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The Challenges Ahead in Feeding the World

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Projected Population Growth

Region	2011	2050	Change	Percent
World	6,987	9,587	+2,600	+ 38
High Income	1,242	1,333	+ 91	+ 7
Low Income	5,745	8,254	+2,509	+ 44
East & S.E. Asia	2,183	2,308	+ 125	+ 6
South Central Asia	1,795	2,574	+ 779	+ 43
Sub-Saharan Africa	883	2,069	+1,186	+134
Lat. America/Carib	596	746	+ 150	+ 25
N. Africa & W. Asia	451	725	+ 274	+ 61

Source: Population Reference Bureau. 2011 World Population Data Sheet.

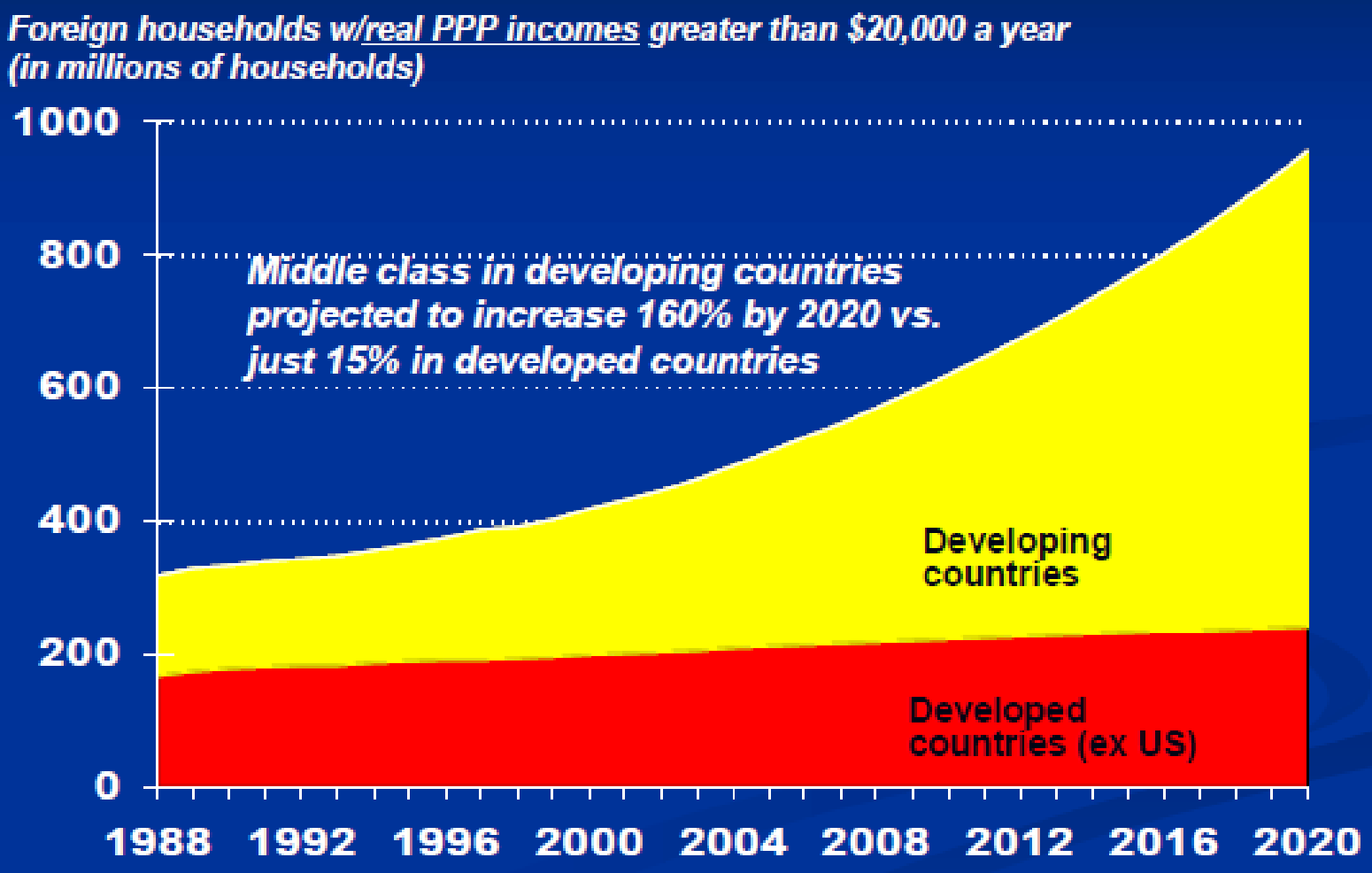
Dynamics of Food Demand Growth

- 1.4 billion people live on less that $1.25/day
  - 1 billion cannot afford 1,800 calories per day.
- 2.6 billion people live on less than $2.00/day
  - At $2.00 per day most hunger (calorie) problems solved, but 1 billion still suffer nutritional deficiencies.
- As their incomes rise from about $2 to $10 per day, people eat more meat, dairy products, eggs, edible oils, fruits & vegetables causing rapid growth in raw ag commodity demand.
- After about $10 per day, people buy more processing, services, packaging, variety, and luxury forms, but not more raw ag commodities.

Projected World Food Demand

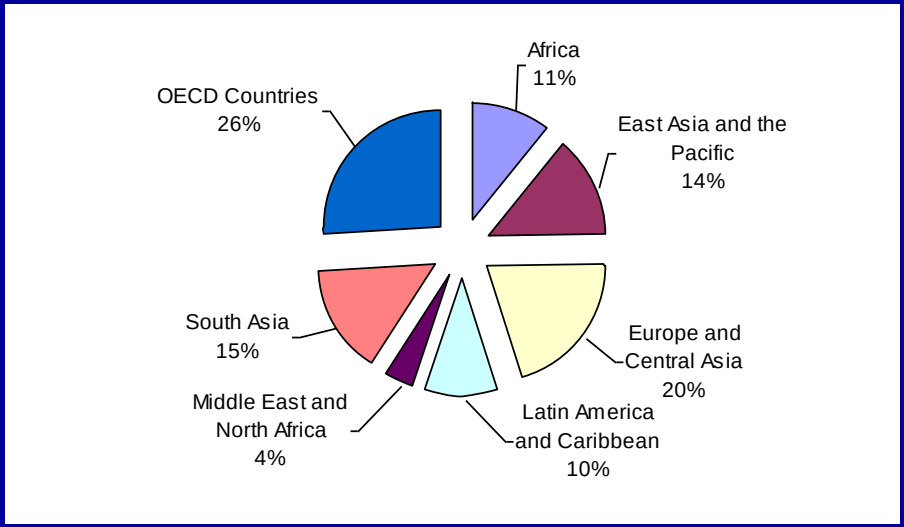
- World food demand to grow 70-80% by 2050
  - 40% increase from world population growth – from 7.0 to 9.6 billion – almost all in developing countries
  - 30-40% increase from broad-based economic growth in low income countries
- The World Bank has estimated the number of people in developing countries in households with incomes >$16,000/year will rise from 352 million in 2000 to 2.1 billion by 2030.
- How many presently low income consumers escape from poverty is the *most important* uncertainty re future global demand for food.
- Policies that accelerate broad-based economic growth in LDCs reduce hunger, but unleash rapid growth in demand for agric. products.

"Middle Class" *Outside the U.S.* Expected to Double By 2020 – Approaching 1 Billion Households

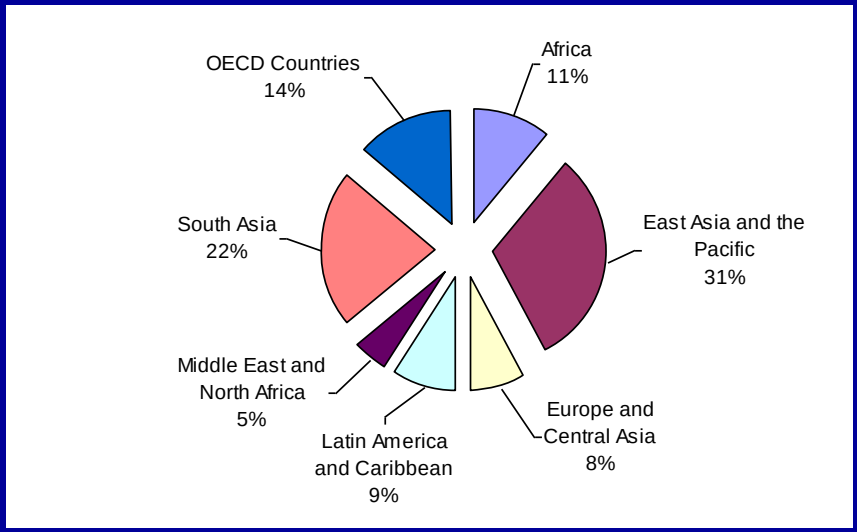


Source: Global Insight's Global Consumer Markets data as analyzed by OGA/FAS/USDA

Larger Fraction of Ag Production to Move Through Trade



Distribution of Arable Land



Distribution of World Population

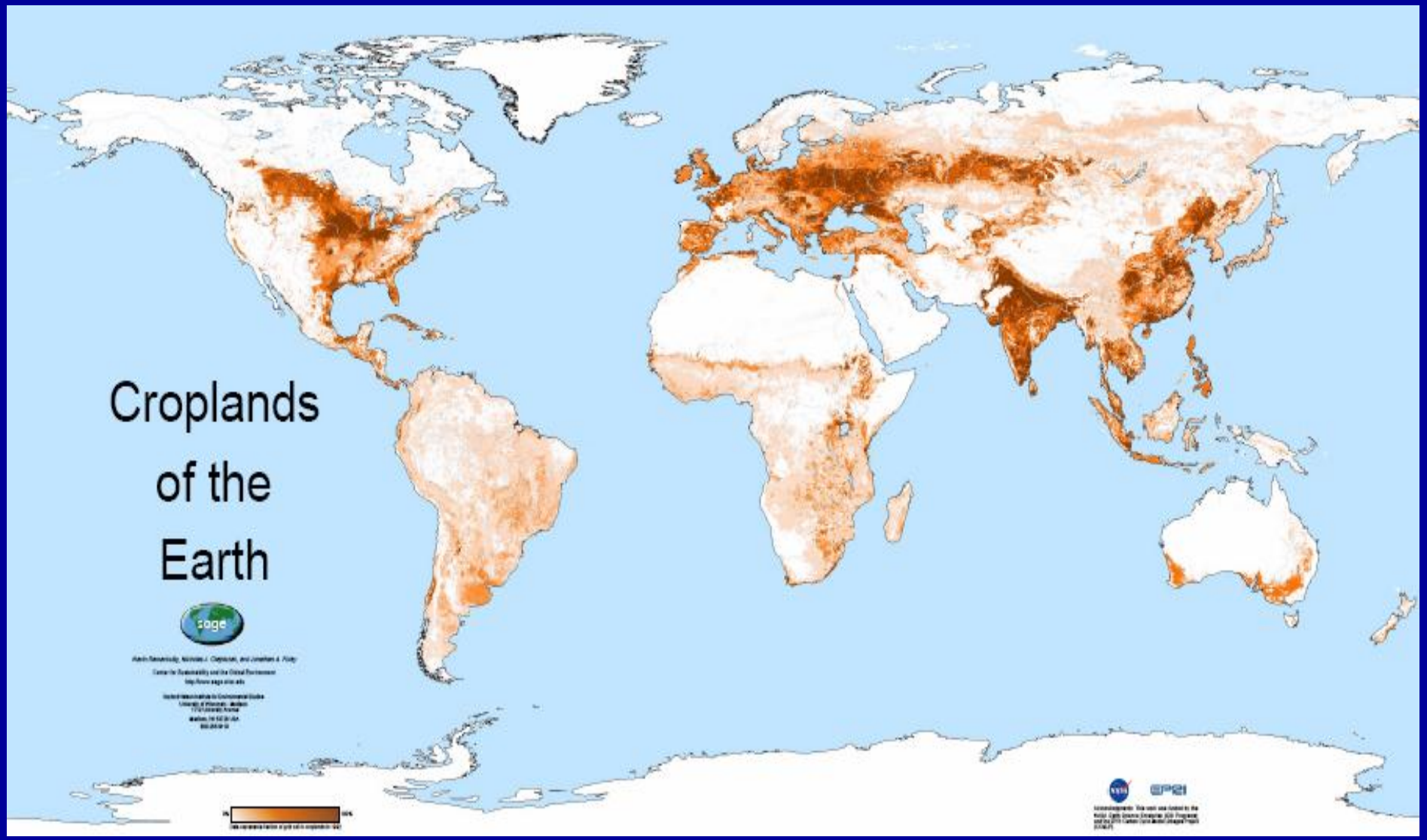
- With population growth, urbanization and broad-based economic development, many low-income countries' food consumption will outstrip their production capacity, and they will become larger net importers.

The Land Constraint

- There is at most 12% more arable land available worldwide that isn't presently forested or subject to erosion or desertification, and…
- Loss and degradation of many soils continues:
  - Urbanization & infrastructure construction
  - Nutrient mining
  - Erosion
  - Desertification
  - Natural reserves
  - Reforestation

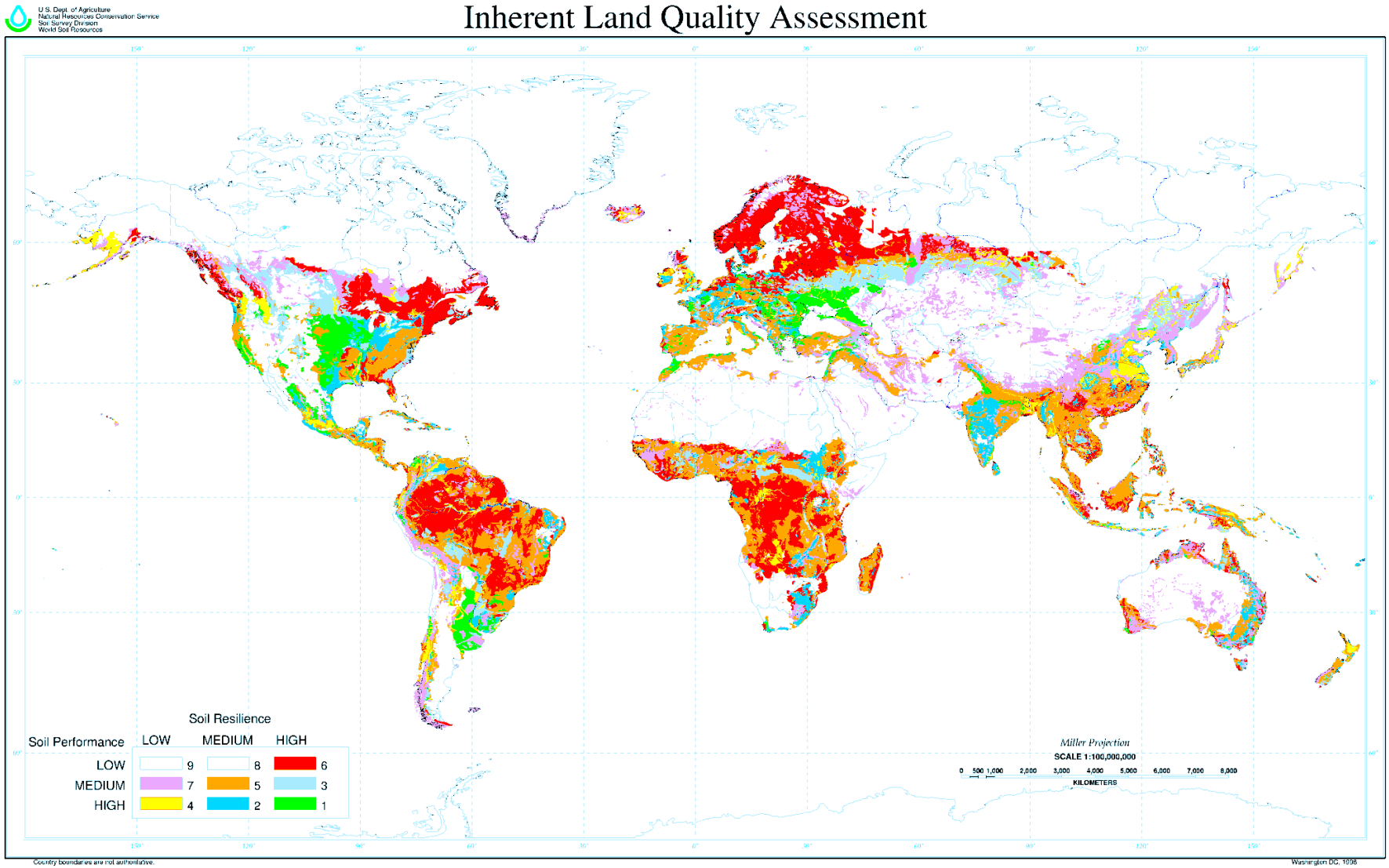
The Land Constraint (cont'd.)

- The area of land in farm production could be doubled…
  - But only by massive destruction of forests and loss of wildlife habitat, biodiversity and carbon sequestration capacity
- The only environmentally sustainable alternative is to double productivity on the fertile, non-erodible soils already in crop production.
- Most available cropland is in remote areas of South America and Sub-Saharan Africa where infrastructure is minimal and soils are inferior in quality to many already in production.



Source: Center for Sustainability and the Global Environment (SAGE), University of Wisconsin.

Inherent Land Quality



Climate Constraints

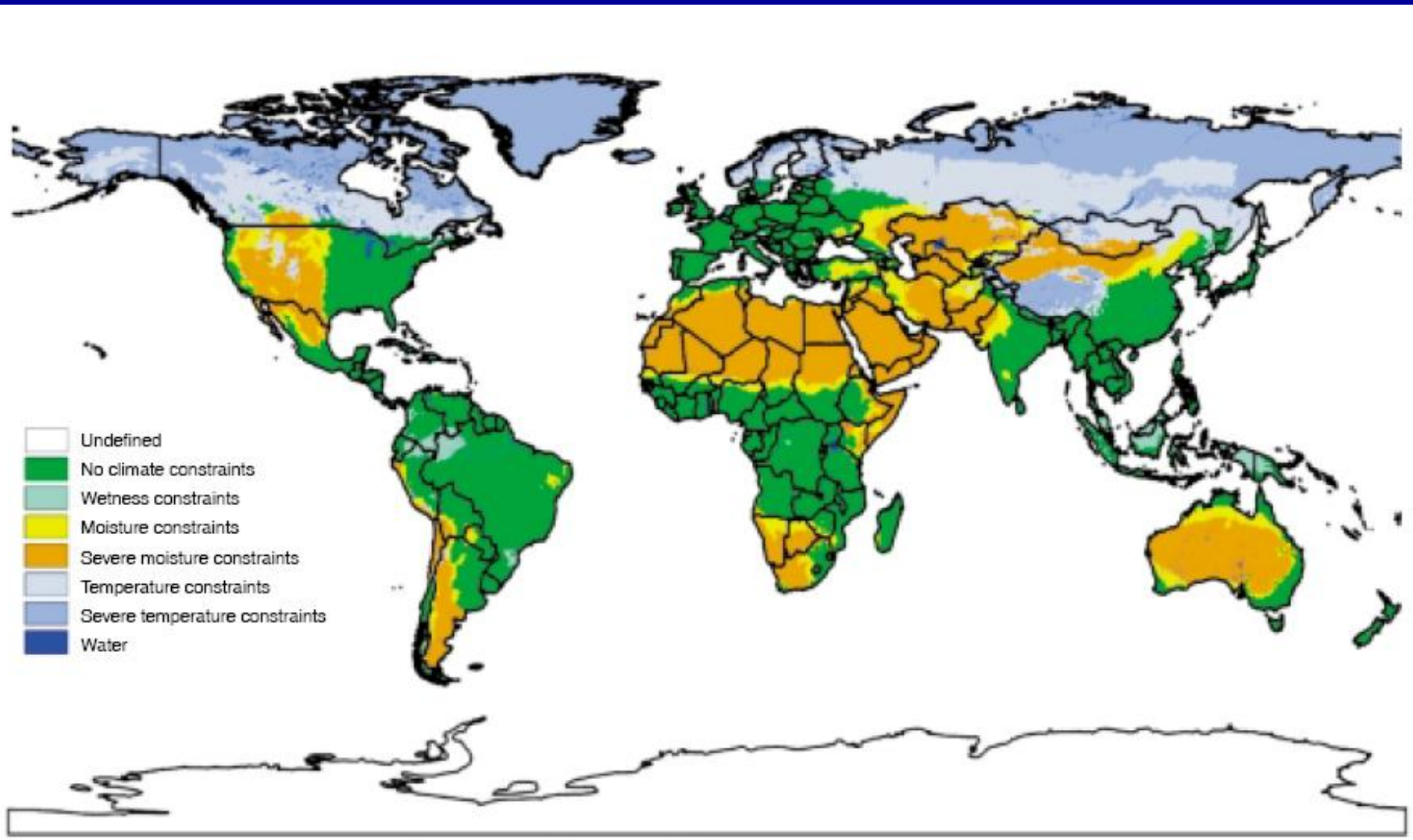


Plate E. Climate constraints.

Source: International Institute for Applied Systems Analysis

Agriculturally Important Effects of Climate Change

- Warming greater over land than over water and greatest at higher latitudes.
- Increases spatial distribution of precipitation
  - Largest reduction in subtropics (especially on their poleward edges)
  - Largest increases in higher latitudes
  - Increase under monsoons
- Increased frequency of extreme events, such as droughts and flooding.

Adaptations Will be Required Due to Global Climate Change

- As all agro-ecosystems shift with climate change, need larger public and private investments in adaptive plant and animal breeding just to sustain present productivity levels.
  - e.g. introduce more drought or heat tolerance.
- Change the mix of what crops are produced in a some geographic locations.
- Rely more on international trade.

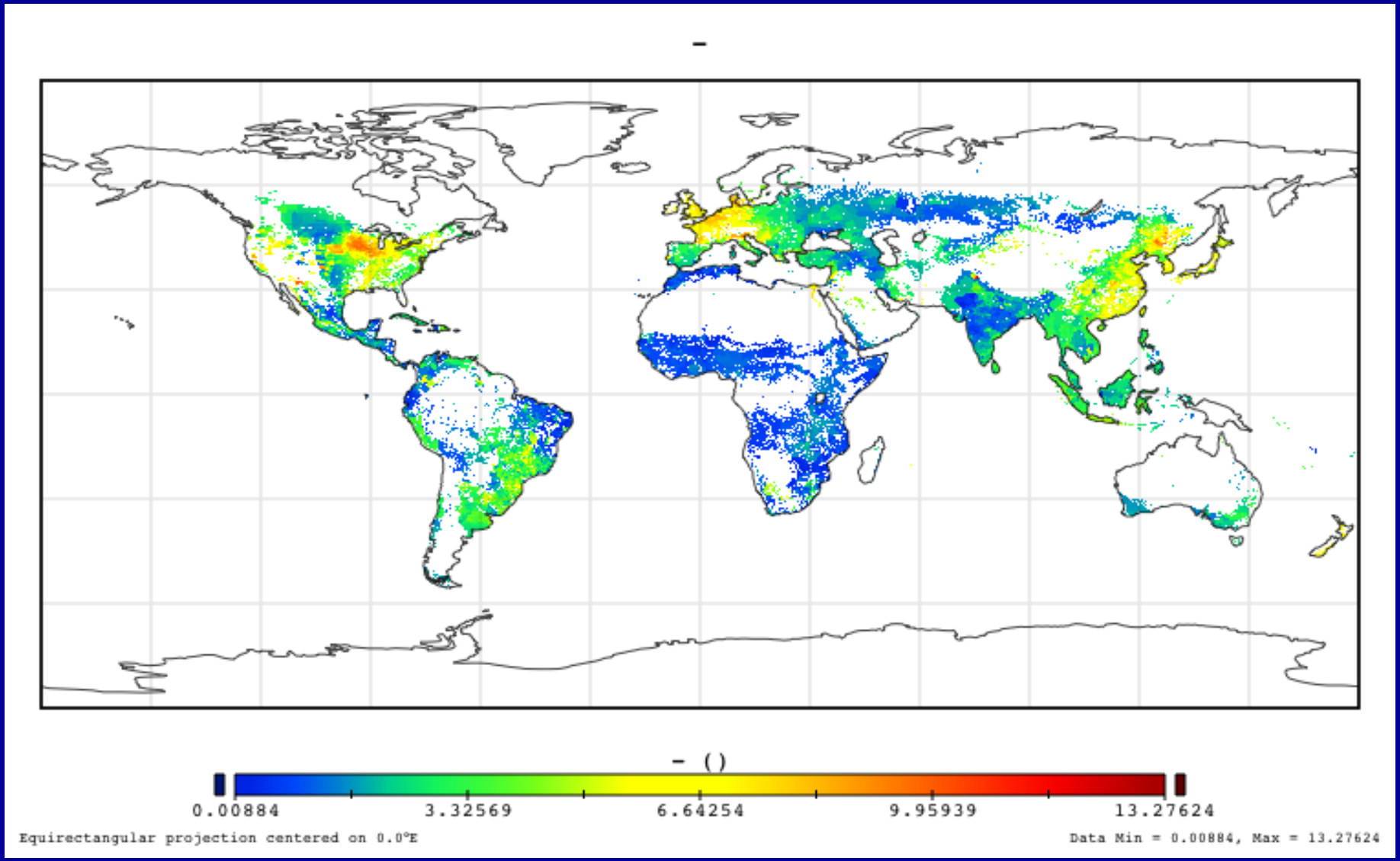
Water--A Growing Constraint

- Farmers account for 70% of the world's fresh water use.
- With the rapid urbanization underway, cities will outbid agriculture for available fresh water.
- The world's farmers, who are being called on to double food production, will have to do it using less fresh water than they are using today.
  - i.e., they will have to more than double the "crop per drop," the average productivity of the water they use.
- This will require investments in research to develop water saving technologies and to increase the drought tolerance and water use efficiency of the crop varieties being grown.

Need to Almost Double the Global Food System Productivity by 2050

- Make presently unusable soils productive
- Increase genetic potential (of individual crops and/or farming system) (ditto for farm animals)
- Achieve as much of that potential as possible by:
  - Improving nutrition of that crop
  - Increasing water availability and control
  - Reducing competition from weeds for water, nutrients and sunlight
  - Reducing losses from disease and insects
- Reduce post-harvest losses

Grain Yields Around the World

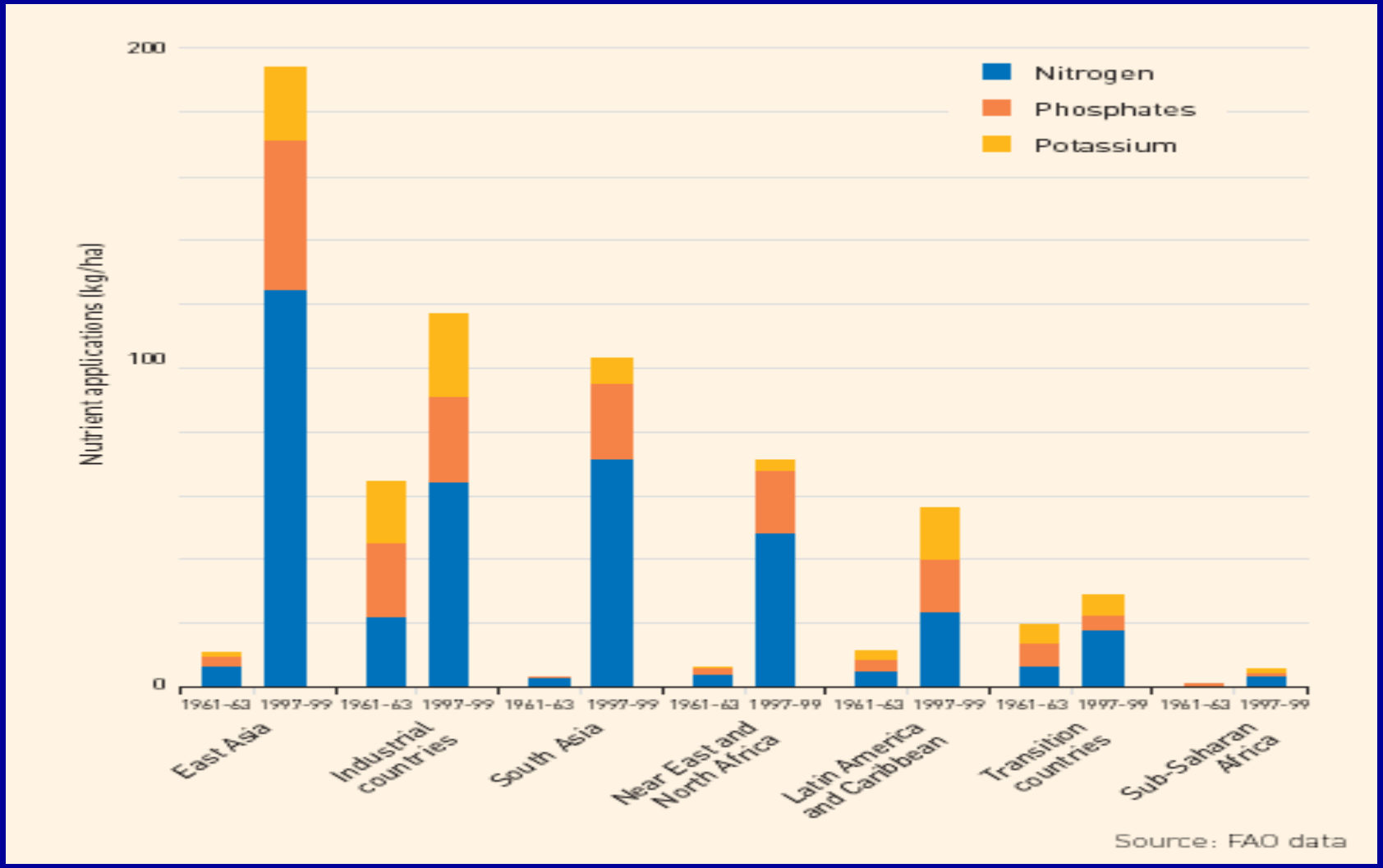


Interpretation: Grain yields (in metric tons per hectare) rise from lowest (dark blue) to highest (dark red)
Source: Center for Sustainability and the Global Environment (SAGE), University of Wisconsin.

Sources of Observed Differences in Crop Yields in Different Locations

- Genetic potential embodied in the seeds of the crop being grown.
- Climatic conditions (level and variation in temperature and precipitation)
- Quality of soil (fertility, water holding capacity; resilience)
- Supplementation of soil fertility and precipitation with fertilizer and irrigation.
- Losses of yield potential from disease and insect infestations and competition from weeds.

Fertilizer Use



More Sources of Observed Differences in Grain Yield in Different Locations

- Existence of markets to supply farmers inputs that embody improved technologies (and available credit) and buy their outputs
  - Requires a business friendly investment climate
- Remunerative input and output prices
  - Reflect public policy and state of transport and communications infrastructure.
- Knowledge and skill of farmers.

Agricultural Research Potential

- There remains more productivity enhancement potential from classical plant and animal breeding, especially with modern genomics, and genetic engineering opens new frontiers:, e.g.
  - Improve nutritional content of grains, etc.
  - Increase tolerance to drought, wetness, temperature, salt, aluminum toxicity, …. (to increase yields and/or planted area under adverse or variable conditions)
  - Internalize resistance to diseases; viruses
  - Reduce pesticide use, esp. insecticides
  - Herbicide-resistant varieties
  - Slow down product deterioration

Decline in Investments in Agriculture Development

- Between 1980 to 2005, foreign aid to LDCs for ag development dropped from $8 billion to $3.4 bill./yr (from 17 to 3% of the whole)
- In the 1980s, 25% of US foreign aid went to agriculture; dropped to 6% by 1990 and 1% last year.
- Share of World Bank lending going to agriculture fell from 30% in 1978 to 16% in 1988 to 8% in 2006.

Long-Run Prospects

- Since Malthus, prophets of doom have argued population growth will increase food demand faster than agricultural production can grow.
- Public and private sector investments in agricultural research have increased productivity faster than demand growth, with resulting 150-year downward trend in real price of grains.
- Need big increase in world food production by 2050 using less water and little more land than today and also produce biofuels feedstocks.
- Future world market price trends will depend on whether land and water productivity rise faster or slower than world demand grows.