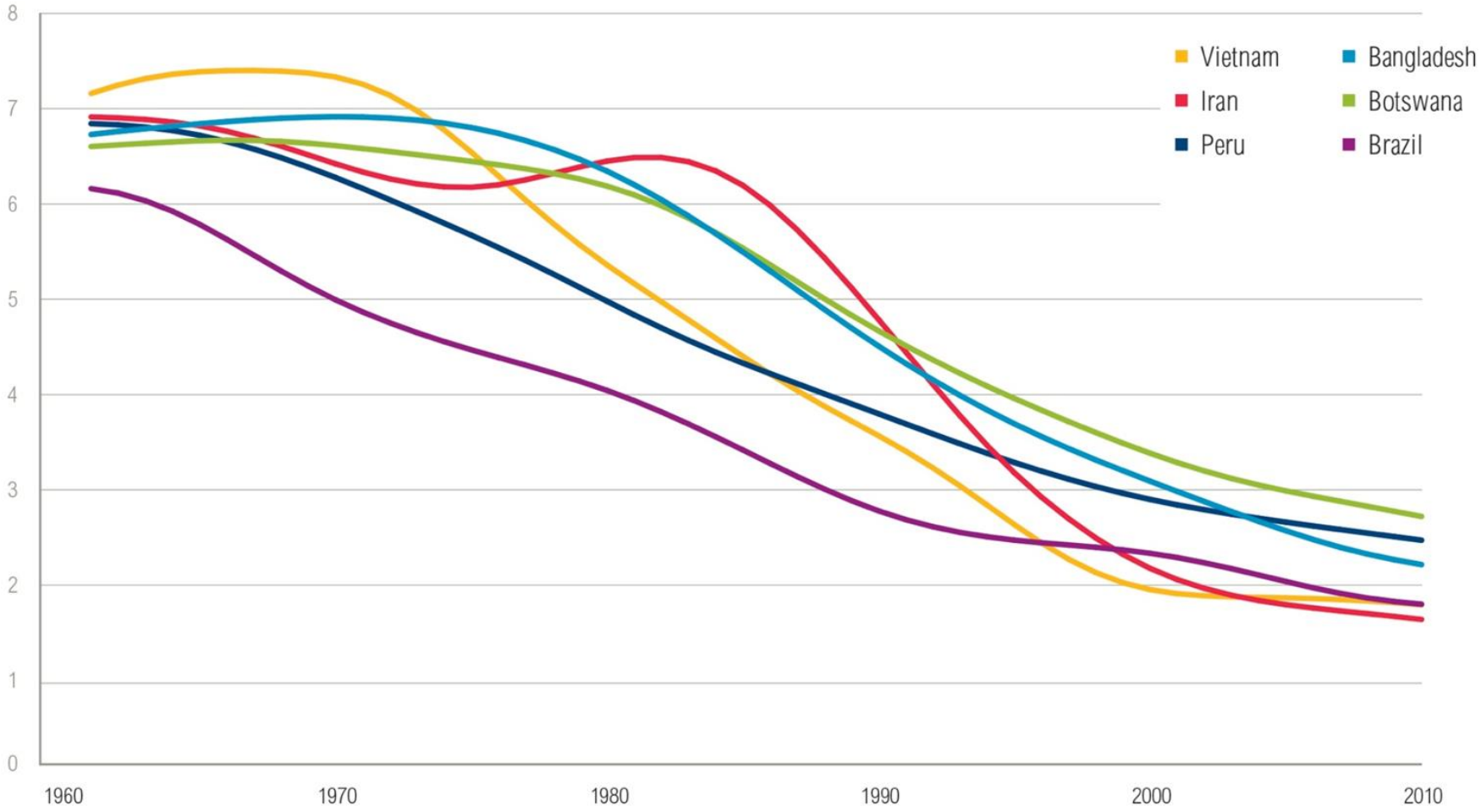
Mortality of children under age 5 per 1,000 live births (2005–2010)



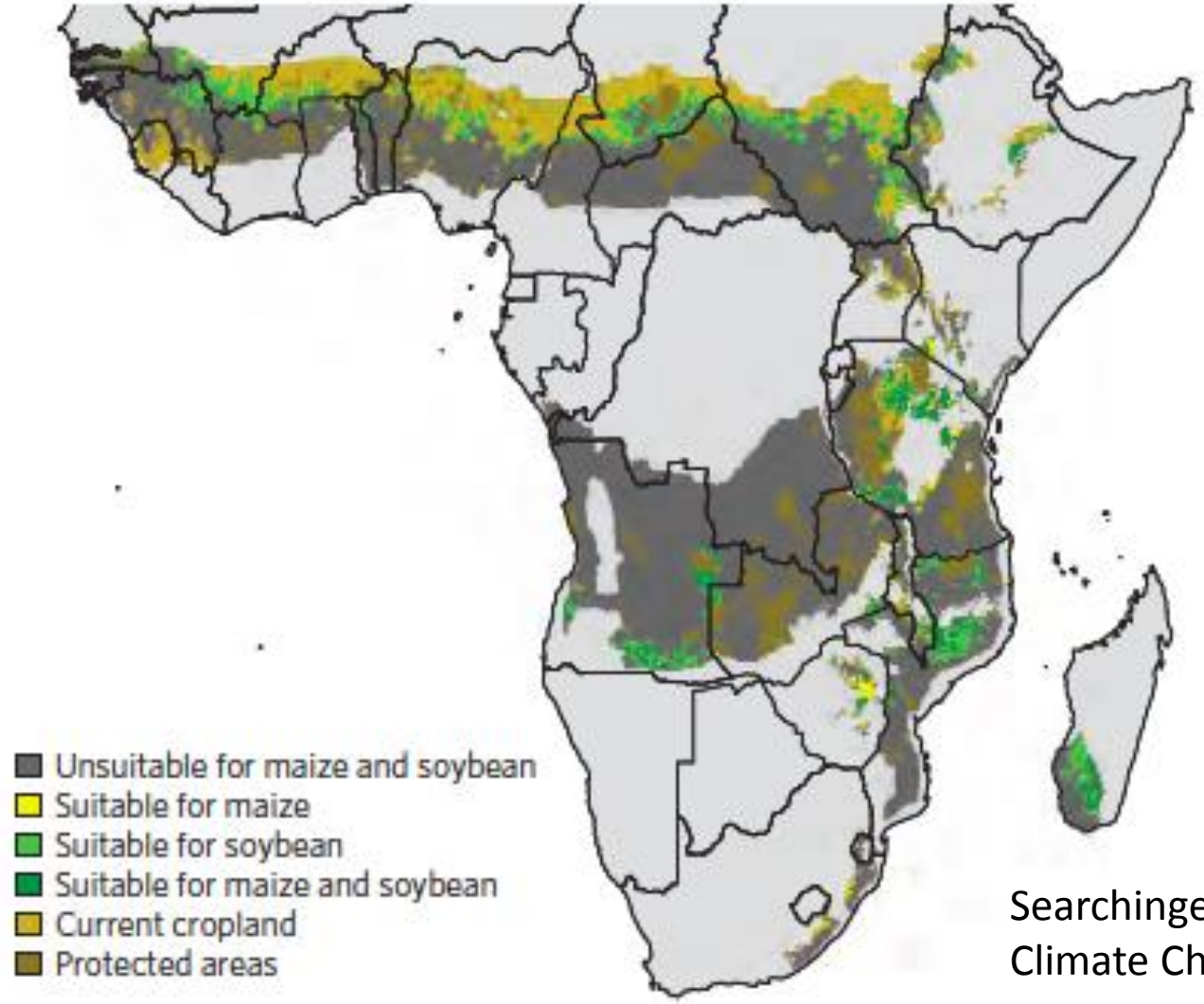
Source: World Bank. 2012. Databank: "Mortality rate, under-5 (per 1,000 live births)." Data retrieved April 2, 2013, from World Development Indicators Online (WDI) database.

Total fertility rates can decline rapidly

Total fertility rate



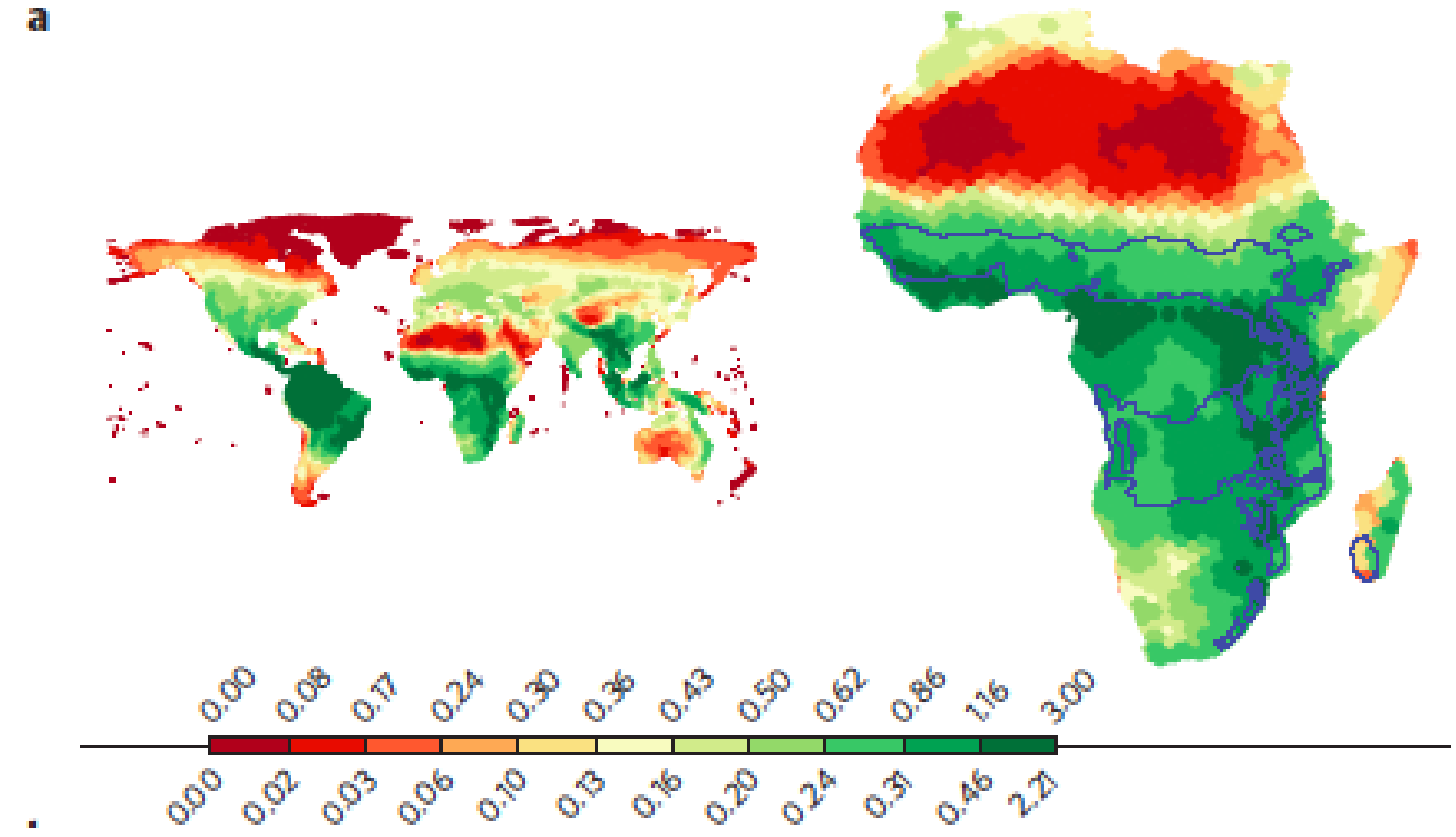
Source: World Bank. 2012. Databank: "Fertility rate, total (births per woman)." Data retrieved November 30, 2012, from World Development Indicators Online (WDI) database.



Searchinger et al., Nature Climate Change 2015

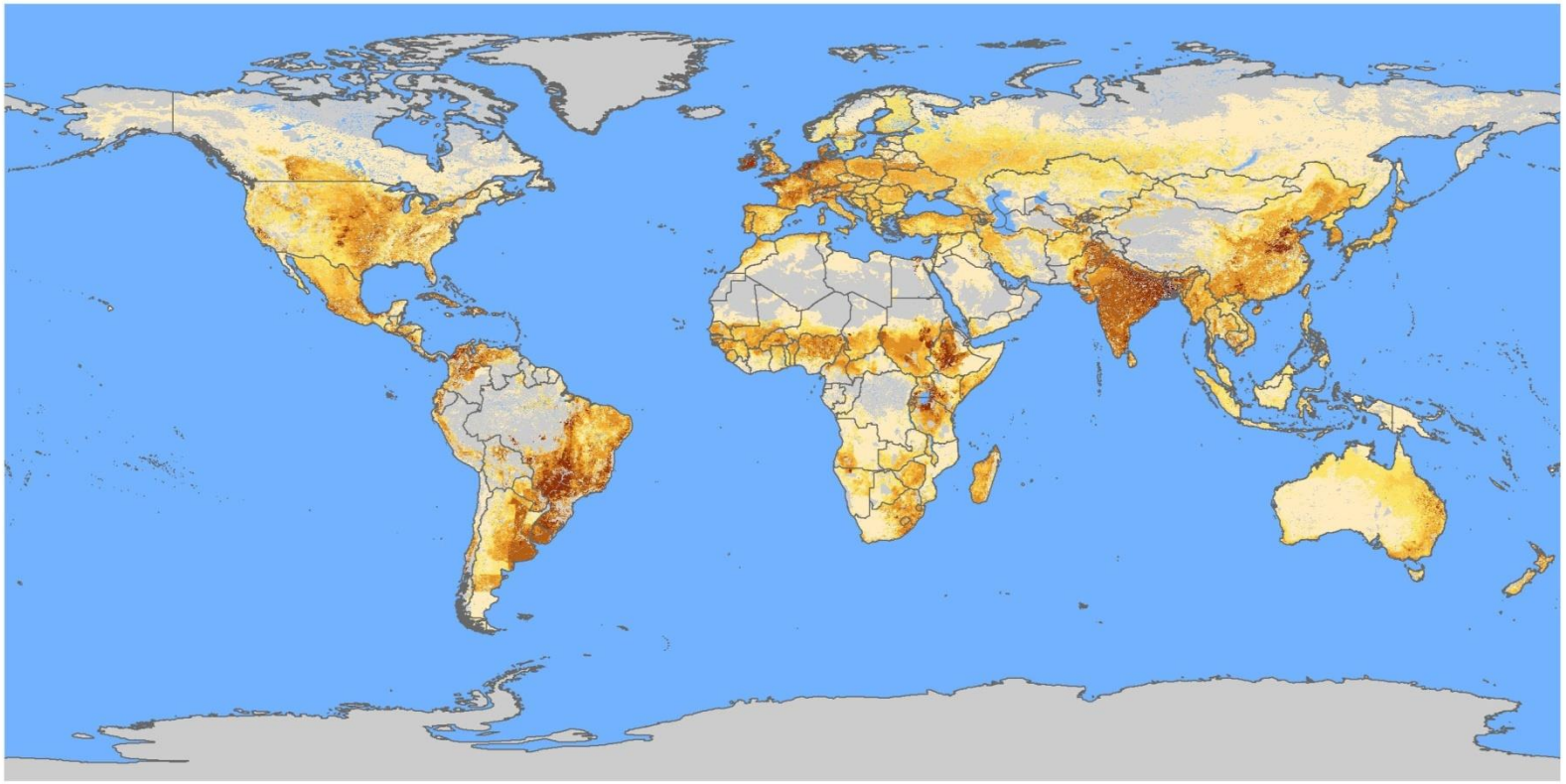
Figure 2 | Low-carbon potential cropland sites. Suitable means: yields $\geq$4 t ha^{-1} (maize) or 1.5 t ha^{-1} (soybeans), yield CV $\leq$30%, crop season failure rates $\leq$10%, and carbon loss/yield ratios 33% lower than global averages for each crop.

Total Vertebrate Biodiversity in Wet Savannas of Africa & the World



Cattle density map matching FAOSTAT 2005 *(modelled)*

AGRICULTURE AND CONSUMER PROTECTION DEPARTMENT
Animal Production and Health Division

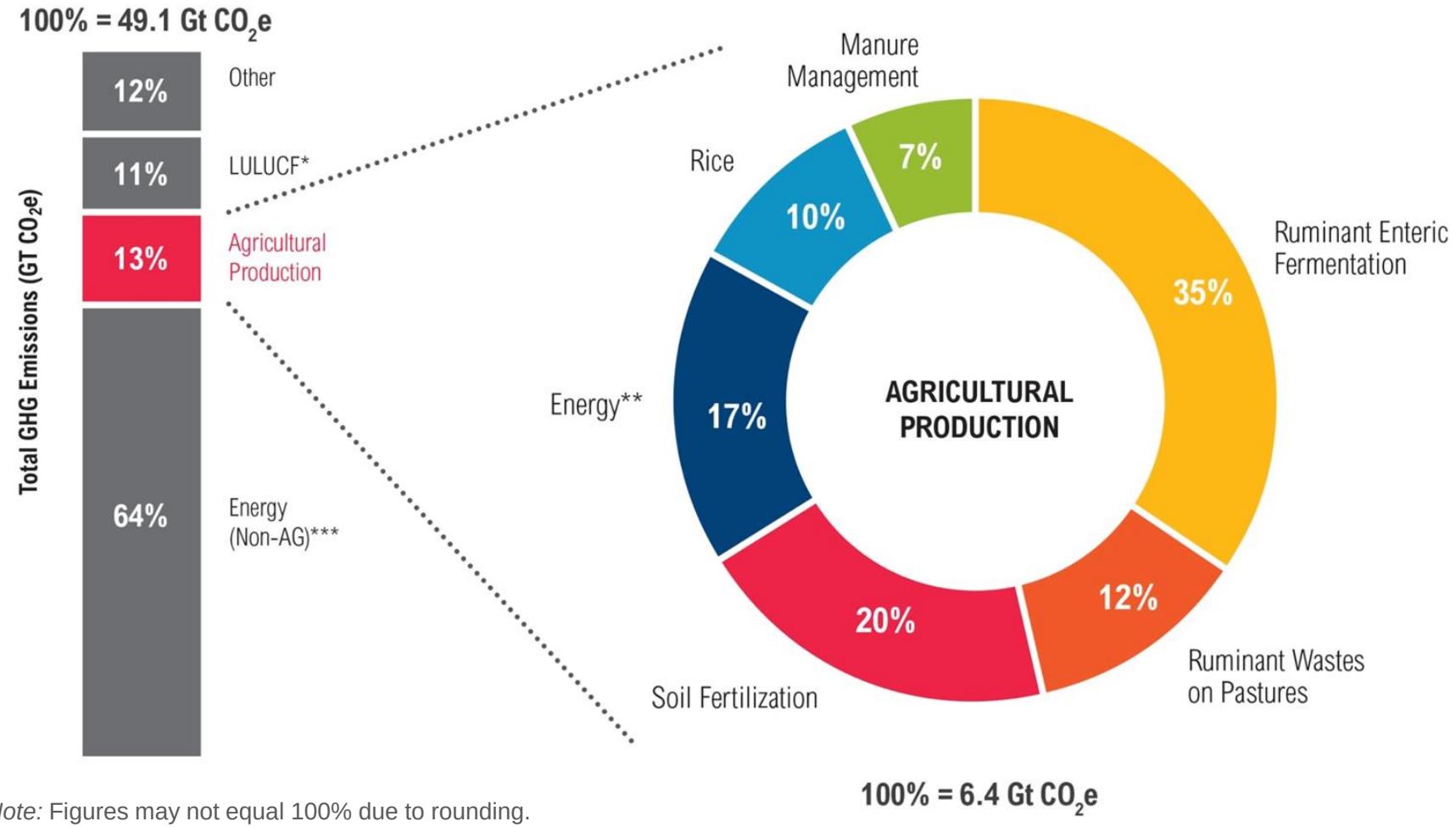


Number per square km

<1	5–10	20–50	100–250	Water
1–5	10–20	50–100	>250	Unsuitable for ruminat

Source: Gridded Livestock of the World

Ruminants contributed nearly half of global greenhouse gas emissions from agricultural production in 2010

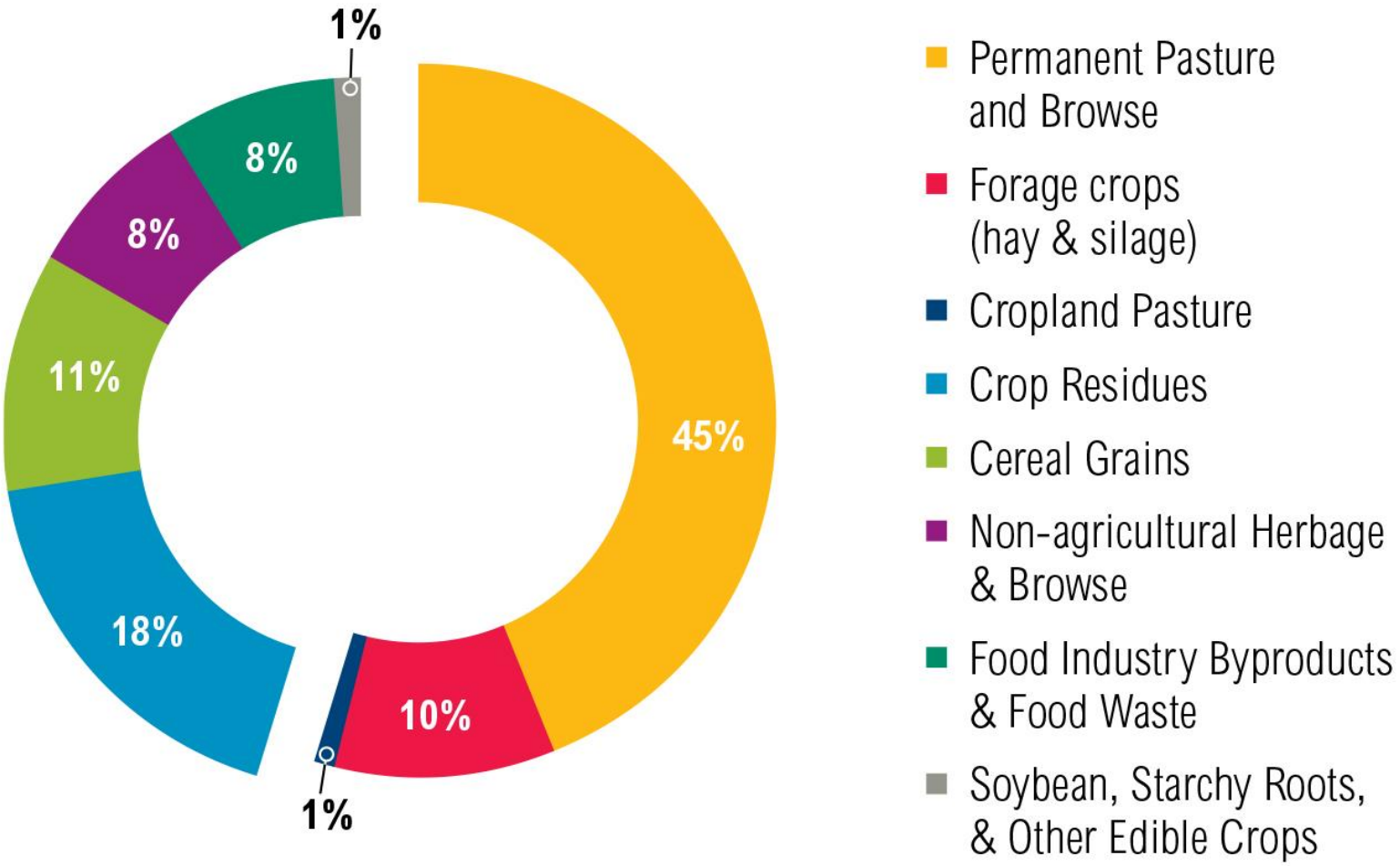


Note: Figures may not equal 100% due to rounding.
* LULUCF = Land Use, Land Use Change, and Forestry.
** Includes emissions from on-farm energy consumption as well as from manufacturing of farm tractors, irrigation pumps, other machinery, and key inputs such as fertilizer. It excludes emissions from the transport of food.
*** Excludes emissions from agricultural energy sources described above.

Source: WRI analysis based on UNEP (2012), FAO (2012e), EIA (2012), IEA (2012), and Houghton (2008) with adjustments.

Grasses provide more than half of all animal feed

Percent, 100% = 6724 Tg dry matter per year (2010)



Note: Soybean and other oil meals are included in "Food industry by-products" while whole soybeans are included in "Soybeans, starchy roots and other edible crops." Data from Wirsenius is for 1992–94 and for 2030.

Source: Wirsenius, S., C. Azar, and G. Berndes. 2010. "How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030?" *Agricultural Systems* 103 (9): 621–38.

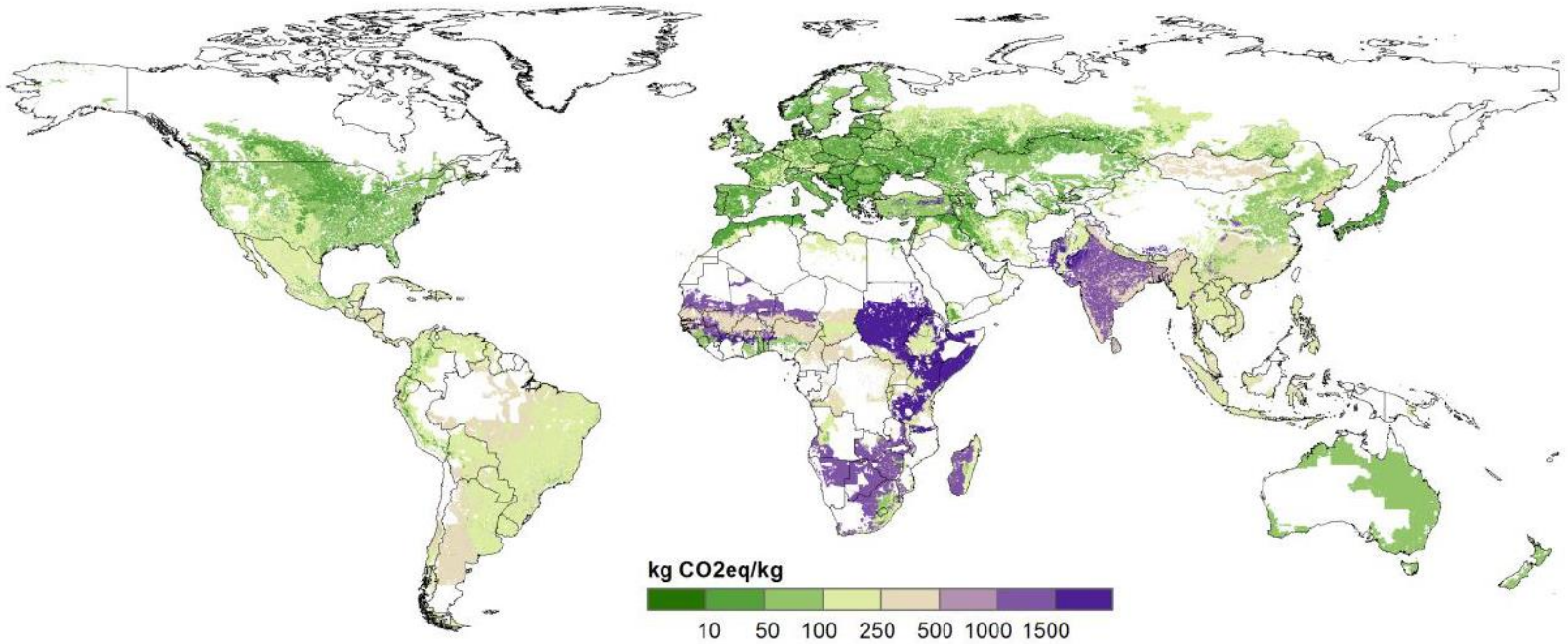


Figure S 47. GHG efficiency of bovine meat production (expressed in kg CO_2eq/g protein) in the year 2000

Herrero et al., PNAS (2013)

Comparative Emissions from Dairy Cows

Gerber et al., FAO (2010)

Africa: 7.5 kg of greenhouse gases per kilogram of milk

U.S.: 1.3 kg of gases per kilogram of milk

Accessible improvements – cut emissions per unit of milk by ½ to 2/3.

- High protein shrub
- Improved pasture
- Increased stover digestibility

Source: Thornton & Herrero 2010 PNAS

Menu item: Increase pastureland productivity

Photo Source: Luis Solarte/CIPAV.

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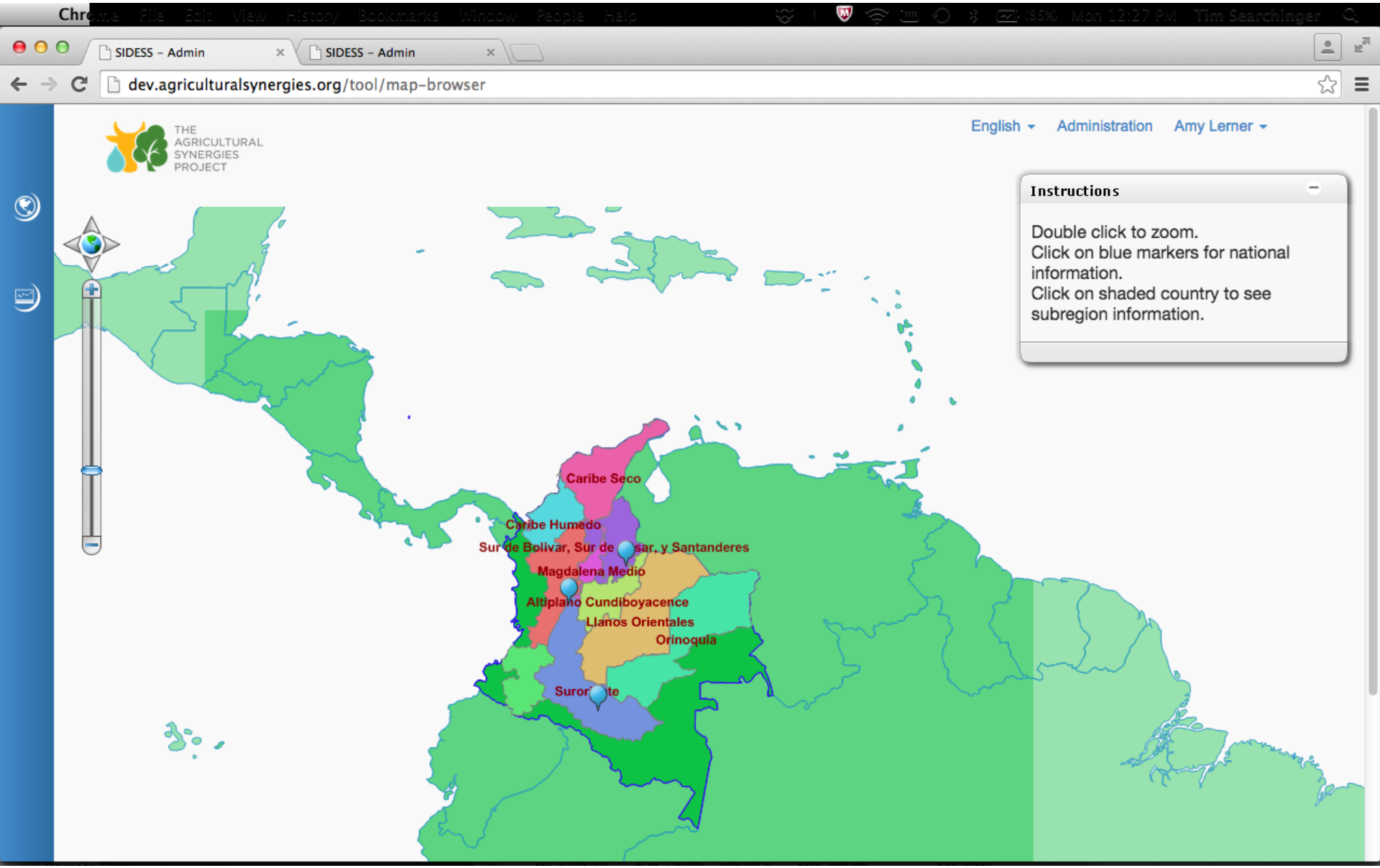
The Agricultural Synergies Project

Improving Food Security Sustainably While Holding Down Greenhouse Gas Emissions

The Agricultural Synergies Project is a collaborative effort of research institutions across the world to develop detailed guidance of ways developing countries can boost food production while reducing agricultural greenhouse gas emissions. This guidance will help countries to develop Nationally Appropriate Mitigation Plans (NAMAs), and international aid agencies to evaluate them. It will also help farmer groups, private companies, and non-profit organizations to identify the most promising synergies between increases in agricultural production and reduction in emissions. The initial efforts focus on three sets of guidance:

1. Sustainable intensification of ruminant livestock
2. Land sparing
3. Agroforestry.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THE AGRICULTURAL SYNERGIES PROJECT
English
Administration
Amy Lerner
Instructions
Double click to zoom.
Click on blue markers for national information.
Click on shaded country to see subregion information.
Caribe Seco
Caribe Humedo
Magdalena Medio
Altiplano Cundiboyacence
Llanos Orientales
Orinoquia

Export to Excel

Supra Region | Country | Region | SystemType | Summary Type | Year | Parameter Type

Value | Cluster

Parameter	Cow-Calf System-Coffee Belt	Dual-Purpose High-Coffee Belt	Dual-purpose Low-Coffee Belt	Fattening System Coffee Belt	Specialized Dairy System-Coffee Belt	Grand Total
Bovine Animals (Million Unit)	0,72	0,06	0,18	0,18	0,37	1,52
Cropland Attributed to feed (Units)	NeuN	NeuN	NeuN	NeuN	NeuN	NeuN
Intensity Level	2,00	10,00	4,00	5,00	10,00	6,20
Kgs CO2eq / Kg Protein	50,07	28,89	35,27	37,39	16,56	33,64
Kgs Protein / Ha	50,01	133,74	36,79	48,23	250,84	103,92
Total Beef (Million Unit)	27,06	8,39	33,27	31,13	27,84	127,70
Total CO2eq (Gg)	757,57	79,71	276,15	221,15	807,17	2.141,75
Total Income (Units)	124.222.712,70	13.275.142,45	20.166.438,60	NeuN	408.993.373,29	566.657.667,04
Total Milk (Million Unit)	199,76	23,29	30,15	NeuN	868,83	1.122,03
Total Pasture Land (Units)	302.500,00	20.628,00	212.806,00	122.650,00	194.275,00	852.859,00
Grand Total	124.526.197,81	13.295.881,90	20.379.584,35	122.902,47	409.189.352,51	567.513.919,04

File Name

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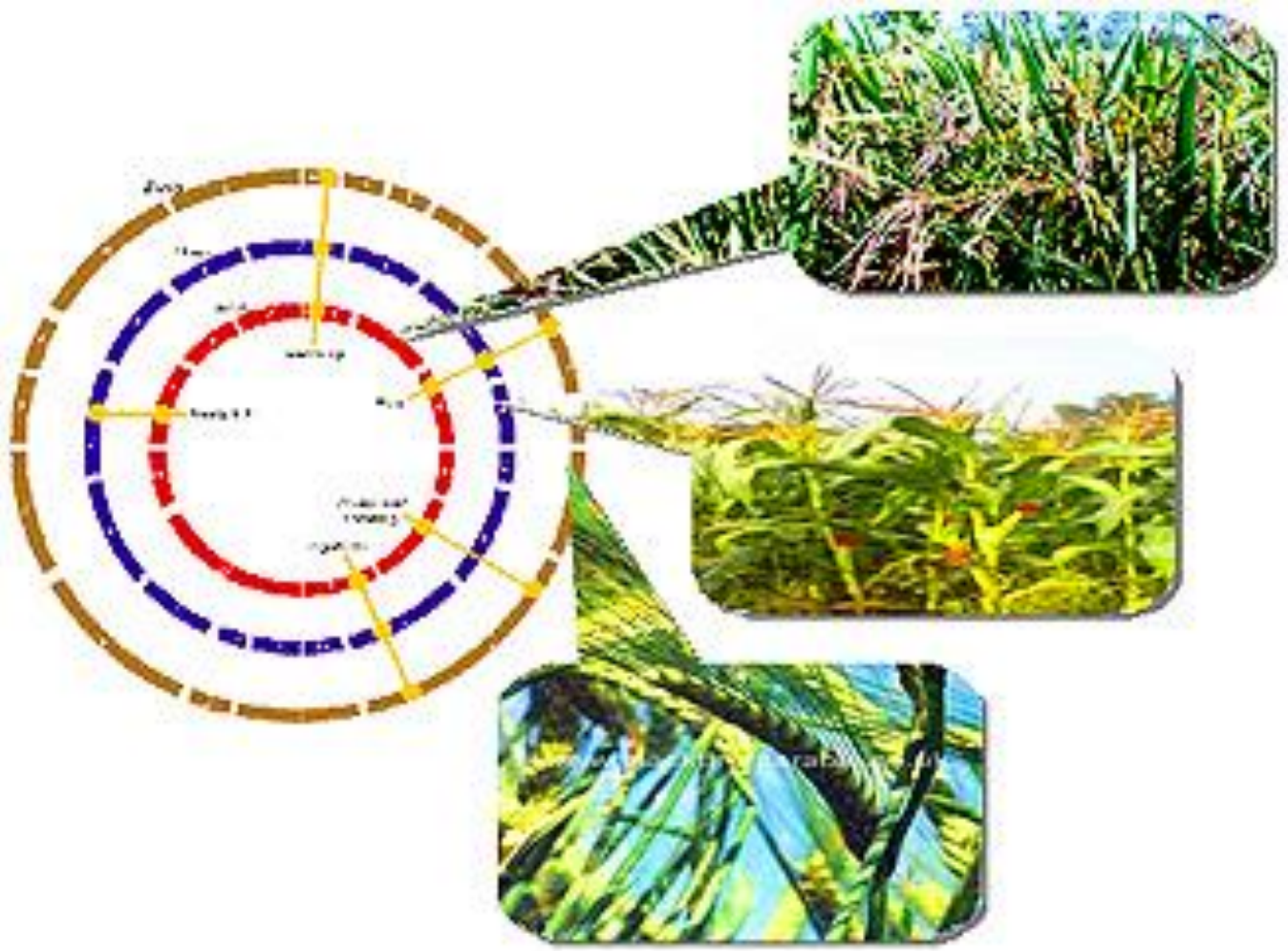
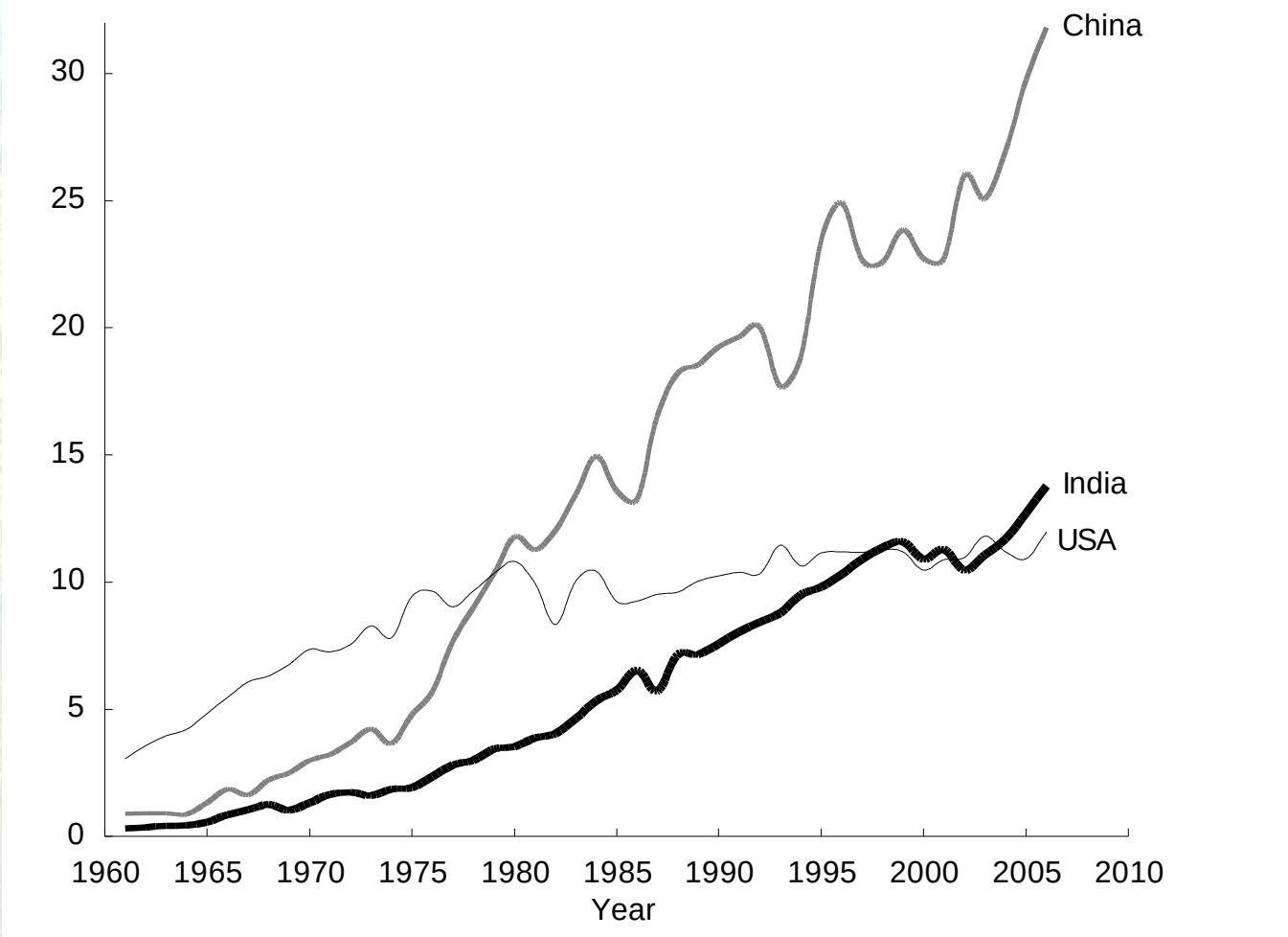
Water Management strategies for reducing impacts (e.g., GHG) from paddy rice

1. Alternative Wet & Dry
2. Single season drawdown
3. Dry seeding
3. Avoid flooding in off-season
4. Bed & furrow (saturated) production
5. Off-season drawdown



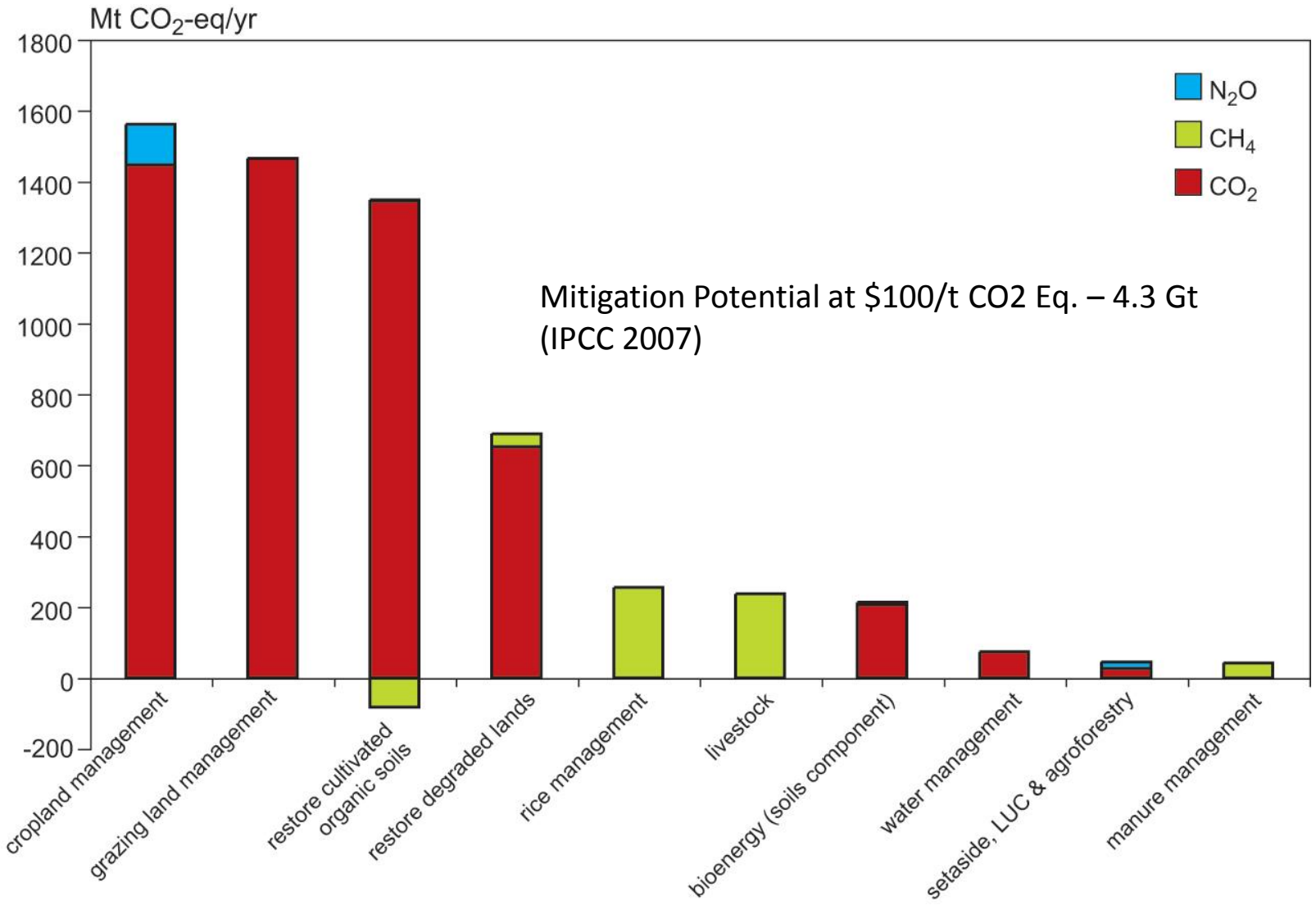
- Genomics for crop breeding

Greatest Overuse of Nitrogen Fertilizer is in China and Parts of India



Slide courtesy of Central Rice Institute, Cuttack, India

Overwhelming Focus on Carbon Sequestration Misplaced



Petland conversion in Southeast Asia today releases 1-2% of all global GHG emissions annually and oil palm expansion could level of emissions for decades

Some Key Takeaways

- The agricultural emissions & land use challenge is big
- Pasture productivity
- Get out of peat
- More efficient use of inputs, particularly livestock
- Demand reduction important: food waste, balance of livestock products (beef); replacement level fertility
- Need to have truly detailed, coordinated strategies